AgroMak 2025

FIRST INTERNATIONAL SCIENTIFIC AGRI-BUSINESS CONFERENCE

PROCEEDINGS

Organic and Functional Food with Rural Tourism - Sustainability and the Future of Macedonia and the Region of Southeastern Europe

Editor: Dragan Cvetkovic

Sveti Nikole, 04-06 April 2025

FIRST INTERNATIONAL SCIENTIFIC AGRI-BUSINESS CONFERENCE "AGRO MAK" 2025.

"ORGANIC AND FUNCTIONAL FOOD WITH RURAL TOURISM - SUSTAINABILITY AND FUTURE OF MACEDONIA AND THE REGION OF SOUTHEASTERN EUROPE"

ПРВА МЕЃУНАРОДНА НАУЧНО АГРО-БИЗНИС КОНФЕРЕНЦИЈА "АГРО МАК" 2025

"ОРГАНСКА И ФУНКЦИОНАЛНА ХРАНА СО РУРАЛЕН ТУРИЗАМ - ОДРЖЛИВОСТ И ИДНИНА НА МАКЕДОНИЈА И РЕГИОНОТ НА ЈУГОИСТОЧНА ЕВРОПА"

PROCEEDINGS

Editor:
Dragan Cvetkovic

EDITION: EcoAgroTour - FOR SUSTAINABLE DEVELOPMENT 🌿

Sveti Nikole, North Macedonia
04. – 06. April, 2025.

Chamber of Organic Producers– COP, Kumanovo, Republic of North Macedonia,
Комора на Органски Производители– КОП, Куманово, РС Македонија

International Slavic University, Sveti Nikole, Republic of North Macedonia
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FIRST INTERNATIONAL SCIENTIFIC AGRI-BUSINESS CONFERENCE
ПРВА МЕЃУНАРОДНА НАУЧНО АГРО-БИЗНИС КОНФЕРЕНЦИЈА

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FOREWORD

Dear participants, guests, and collaborators,

It is with great honor and pleasure that we present to you the collection of papers from the international agribusiness conference "AGRO MAK 2025." This significant event serves as a leading platform for the exchange of knowledge, experiences, and innovations in the fields of agriculture, the food industry, and rural development. Through this conference, we have the opportunity to bring together scientists, experts, the business community, agricultural producers, and institutional representatives to discuss the current challenges and prospects in the agribusiness sector.

Agriculture is one of the most important economic sectors, playing a crucial role in economic development and the quality of life in rural areas. The development of modern technologies, sustainable practices, and efficient business models are fundamental elements for its future. Within the framework of the conference, a wide range of topics will be discussed, including sustainable agriculture, digitalization, innovations in food production, and strategies for enhancing the competitiveness of local producers in the global market.

The papers in this collection represent carefully selected research, analyses, and recommendations that not only reflect the current challenges but also offer concrete solutions and directions for the future. Their goal is to encourage constructive dialogue and collaboration among different stakeholders in the agribusiness sector, creating opportunities for new partnerships, investments, and practically applicable innovations.

In the spirit of unity and knowledge, we express our sincere gratitude to all authors, researchers, and participants who have contributed to the success of this conference through their papers and active participation. We extend special thanks to the organizers, partners, and supporters of "AGRO MAK 2025," whose dedication has made this significant gathering place for agribusiness a reality.

We hope that this collection will serve as a valuable source of information and inspiration for your future research, projects, and business activities. We wish you successful participation in the conference and fruitful discussions, with the hope that this collaboration will continue to deepen in the future.
Sincerely,

Sincerely,

Editor:
Dragan Cvetković
AGRO MAK 2025

Sveti Nikole,
April 4-6, 2025

ПРЕДГОВОР

Почитувани учесници, гости и соработници,

Со особена чест и задоволство ви го претставуваме зборникот на трудови од меѓународната агробизнис конференција „АГРО МАК 2025“. Ова значајно событие претставува водечка платформа за размена на знаење, искуства и иновации во областа на земјоделството, прехранбената индустрија и руралниот развој. Преку оваа конференција, имаме можност да ги обединиме научниците, стручњаците, бизнис-заедницата, земјоделските производители и претставниците на институциите со цел да дискутираат за актуелните предизвици и перспективи во агробизнис секторот.

Земјоделството е една од најзначајните стопански гранки која има клучно влијание врз економскиот развој и квалитетот на животот во руралните средини. Развојот на модерни технологии, одржливи практики и ефикасни бизнис модели се основни елементи за неговата иднина. Во рамките на конференцијата, ќе се дискутира за широк спектар на теми, вклучувајќи одржливо земјоделство, дигитализација, иновации во производството на храна, како и стратегии за подобрување на конкурентноста на локалните производители на глобалниот пазар.

Трудовите во овој зборник претставуваат внимателно избрани истражувања, анализи и препораки, кои не само што ги одразуваат актуелните предизвици, туку и нудат конкретни решенија и насоки за иднината. Нивната цел е да поттикнат конструктивен дијалог и соработка меѓу различните чинители во агробизнис секторот, создавајќи можности за нови партнерства, инвестиции и практични применливи иновации.

Во духот на заедништво и знаење, изразуваме искрена благодарност до сите автори, истражувачи и учесници кои со своите трудови и активно учество придонесоа за успешноста на оваа конференција. Посебна благодарност упатуваме и до организаторите, партнерите и поддржувачите на „АГРО МАК 2025“, кои со својата посветеност овозможија реализација на ова значајно собирно место за агробизнисот.
Се надеваме дека овој зборник ќе ви биде вреден извор на информации и инспирација за вашите идни истражувања, проекти и деловни активности. Ви посакуваме успешно учество на конференцијата и плодна дискусија, со надеж дека оваа соработка ќе продолжи да се продлабочува и во иднина.

Со почит,

Уредник:
Драган Цветковиќ
АГРО МАК 2025

Свети Николе,
04-06. април 2025

C O N T E N T S

INVITED SPEAKERS

PLENARY PRESENTATIONS

SESSION A

DRAFT PLAN FOR HARMONIZATION OF THE MACEDONIAN ORGANIC PRODUCTION WITH THE EU REGULATION 2018/848

НАЦРТ ПЛАН ЗА ХАРМОНИЗАЦИЈА НА МАКЕДОНСКОТО ОРГАНСКО ПРОИЗВОДСТВО СО ЕУ РЕГУЛАТИВАТА 2018/848

Ljupčo Mihajlov, Full professor,[1]
Zoran Dimov, Full professor,[2]

Abstract: *The purpose of this paper is to analyze the development of organic agriculture in North Macedonia and propose key policies, legal adjustments, and strategic directions necessary for its harmonization with EU Regulation 2018/848. The plan is proposed to support sustainable growth of the organic sector, enhance rural development, and ensure compliance with European standards. A comparative analysis and adaptation of specific articles from the regulation, to the conditions of these areas in North Macedonia are used as methodologies applied in the preparation of the draft plan.*

Key words: *organic, agriculture, sustainable, rural development*

Апстракт: *Целта на овој труд е да го анализира развојот на органското земјоделство во Северна Македонија и да предложи клучни политики, законски прилагодувања и стратешки насоки неопходни за негово усогласување со Регулативата на ЕУ 2018/848. Планот е предложен со цел да го поддржи одржливиот раст на органскиот сектор, да го подобри руралниот развој и да обезбеди усогласеност со европските стандарди. Компаративна анализа и адаптација на конкретни членови од регулативата, кон условите и состојбите во овие области во Северна Македонија се користеа како методологии применети во подготовката на нацрт-планот.*

Клучни зборови: *органско, земјоделство, одржливо, рурален развој*

1. INTRODUCTION

The first activity in the organic sector in the Republic of Macedonia was recorded in 1997 when the company “Alkaloid” applied for the country’s first organic certificate to market wild herbs, such as linden and chamomile, as organic on the national market. The first inspection of organic production in the Republic of Macedonia was conducted in 2003, and the first organic production certificate was issued in 2004, (National Plan for Organic Production of the Republic of Macedonia 2013 – 2020).

In 2007, the Government of the Republic of Macedonia adopted the National Strategy with an Action Plan for Organic Agriculture for the period 2008–2011, (National Strategy with Action

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Plan for Organic Agriculture 2008 – 2011, Ministry of Agriculture, Forestry and Water Management of the Republic of Macedonia).
In 2013, a new National Strategy for Organic Production, 2013 - 2020 was adopted, (www.mzsv.gov.mk, 2013).

The Law on Organic Agricultural Production was first adopted in 2004. In 2009, a new Law on Organic Agricultural Production was enacted, fully aligning with European Regulation 834/2007 (European Regulation 834/07), and 889/2008 (European Regulation 889/08).

In 2010, the bylaws for harmonization were officially enacted in alignment with Council Regulation (EC) 834/2007 (28.06.2007) and Council Regulation (EC) 889/2008 (05.09.2008). These regulations were published in the Official Gazette of the Republic of Macedonia, No. 161/2010 (15.12.2010) and No. 163/2010 (17.12.2010).

A chronologically following official document on the development of the Macedonian organic sector is the National Strategy with Action Plan for Organic Production in the Republic of Macedonia 2013–2020**.**

A new Law on Organic Farming was adopted in 2021, (Law on Organic Farming **(**2021), further aligning national regulations with the latest European Union standards and requirements. This law aims to modernize organic production in line with the latest European standards, particularly in the areas of:

- **Certification** – Enhancing the certification process to ensure compliance with organic regulations.
- **Control** – Strengthening monitoring and enforcement mechanisms to maintain high organic production standards.
- **International Trade in Organic Products** – Facilitating the export and import of organic products by aligning with EU trade policies.
- **Support for Organic Producers** – Increasing subsidies and financial assistance to encourage the growth and sustainability of the organic sector.

Currently, the preparation of a new Draft Law on Organic Production is in its final phase, with a draft text of the proposed law already completed, (www.mzsv.gov.mk (2024). The purpose of adopting this law is to align it with **Regulation (EU) No. 2018/848** of the European Parliament and of the Council of **30 May 2018** on organic production and labeling of organic products, which repeals **Council Regulation (EC) No. 834/2007**. Another significant reason for adopting this law is the harmonization of Macedonian legislation with **Commission Implementing Regulation (EU) 2021/1165 of 15 July 2021**, which authorizes certain products and substances for use in organic production and establishes their official list.

2. MATERIALS AND METHODS

Adaptation of specific articles from the Regulation (EU) No. 2018/848, to the conditions of these areas in North Macedonia are used as methodologies applied in the preparation of the draft plan. Emphasis was placed on preparing **draft versions of four by-laws** at the national level to harmonize them with the Law on Organic Agriculture as well as EU Regulation 2018/848. The regulations should be applicable to all parties in North Macedonia involved in any stage of production, preparation, labelling, distribution, marketing, and other activities related to the production and trade of organic products. The four draft national-level bylaws that align with the **national organic agriculture regulation** as well as **EU Regulation 2018/848** are:

1. Rulebook on the Detailed Provisions for Placing on the Market of Plant Reproductive Material from Organic Heterogeneous Material;
2. Rulebook on the for Special Rules for the Production of Organic Processed Food and the Use of Certain Products and Substances in Food Processing;
3. Rulebook on the Detailed Rules for the Use of Terms Related to Organic Production;
4. Rulebook on the Special Rules for Closer Conditions and Rules for Groups of Certification Entities;

Since the objectives of this Regulation, in particular fair competition and the proper functioning of the internal market in organic products, as well as ensuring consumer confidence in those products, Official Journal of the European Union (OJEU), L 150/17, (2018)

3. RESULTS AND DISCUSSION

The analysis of the development of organic agriculture in **North Macedonia** is presented in **four chapters** in the following text. Additionally, the final part of this section contains an explanation of some of the **key activities undertaken to align the new Law on Organic Agriculture with EU Regulation 2018/848,** listed above in the **"Materials and Methods"** section.

3.1. Major strategic documents with goals for the development of organic agriculture in the RN Macedonia

To date, four major strategic documents addressing organic agriculture have been adopted in the Republic of North Macedonia. These include two national strategies exclusively focused on organic agriculture: The National Strategy with an Action Plan for Organic Agriculture of the Republic of Macedonia (2008–2011), and The National Plan for Organic Production (2013 – 2020), as well as two National Strategies for Agriculture and Rural Development (2014 – 2020 and 2021 – 2027), which assign significant importance to organic production.
The strategic and implemented goals from the National Strategy for Organic Agriculture (2008 – 2011) are outlined below (Table 1.):

Table 1. Strategic and Implemented Goals for Organic Agriculture, 2008 – 2011

Target Set	Target Achieved
By 2011, organic arable land to account for 2% of the total arable agricultural land in the Republic of Macedonia	In 2011, organic arable land accounted for 1.29% of the total arable agricultural land in the Republic of Macedonia, amounting to 6,580.92 hectares. The total arable agricultural land in the Republic of Macedonia in 2011 was 511,000 hectares.
Certified areas for wild plant and fruit collection to account for 5% of the total land area in the Republic of Macedonia	Certified areas for wild species collection have increased to approximately 250,000 hectares. Since wild plant and fruit collection occurs on pastures, meadows, and forests, a significant portion of these areas is not registered in cadastral records, making precise measurement impossible. Additionally, there is no nationwide database or record for wild plant and fruit collection from regular production, meaning the total certified areas for such collection cannot be accurately calculated.

By 2011, the majority of consumers in the Republic of Macedonia should understand what organic agriculture is and create domestic demand for organic products	A growing number of consumers in Macedonia understand what organic agriculture represents and recognize the value of organic food. However, much work remains in this area. To establish a strong domestic supply and demand for organic products, continuous consumer education and awareness-raising through targeted campaigns, promotions, and other informational tools are essential.
By 2011, establish stable export connections	Certain entities, primarily companies, have independently established export connections with EU countries, but organized export of organic products has not yet been achieved.

The national strategic goal outlined in the **National Organic Production Plan (2013 – 2020),** was to enhance the competitiveness of organic production in the country for successful placement in domestic and international markets. Specific objectives for 2020 related to primary agricultural production included:

- **Achieve 4% organic production share** of the total arable agricultural land in Macedonia and ensure 4% of the total certified livestock in organic farming (including beekeeping and aquaculture) from the total livestock population**.**
- **Identify and support strategically significant organic products.**
- **Improve the availability of inputs permitted for use** in organic production.

Additionally, specific goals and methods of realization were detailed for the processing industry, trade, control and certification, education and science, policy and legislation, and the collection of wild species.

The National **Strategy for Agriculture and Rural Development (2014 – 2020)** emphasized that organic production should align with real domestic market interest. The policy's desired projection was:

- **2% cultivated land under organic production** of the total arable agricultural land.
- **2% certified organic livestock** (including beekeeping and aquaculture), of the total livestock population.

A more ambitious approach was deemed possible only with serious reorganization among organic producers, focusing on increasing their presence in foreign markets with higher demand for organic products.

In the National **Strategy for Agriculture and Rural Development (2021 – 2027),** the state of organic agriculture was acknowledged: despite growth in previous years, organic production remains under **2%** of total agricultural land and livestock. This remains the target for the next period. To address this, organic production must focus on leveraging its added market value rather than relying solely on income support. Recommendations include:

- Finalizing organic products;
- Improving organic product marketing domestically and internationally;
- Raising public awareness of organic food.

Further suggestions included stimulating trade in seeds, fertilizers, and plant protection products, increasing subsidies for organic product processing, enhancing monitoring and laboratory testing systems, and more.
Additional key policy documents addressing organic agriculture include:

- **Stabilization and Association Agreement (2001):** Covers social justice, employment, and sustainable resource use in North Macedonia.
- **Strategy for Harmonizing the Macedonian Agro - Food Sector with the EU's Common Agricultural Policy:** Highlights the need to identify regions suitable for organic production and align with EU regulations.

World Trade Organization Agreement (2003): Aims to improve international food safety and security standards as adopted by Codex Alimentarius ((National Strategy with Action Plan for Organic Agriculture 2008 – 2011, Ministry of Agriculture, Forestry and Water Economy of the Republic of Macedonia).

3.2. Organic agricultural production in the RN Macedonia

Statistical data on organic production in RN Macedonia can be obtained from two primary sources:

I. Website of the Ministry of Agriculture, Forestry, and Water Economy (MAFWE):
A dedicated section provides information on organic production, including legislation, an overview of organic production areas and livestock, a registry of organic producers, relevant literature, contacts, and more.
II. MakStat Online Database of the State Statistical Office (SSO):
This database displays statistical data on areas under organic crops, organic livestock production, and beekeeping families.

According to the latest data, in 2023, there were 6,001 hectares of certified organic production, representing 1.17% of the total arable land in 2023 (514,375 hectares). This figure still falls short of one of the specific goals outlined in the National **Strategy of Agriculture and Rural Development (2021–2027),** which aims for the share of total organic area in total arable land to reach 2%. The number of certified organic operators has been gradually increasing, with the highest total recorded in 2021 at 929 operators. However, the number has decreased over the past two years, standing at 913 operators in 2023, with an average area per operator of 5.3 and 6.6 hectares, respectively.
From the organic crop production cereals occupy the largest share of the total certified organic area, followed by fruit and fodder crops (Chart 1.) (**MAFWE, 2023; SSO, 2023**).

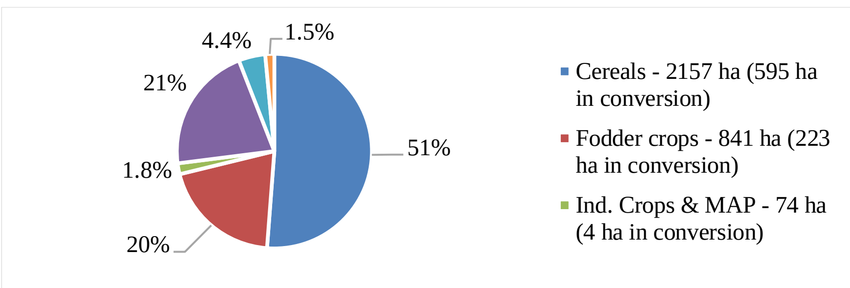

Chart 1. Area of organic crop production, 2023.

In organic livestock production, sheep account the largest share of the certified livestock population, mainly because sheep farming in the country is predominantly extensive due to the large pasture areas. The number of sheep in organic production in 2023 is 120,514, of which 50,092 are fully organic and 70,422 are under conversion. Organic milk production totaled 2,437,000 liters. The number of cattle in organic production is 7,528, producing 48,300 liters of milk, while the number of goats 4,966, yielding 268,000 liters of milk. Additionally, 10,944 beehives were certified for organic honey production, with a total output of 67,886 kilograms of honey (24,470 kilograms in conversion) (MAFWE, 2023). Other organic livestock production is minimal. There is some potential for organic poultry production, but this sector requires further development.

3.3. Budgetary support for organic agriculture in RN Macedonia

Organic production in North Macedonia is supported in accordance with the Law on Agriculture and Rural Development under two pillars of measures: i) for agriculture and ii) rural development. The total amount of funds paid to beneficiaries in the program period from 2015 to 2023 reached 12.3 million euros. From year to year, the amounts for support are increasing, which is expected to lead to an increase in both production and the number of producers who choose this type of production. The financial support for organic agricultural production for 2023 amounts to a total of 104,000,000.00 MKD (1.68 million euros or 1.6% of the total financial support for agriculture)[2]. In addition to domestic support, organic production support will also be provided through the IPARD program for the next period, Measure 4: Agro ecology, Climate, and Organic Production.

3.4. Strategic and specific goals for organic agricultural production in RN Macedonia until 2027

Taking into account the importance of agriculture as one of the key sectors in the country, and especially organic production, for which there is broad consensus among all relevant stakeholders that it must be increased if we want to be recognized on the European map, the strategic goals for organic production by 2027 should be directed towards:

- Increasing the competitiveness of organic production in RN Macedonia for successful placement in domestic and foreign markets;
- For organic agriculture to be a fully developed sector of agriculture with all appropriate characteristics, such as a stable market, services, and state policy support, the aspects related to the environment and animal welfare must be satisfied.

  Additionally, some of the strategic goals should include:
- An effective connection between primary production and processing activities, across the entire organic agriculture chain;
- To create infrastructure that will enable continuous and sustainable development while creating conditions for organic products to be a significant aspect of Macedonian organic agriculture (significantly increasing the production of organic food with Macedonian origin).

[1] The funds for financial support in agriculture for 2023, in the total amount of 6,437,634,000.00 MKD, are provided in accordance with the Budget of the Republic of North Macedonia for 2023 (Official Gazette of the Republic of North Macedonia, No. 282/22), section 140.04, program 2, subprogram 20, item 464 – various transfers.

According to the National Strategy for Agriculture and Rural Development of the Republic of Macedonia 2021-2027 and the National Organic Production Plan of the Republic of Macedonia 2013-2020, specific goals until 2027 are:

I. Primary Agricultural Production:

• Organic production should cover 2% of total agricultural land in the Republic of North Macedonia and 2% of the total certified livestock in organic farming (including beekeeping and fishing) of the total livestock population in the country;

• To identify and support strategically important organic products;

• To improve the availability of approved raw materials for use in organic production.

II. Processing Industry:

• **Contract Farming:** Collaborate with organic farmers through long-term agreements to ensure a consistent supply of high-quality organic raw materials;

• Adopting Sustainable Processing Practices that preserve the natural integrity of organic ingredients, such as cold-pressing, freeze-drying, or fermentation.

- **Waste Management**: Develop systems to minimize waste and recycle by-products into organic compost or animal feed.

III. Trade:

• To increase the assortment and quantities of organic agricultural products;

• To increase demand and consumption of organic agricultural products;

• To raise public awareness of organic food;

• To exploit the potential for organic product consumption through the development of rural tourism;

• To increase the placement of Macedonian organic agricultural products in export markets.

IV. Control and Certification:

• To increase competition in the supply of control and certification services;

• Institutional strengthening of the monitoring system in organic production.

V. Education and Science:

• To increase the share of education in the field of organic production (both formal and informal education);

• To intensify research on organic agricultural techniques;

• To intensify and expand research on the potential of natural resources;

• To begin market research.

VI. Policy and Legal Regulation:

• To institutionally strengthen and professionally train institutions involved in the organic production system (knowledge, human resources, infrastructure);

• To increase cooperation and communication between all involved and affected parties;

• To strengthen organic farmers' associations and other non-governmental organizations and support their networking and cooperation.

3.5. KEY ACTIVITIES UNDERTAKEN TO ALIGN THE NEW LAW ON ORGANIC AGRICULTURE WITH EU REGULATION 2018/848

The activities for the preparation of the four draft rulebooks took place from June 12, 2024, to November 25, 2024**,** within the framework of the **project:** "**Germany - Western Balkan Agricultural Policy Dialogue (APD-WB)" (2024).** As a result of the activities carried out within the framework of the aforementioned project, four **draft Rulebooks** has been prepared.

The first of the draft bylaws is the **Rulebook on the Detailed Provisions for Placing on the Market of Plant Reproductive Material from Organic Heterogeneous Material**, ensuring alignment with **EU Regulation 2018/848, (**OJEU, L 150/27, Artille 13, (2018). The subject of regulation is the determination of the rules related to the **production and placing on the market** of **plant material from organic heterogeneous material**, namely:

- Seeds of field crop plant species;
- Reproductive material from vegetables (except seeds);
- Reproductive material from ornamental plants;
- Reproductive material from vines;
- Reproductive material from fruit plants;

In the above-mentioned first draft by-law they are justified Specific provisions for the marketing of plant reproductive material of organic heterogeneous material among which the most important is the first:
1. Plant reproductive material of organic heterogeneous material may be marketed without complying with the requirements for registration and without complying with the certification categories of pre-basic, basic and certified material or with the requirements for other categories, which are set out in Directives 66/401/EEC, 66/402/EEC, 68/193/EEC, 98/56/EC, 2002/53/EC, 2002/54/EC, 2002/55/EC, 2002/56/EC, 2002/57/EC, 2008/72/EC and 2008/90/EC or acts adopted pursuant to those Directives. in the sense of the directives, (OJEU, L 150/27, Artille 13, (2018).

The second of the draft bylaws is **The Regulation on the Special Rules for the Production of Organic Processed Food and the Use of Certain Products and Substances in Food Processing.**

This Regulation establishes the **specific rules for the production of organically processed food for humans and animals** and the **use of certain products and substances in food processing**. These provisions are designed to enhance **precautionary and preventive measures** implemented by commercial global entities and may be subject to amendments or additions to ensure compliance with evolving organic production standards. Official Journal of the European Union (OJEU, L 150/29, Artille 16, (2018).

The third by-law is **Regulations on the Special Rules for the Use of Terms related to Organic Production.** This Regulation establishes **detailed provisions on the special rules for the use of terms related to organic production**. For the purposes of this Regulation, a product is considered to be labeled with a term referring to organic production if **its labels, promotional materials, or commercial documents** describe the product, its ingredients, or the **feed components used in animal feed production** in a way that suggests to the purchaser that they have been produced in accordance with this Regulation, (OJEU, L 150/37, Artille 30, (2018).
The fourth draft bylaw is **The Regulation on the Special Rules for Closer Conditions and Rules for Groups of Certification Entities.** This draft document defines **the groups of entities** and the **conditions** under which they may engage in the **processing, preparation, or placing on the market** of organic food or organic animal feed, OJEU, L 150/39, Artille 36, (2018).

4. CONCLUSION

As a production system, organic farming has great potential for RN Macedonia due to the extensive traditional agriculture, predominantly found in mountainous areas with very favorable ecological conditions for its sustainable development (over 50% of the country's total agricultural land). Products from these regions already enjoy a good reputation among Macedonian consumers, who often refer to them as "eco-friendly" products. However, although the first activities in the organic sector date back to 1997, organic production in RN Macedonia is still in its pioneer phase. Organic production accounts 1.2% of the total agricultural land under conventional farming in the country. Despite the optimistic indicators, organic farming and organic food production still face many challenges. Areas that require attention include improving quality in agricultural production, establishing sustainable supplier-buyer relationships, supporting local sales of organic products, enhancing professionalism, and transferring scientific knowledge into practice. Agricultural producers and organic food processors need to become respected leaders by implementing advanced technologies and ecological standards. Also, international cooperation and partnerships, including programs for international collaboration, are key components of a holistic approach to implementing activities that will contribute to the continuous and sustainable growth of the Macedonian organic sector.

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POTENTIAL USE OF COLD PRESSED BLACK SEED OIL IN PRODUCING NOVEL FOOD AND FUNCTIONAL FOOD

ПОТЕНЦИЈАЛНА УПОТРЕБА НА ЛАДНО ЦЕДЕНО МАСЛО ОД ЦРНО СЕМЕ ВО ПРОИЗВОДСТВОТО НА НОВА И ФУНКЦИОНАЛНА ХРАНА

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Abstract: *Black seed oil (Nigella sativa oil) is obtained through the extraction of seeds from the Nigella sativa plant, also known as "black seed" or "black cumin," and grows in countries around the Mediterranean Sea, as well as in Pakistan, India, and Iran. Due to its richness in bioactive substances, NSO is used in traditional medicine to treat various ailments and shows significant medical and pharmacological properties. Nigella sativa oil is considered a promising trend for producing products with greater functional benefits. In recent decades, the biological properties and medicinal aspects of NSO have been studied, particularly the active compounds such as thymoquinone, thymohydroquinone, ρ-cymene, carvacrol, and t-anethole, which exhibit antioxidant, antimicrobial, antifungal, anti-inflammatory, anticancer, antidiabetic, antihypertensive, and hypolipidemic activities with low toxicity. These properties make NSO useful for food applications, such as improving sensory characteristics, stability, and shelf life of various products like bread, baked goods, and other functional food items.*
However, its use in the food industry is limited due to its low water solubility, high volatility, and specific organoleptic properties, which may make the product unacceptable if used in higher concentrations. To successfully incorporate NSO into food products, innovations in stabilization processes and improving its bioavailability and organoleptic properties are needed.
The aim of this paper is to provide an overview of NSO and its application in the food industry, as well as to explore its biological activities and potential industrial uses of NSO as an ingredient in food products.

Key words: *Nigella sativa, cold-pressed oil, bioactive compounds, food industry, antioxidant.*

Апстракт: *Маслото од црно семе (Nigella sativa oil) се добива со екстракција од семките на растението Nigella sativa, познато и како "црно семе" или "црн ким", и расте во земјите околу Средоземното Море, во Пакистан, Индија и Иран. Поради богатството со биоактивни супстанции, NSO се користи во традиционалната медицина за лекување на различни заболувања и покажува значајни медицински и фармаколошки својства. Маслото од Nigella sativa се смета за ветувачки тренд за добивање на производи со поголеми функционални придобивки. Во последните децении, истражени се биолошките својства и медицински аспекти на NSO, посебно на активните соединенија во неговиот состав, како што е тимокинон, тимохидрокинон, ρ-цимен, карвакрол и t-анетол кои покажуваат антиоксидативни, антимикробни, антифунгални, антиинфламаторни, антиканцерогени, антидијабетични, антихипертензивни и хиполипидемични активности со ниска токсичност, што го прави корисно и за прехранбени апликации. Во прехранбената индустрија, NSO ги подобрува сензорните карактеристики, стабилноста и рокот на траење на различни производи*

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како што се леб, пекарски производи и други функционални намирници. Сепак, неговата примена е ограничена поради ниската растворливост во вода, високата испарливост и специфичните органолептички својства, кои може да го направат производот неприфатлив доколку се користи во поголеми концентрации.
За успешно вклучување во прехранбените производи, потребни се иновации во процесите за стабилизација и подобрување на неговата биорасположивост и органолептички својства. Целта на овој труд е да даде преглед на NSO и неговата примена во прехранбената индустрија, како и да ги разгледа биолошките активности и потенцијалните индустриски примени на NSO како состојка во прехранбени производи.

***Клучни зборови:** Nigella sativa, ладноцедено масло, биоактивни соединенија, прехранбена индустрија, антиоксиданси.*

1. INTRODUCTION

Nigella sativa is an annual flowering plant from the Ranunculaceae family, which originates and is cultivated in South and Southwestern Asia, but it is also grown in Mediterranean countries, Central Europe, and Western Asia (Hassanien et al., 2015; Mazaheri et al., 2019; Fidan et al., 2019; Alu'datt et al., 2024). The fruit of the plant is a spherical capsule containing numerous black seeds with a bitter and aromatic taste (Rahim et al., 2022).

In traditional medicine, black seed is considered a miraculous herb and is used to treat various disorders and diseases (Ahmad et al., 2013), including headaches, respiratory diseases, diabetes, hypertension, male infertility, paralysis, infections, and digestive system diseases. Additionally, it is used to strengthen the immune system and as a remedy for coughs (Hassanien et al., 2015; Mazaheri et al., 2019; Mukhtar et al., 2019; Jufri et al., 2022). Furthermore, Nigella sativa shows analgesic, antipyretic, contraceptive, anti-oxidative, antitussive, and anti-inflammatory properties (Jufri et al., 2022). The mechanism of its anti-inflammatory action involves the inhibition of pro-inflammatory cytokines, interleukin 1-beta (IL-1β) and interleukin 6 (IL-6) (Rahim et al., 2022). The oil of *Nigella sativa* is considered a potential therapeutic supplement for autoimmune disorders, offering a natural and promising approach for the treatment of psoriasis, arthritis, systemic lupus, ankylosing spondylitis and type 2 diabetes (Saifullah, 2024). Avicenna referred to black seed as "the canon of medicine" due to its ability to stimulate the body's energy and contribute to recovery from fatigue and discomfort (Ahmad et al., 2013). Besides its use in medicine, *Nigella sativa* seeds have traditionally been used as a spice and natural preservative in various food products, including yogurt, pickles, sauces, and salads, especially in the bakery industry and cheese production (Hassanien et al., 2015; Kiralan et al., 2015). Its nutritional value is significant, as it contains an appropriate amount of proteins and fats, as well as essential fatty acids, vitamins and minerals (Hannan et al., 2021).

Cold-pressed black seed oil (BSO) is known for its antioxidant properties and health benefits. This oil contains a wide range of bioactive compounds with significant health improving effects and is used in various food applications (Kiralan et al., 2020). Lipid oxidation poses a significant challenge in the food industry, especially in unsaturated and polyunsaturated fatty acids (PUFAs), which are prone to degradation (Ramadan et al., 2011). Oxidation of these lipids can occur through photooxidation, autoxidation, or enzyme-catalyzed oxidation (Sun et al., 2011).

2. CHARACTERISTICS AND COMPOSITION OF NIGELLA SATIVA

Cold-pressed black seed oil contains fats in the range of 26–34%, of which 0.4% – 2.5% are essential oils, proteins (26%), carbohydrates (25%), dietary fibers (8.4%), alkaloids, and saponins (Hassanien et al., 2015; Zeyada et al., 2023). *Nigella sativa* seeds mainly consist of essential (volatile) and fixed (stable) oils, which are responsible for the health benefits of this plant. The fixed oil contains significant amounts of unsaturated fatty acids such as linoleic and oleic acids, while saturated fatty acids such as arachidonic and eicosanoic acids are present in smaller quantities, along with thymoquinone (2-isopropyl-5-methyl-1,4-benzoquinone) (Mukhtar et al., 2019). The oil from black seed exhibits pharmacological potential, including antioxidant, antifungal, and antimicrobial activities (Kiralan et al., 2013; Hassanien et al., 2015). Antimicrobial activity of essential oils obtained from spices and culinary herbs originates from their phenolic compounds (Hassanien et al., 2015; Liao et al., 2020). Thymoquinone and melanin are among the most important active ingredients of *Nigella sativa* and are responsible for its antioxidant and antibacterial effects against a wide range of pathogens and spoilage bacteria, such as *Staphylococcus aureus*, *Micrococcus luteus*, *Listeria monocytogenes*, *Bacillus cereus*, *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*, *Escherichia coli* and *Klebsiella pneumoniae* (Mahros et al., 2020).

Medicinal plants are rich with phytochemicals, such as phenols, proteins, and peptides are recognized for their potential application as functional food products (Alu'datt et al., 2024). The correlation between total phenolic compounds and the oxidative stability of oils is an important factor for their quality, as it is related to shelf life, sensory quality, and resistance to autoxidation (Mazaheri et al., 2019). The phenolic compounds in *Nigella sativa* seeds contribute to its stabilizing, antioxidant, and antimicrobial properties, which help extend the shelf life of food and beverages (Mohammed et al., 2021). Natural antioxidants are essential in human nutrition because they reduce the presence of free lipid radicals in food and the body after ingestion (Mohammed et al., 2021). Although phenolic compounds play a key role in the antioxidant capacity of oils, research by Kiralan et al. (2015) didn't found correlation between total phenols, tocopherols, and the oxidative stability of oils (Kiralan et al., 2015).

Black seed oil contains significant amounts of carbohydrates, amino acids and proteins. Its nutritional value includes 84 g of fiber, 216 g of protein, 45 g of ash, 38 g of moisture, 406 g of fats, 249 g of free nitrogen extract, as well as minerals such as 60 mg zinc, 105 mg iron, 527 mg phosphorus, 15.4 mg thiamine, 18 mg copper, 57 mg niacin, 0.16 mg folic acid, and 1860 mg calcium per kg (Rahim et al., 2022). Among vitamins, the most prevalent are vitamin C (ascorbic acid), vitamin E (tocopherol), vitamin B1 (thiamine), B6 (pyridoxine), niacin, folic acid, and B2 (riboflavin) (Rahim et al., 2022).

Triacylglycerols are the main components of oils and fats, making up 96–98% of their composition. The dominant triacylglycerols (TAGs) in black seed oil are tri-linoleoyl, oleoyl-di-linoleoyl, palmitoyl-di-linoleoyl, palmitoyl-oleoyl-linoleoyl, and dioleoyl-linoleoyl (Mazaheri et al., 2019). Fatty acid profiling shows the presence of saturated (22.7% – 25.5%) and unsaturated fatty acids (74.8% – 77.5%) (Mazaheri et al., 2019). *Nigella sativa* oil contains high levels of linoleic acid (61.6%), oleic acid (22.8%), palmitic acid (12.4%), stearic acid (3.5%) and α-linolenic acid (0.4%). The fatty acid composition depends on the quality of the seed, ecological conditions and extraction method (Zeyada et al., 2023). Oil obtained by the Soxhlet method contains high concentrations of unsaturated fatty acids (85.16%) and saturated fatty acids (15.02%), with linoleic acid (57.71%) and oleic acid (24.46%) being dominant (Albakry et al., 2022). Cold-pressed black seed oil is categorized as a functional oil due to its high content of omega-9 (oleic, 15–24%) and omega-6 (linoleic, 54–70%) fatty acids (Rahim et al., 2022). Based on its fatty acid composition, it falls into the category of oils with a high content of linoleic acid, similar to sunflower oil, corn, grape seed, and sesame oil (Mazaheri et al., 2019). The essential oils of black seed contain bioactive components such as p-cymene, thymoquinone, α-thujene, longifolene, β-pinene, α-pinene, and carvacrol, which are considered responsible for its antimicrobial potential (Hassanien et al., 2015; Mohammed et al., 2021). These compounds have antioxidant, antibacterial, and anti-inflammatory properties with low toxicity and are useful for food applications (Liao et al., 2020; Mohammed et al., 2021).

2.1. Extraction Methods

Extraction methods for essential oil that can be applied to *Nigella sativa* seeds include hydrodistillation (steam distillation), solvent extraction, supercritical fluid extraction (CO2) and cold pressing (Mohammed et al., 2021). The cold-pressing method is becoming a popular alternative to conventional practices due to consumer demand for natural and safe food products. Cold pressing is a technology that don't involves heat or chemical treatments during the oil extraction process. This method does not include refining and can preserve high levels of lipophilic phytochemicals, including antioxidants and thymoquinone derivatives (Lutterodt et al., 2010; Kiralan et al., 2015). Cold-pressed oils are important sources of essential fatty acids, phenols, sterols, tocopherols and carotenoids, possessing health-promoting properties. Additionally, they retain their characteristic taste, aroma and color and can be classified as natural products. Cold pressing avoids the degradation of thermosensitive compounds and oils obtained by this method contain more bioactive compounds, including pro-oxidants (free fatty acids, hydroperoxides, chlorophylls and carotenoids) and antioxidants (tocopherols, phenols, and polar lipids) (Kiralan et al., 2017; Kiralan et al., 2019). The stability of cold-pressed oils is typically from 6 to 12 months and depends on the level of polyunsaturated fatty acids (PUFAs) and present antioxidants (Kiralan et al., 2017).

2.2. Stability of BSO

Cold-pressed black seed oil (BSO) is unrefined and rich in lipophilic phytochemicals such as natural antioxidants and thymoquinone derivatives (Lutterodt et al., 2010). Due to its minimal processing, cold-pressed oils may contain components with prooxidant effects, including metal ions, chlorophylls, and lipid peroxides (Grajzer et al., 2020). Unlike refined oils, cold-pressed oils often exhibit a higher potential for auto-oxidation and less predictable oxidative stability (Grajzer et al., 2020). The quality and stability of vegetable oils are influenced by factors such as growing conditions, raw material quality, pressing method and storage conditions (Cichocki et al., 2023). Lipid oxidation is one of the main changes that can occur during the processing, marketing, and storage of food (Hassanien et al., 2015). Autoxidation is a non-enzymatic process between unsaturated fatty acids and oxygen, influenced by factors such as fatty acid composition, degree of unsaturation, presence of antioxidants, and storage conditions (Colakoglu et al., 2006). Cold-pressed oils are considered more favorable than refined oils due to the presence of bioactive substances like phenols, tocopherols, polyphenols and squalene, which can help delay lipid oxidation (Grajzer et al., 2020). The antioxidant activity of phenolic compounds arises from their high reduction potential (Viuda-Martos et al., 2011). According to the analysis of Symoniuk et al. (2022) and Kiralan (2013), black seed oil demonstrated resistance to oxidation under accelerated conditions (60°C and 100°C). The high resistance of NSO at 60°C and 100°C is attributed to stable compounds like thymoquinone, α-longipinene, carvacrol and 4-terpineol (Mazaheri et al., 2019).

Lipid oxidation results in the formation of lipid hydroperoxides through the replacement of a hydrogen atom in the lipid hydrocarbon chain with a hydroperoxide group. Once formed, hydroperoxides are susceptible to further oxidation, leading to the formation of secondary reaction products such as aldehydes, ketones, acids and alcohols. Many of these secondary products negatively impact the taste, aroma, flavor, nutritional value, and overall quality of food (Turner, 2013). During auto-oxidation, oxygen interacts with unsaturated lipids, limiting the use of unsaturated lipids in functional foods (Sun et al., 2011). Factors influencing oxidation include the presence of oxygen, light, heat, metals, and the degree of unsaturation of lipids, with PUFAs being especially sensitive (Ramadan et al., 2011).

Unlike refined oils, cold-pressed oils often exhibit higher initial auto-oxidation rates and less predictable oxidative stability. Pro- and antioxidant interactions can influence the antioxidant activity of the oil, which in turn affects its shelf life. Numerous methods have been developed to assess the antioxidant capacity of oils. Among them, the ability of antioxidants in oil to reduce the stable 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical (DPPH analysis) is commonly used to determine the radical-scavenging activity of hydrophilic and lipophilic antioxidants in oils (Grajzer et al., 2020). The radical-scavenging capacity of oils strongly depends on the content of tocopherols and other polyphenols (Grajzer et al., 2020). In Grajzer's study, it was noted that the tocopherol content in cold-pressed oils negatively correlates with their antioxidant capacity, while the content of phytosterols showed a positive correlation with the radical-scavenging capacity in the lipophilic fraction of cold-pressed oils rich in n-3 polyunsaturated fatty acids (PUFAs) (Grajzer et al., 2020). Antioxidants can slow down this reaction by neutralizing free radicals or binding metals. Oxidation control is achieved by adding antioxidants, optimizing processing and storage and using techniques such as vacuum packaging and inert gases (Ramadan et al., 2011). The most commonly used primary antioxidants in food include synthetic compounds such as phenolic antioxidants, including butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), propyl gallate (PG) and tertiary butylhydroquinone (TBHQ) (Sun et al., 2011).
The selection of natural antioxidants that could be used to extend the shelf life of oils is limited and depends on several factors, such as the fatty acid profile of the oil, the minor components and the structure of the antioxidants. Food producers are increasingly interested in finding natural alternatives to synthetic antioxidants that not only slow down oxidation processes but also have a positive impact on consumer health (Odeh et al., 2021).

Although the auto-oxidation process cannot be completely prevented, it can be delayed and minimized by adding antioxidants that donate hydrogen atoms to free radicals, thus leading to stable products (Köckritz & Martin, 2008; Moigradean et al., 2014). Today, natural antioxidants from herbs and spices are increasingly used for toxicological reasons, including rosemary, garlic, parsley, black seed, thyme and others (Temelkovska & Pavlovska, 2021). The use of various synthetic antioxidants in food products is limited due to potential health risks and toxicity. The most commonly used antioxidants, BHT and BHA, have been shown to induce DNA damage (Wangensteen et al., 2004).

Phenolic compounds, ascorbic acid, carotenoids, phospholipids, sterols, and others are natural antioxidants found in food (Embuscado, 2015). Herbs and spices, whether whole or ground, along with their extracts and essential oils, are also used in inhibiting lipid oxidation and microbial growth in food, and are crucial in reducing the formation of harmful substances such as heterocyclic amines (HCAs). Their use results in clean-label products, entirely natural and GMO-free, which are desirable qualities for consumers (Embuscado, 2015).

3. USE OF BSO IN THE FOOD INDUSTRY

Cold-pressed black seed oil (BSO) has been used as an additive in meat due to its antibacterial and antioxidant properties, which improve the safety, quality, and shelf life of meat. This was investigated in a study by Mahros et al. (2020), which aimed to examine the effects of black seed oil and black seed powder during meat storage. The best antibacterial effect was achieved with the addition of 3% BSO, which significantly reduced the colony count and psychotropic bacteria during the first week of storage and BSO caused a reduction of *Escherichia coli* (Mahros et al., 2020). The study by Wojtasik-Kalinowska et al. (2017) demonstrated a positive effect of adding BSO on the fatty acid profile of meatballs made with pork. In samples with added oil, there was a 60% slower lipid oxidation compared to control samples, without changes in the sensory properties of the meatballs (Wojtasik-Kalinowska et al., 2017).

In order to produce a low-fat, dairy-free cream, BSO extracted by supercritical fluid technique was used. The sensory evaluation of the obtained coffee cream showed high sensory acceptability and the high potential of microencapsulated oil for mass production and commercialization of dairy-free functional cream (Mohammed et al., 2019). The addition of encapsulated oils from *Moringa oleifera* and *Nigella sativa* in yogurt affected its viscosity, pH, acidity and microbiological properties. There was absence of harmful bacteria and the sensory evaluation showed that both oils, used at a concentration of 4%, improved the taste and texture (Elshiekh & Omar, 2024). The addition of essential black seed oil in Feta cheese reduced the number of bacteria and fungi compared to the control sample and affected the sensory characteristics of the cheese during a 90-day storage period. The results also showed that the addition of 0.5% essential *Nigella sativa* oil prevented microbial growth and oxidative degradation, but also improved the taste and overall acceptability of the cheese (Al-Kaabi et al., 2024). Incorporating black seed oil into Edam cheese reduced the number of yeasts and inhibited the growth of coliform groups, while proteolytic bacteria were found in larger numbers than lipolytic bacteria. Panelists accepted the taste, appearance and aroma of the Edam cheese with the addition of 0.6% black seed oil (Elmontaleb et al., 2020).The goal of the study by Mohamed et al. (2020) was to develop an ice cream product enriched with nanoemulsion of Nigella sativa oil in four ratios (0% control, 3%, 5%). Improvements in rheological and sensory properties were observed and the ice cream enriched with 5% nanoemulsion of BSO was the most preferred form of the four formulations (Mohamed, 2020).

The impact of natural oils from black seed, cumin, thyme and wheat on bread was investigated in relation to dough and bread quality. The use of oils resulted in a reduction of dough consistency and the greatest influence on the extension of dough development time was observed in bread enriched with thyme, cumin and black seed oils (Debonne et al., 2018). Results from a study aimed at developing enriched biscuits by incorporating BSO as a nutrient showed that the product with 6% added BSO had the most acceptable sensory attributes, physical and nutritional quality (Bornare et al., 2015). A chickpea paste (hummus), enriched with BSO at a concentration of 6%, showed increased sensory acceptability compared to the control sample and other samples with the addition of cold-pressed black seed oil at concentrations of 4%, 8%, and 12% (Delinikolova & Jankuloska, 2025).

BSO can also be used to improve the oxidative stability of other vegetable oils. For example, the addition of black seed oil to sunflower oil improved its oxidative stability (Mazaheri et al., 2019). To increase the oxidative stability and phytochemical content of rapeseed oil, blends with 5%, 10%, and 20% rice bran oil and black seed oil were prepared. The blends of rapeseed oil with BSO showed higher levels of α- and γ-tocopherols and tocotrienols, a reduction in the PUFA/SFA ratio, an increase in the omega-6/omega-3 ratio from 2.1 to 3.7, and improved stability (Rudziń ska et al., 2015).

Improved oxidative stability and taste were observed in mayonnaise enriched with BSO. Four different formulations of mayonnaise were used (control, and samples with 5%, 10%, and 20% BSO). After four weeks of storage at 20°C, the peroxide values were lower and sensory analysis showed better acceptability for the mayonnaise with 5% BSO compared to the control sample (Ozdemir et al., 2018). The results of the effect of essential black seed oil on butter stability showed that it could be considered a source of natural antioxidant. In the samples with 0.05%, 0.1%, and 0.2% BSO and the sample with BHT (100 ppm), the addition of 0.2% BSO showed strong antioxidant activity, nearly equal to that of BHT, and a reduction in the total number of aerobic mesophilic bacteria, lactic acid bacteria, and coliform bacteria during storage. The samples with added essential oil were preferred by panelists compared to the control sample (Çakmakçi et al., 2014).

4. CONCLUSION

Cold-pressed black seed oil is a rich source of bioactive compounds, including p-cymene, thymoquinone, α-thujene, longifolene, β-pinene, α-pinene, and carvacrol. The oil has antioxidant potential and demonstrates various biological activities, including antimicrobial, antifungal, and antibacterial properties. The benefits of cold-pressed oil are of particular health interest when used in stable production formulations.

Black seed has recently become an important research topic worldwide. Cold- pressed black seed oil has been registered as a novel food in the register of food produced with innovative technologies, and given that, its potential for implementation in food products is even greater. However, its application in food products remains modest and therefore further research is needed to explore new possibilities for its incorporation into novel and functional foods

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THE QUALITY OF RURAL DEVELOPMENT - ANALYSIS, STRATEGIES, AND CHALLENGES

KVALITET RURALNOG RAZVOJA - ANALIZA, STRATEGIJE I IZAZOVI

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Abstract: *The departure of young people is one of the key issues for the survival of rural areas, not only in Serbia and North Macedonia but also across the broader Balkan region, both in demographic terms and consequently in economic, social, cultural, political, and other aspects. The decreasing share of young people in the rural population is reflected in the aging of rural areas, deagrarization, overall deruralization, and the continuous decline of these areas as places of living and work. Given that young people mainly leave for further education or employment due to the lack of opportunities, even for those with higher education, the aim of this paper is to explore and highlight the factors influencing the quality of rural development and the attraction or deterrence of young highly educated individuals in these areas to return or choose to live in rural regions.*

Key words: *quality of rural development, deagrarization, depopulation, rural area policy.*

Apstrakt: *Odlazak mladih predstavlja jedan od ključnih problema za opstanak ruralnih područja ne samo u Srbiji i RS Makedoniji, već i na širem području Balkana, kako u demografskom tako i posledično u ekonomskom, socijalnom, kulturnom, političkom i svakom drugom smislu. Smanjenje udela mladih u ruralnom stanovništvu ogleda se u senilizaciji ruralnih područja, deagrarizaciji, odnosno sveukupnoj deruralizaciji i kontinuiranom propadanju tih područja kao mesta življenja i rada. S obzirom na to da mlado stanovništvo uglavnom odlazi zbog daljnjeg obrazovanja ili zaposlenja, jer prilika ima naročito malo pa i za one s višim obrazovanjem. Cilj je ovog rada da istraži i ukaže na činioce kvaliteta ruralnog razvoja i privlačenja ili odbijanja iz perspektive mladog visokoobrazovanog stanovništva ovih područja da se vrate ili dođu da žive u ruralnim područjima.*

Ključne reči: *kvalitet ruralnog razvoja, deagrarizacija, depopulacija, politika ruralnog područja.*

1. INTRODUCTION

The concept of rural development has been present in economic practice for the past few decades and represents a significant challenge for both developed and developing countries. The concept of rural development should contribute to reducing pressure on urban areas and ensuring balanced

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national development. Government interventions should facilitate the development of various sectors, including agricultural production, industry, services, tourism, and crafts.

According to Đorđević-Milošević and Milovanović (2012), at the end of the last century, the concept of rural development gained importance in both developed and developing countries, including Serbia. The perspective on socio-economic development policy as a whole has changed dramatically. The focus is not only on overcoming regional disparities and differences between urban and rural development but also on coordinating the development of agriculture with other industries and services in rural areas to ensure a better quality of life and improve the living standards of the population through the rational use of resources and their preservation for future generations. This integrated approach is now the foundation of all development policies in EU countries, whose membership Serbia aspires to.

Traditionally, a village is defined as a settlement whose population is primarily engaged in agriculture, livestock breeding, or fishing—so-called primary activities. However, rural areas also have a non-agricultural population. In modern villages, this non-agricultural population can sometimes even outnumber the agricultural one. In Europe, as well as in Serbia, North Macedonia, and the broader Balkan region, agriculture is more often a way of life than a means of production. Therefore, rural settlements should be viewed more as anthropogeographic phenomena rather than purely agricultural settlements. As agricultural populations gradually decline, rural settlements increasingly transform into residential areas with different functions, such as tourism, or into secondary residences for urban populations or those who have withdrawn from urban life when and if they were able to do so (European Communities – Commission, 1988).

For many years, sociologists, geographers, and economists have attempted to define rural areas. Based on previous experiences, rural areas are characterized by factors such as a small population, predominant use of land and forests for human subsistence, social structure, traditions, and rural identity. Rural areas typically feature diverse landscapes, including mountains, canals, nature reserves, coastlines, agricultural lands, rivers, lakes, etc. These varied environments make rural areas suitable for tourism development, making them attractive destinations for tourists. Today, there is a renewed desire for rural experiences, driven by an interest in villages and even more so in vast rural spaces and untamed nature. (Matejić, et.al. 2024)

The most important characteristics of rural areas include a peaceful environment, the absence of noise, preserved nature, interaction with local hosts, traditional food, and engagement in rural activities. The rural tourism movement revitalizes rural environments, restores traditional economic activities characteristic of villages, and is increasingly widespread and in demand among consumers. The quality of rural development has reached a high level, making it clear that rural tourism is experiencing significant growth—not only in Serbia and North Macedonia but also across the broader Balkan region and Europe.

Sustainability and quality are key components of the development process, as they ensure a necessary balance between societal, economic, and environmental growth, leading to stable and continuous progress without endangering any essential elements of the development process. Therefore, rural development should be understood and supported as a long-term and demanding process that should be encouraged from the top down while being designed and managed from the bottom up. The process of rural development significantly contributes to the democratization of society and the decentralization of governance (Bryden, J. M., 2006).

Today, rural areas face serious demographic challenges, primarily characterized by population aging and the departure of young people who do not return. Another major issue is deagrarization, as those who remain in rural settlements are predominantly elderly and often no longer engaged in agriculture. Consequently, as the rural population declines, agriculture as an occupation is also disappearing (Vonderach, G., 2003).

2. RURAL DEVELOPMENT OF THE EUROPEAN UNION

The rural development policy of the European Union has evolved from a policy addressing structural problems in the agricultural sector to a policy focusing on the multifunctional role of agriculture in society, as well as the challenges faced in a broader rural context.

Approximately 57% of the EU population lives in rural areas, which cover over 90% of the Union's territory. The average population density ranges from 38 inhabitants/km² in predominantly rural regions to 125 in intermediate regions and 614 in predominantly urban regions. In remote or sparsely populated areas, such as northern Finland, the density can be as low as 2 inhabitants/km². Rural areas are rich in landscape diversity and cultural heritage and represent a vast reserve of human skills and energy. These areas provide most of Europe's food, timber, and other resources. They also serve as spaces for recreation for European citizens and host a growing number of both local and international tourists (Đorđević-Milošević & Milovanović, 2012).

According to Milić (2011), the European Union defines rural development as a multifunctional concept in which rural development, in relation to general social development, has four key roles:

- Economic role – Rural areas provide food and other agricultural raw materials to meet the growing needs of the population while ensuring competitive income. The term "peasant economy" refers to a socially structured system of family farms where family-based production is the dominant type of production.
- Ecological role – Rural areas are suitable for sustainable management of natural resources (land, water, forests), ensuring environmental preservation and sustainability.
- Cultural role – Rural communities have a distinct cultural identity. The cultural heritage of rural areas is rich and has national and international significance. The cultural aspect of rural development is increasingly recognized when defining the economic potential of rural areas and communities.
- Sociological role – Rural areas form a unique social system where people feel a deep connection with their communities, recognizing them as places of shared care and cooperation. This system is long-lasting and is expected to endure, relying on mutual collaboration with minimal enforcement or coercion.

In the last decade of the previous century, the EU initiated radical reforms of the Common Agricultural Policy (CAP) and modified its agricultural policy system. Direct payments were introduced, and rural development policy became the second pillar of agricultural policy. The Agenda 2000 (Agenda 1997) introduced new funding rules, reorganized financial mechanisms, and adopted a decentralized approach to funds. The reformed CAP's solutions in the field of rural development respect the specificities and inherited structural issues of new EU member states, allowing them to adjust their agricultural sectors to the new economic and business environment. Additionally, the EU expansion increased the agricultural land area by over 50%, and the agricultural workforce doubled. The reform adopted in 1997, known as Agenda 2000, placed greater emphasis on rural development and the creation of alternative jobs for farmers. However, EU rural areas still generate 45% of newly created value, employ 53% of the total workforce, and house more than 56% of the population, covering over 91% of the EU's territory. The EU has embraced the concept of promoting sustainable rural development based on sustainable economic growth, which aims to improve living standards while simultaneously preserving natural, cultural, and traditional heritage (Milić, 2011).

In 2005, the EU Agricultural Council adopted a fundamental reform of rural development policy for the 2007–2013 period. Two new funds were established: the European Agricultural Guarantee Fund (EAGF) and the European Agricultural Fund for Rural Development (EAFRD). The EU's strategic approach aimed to improve the implementation of rural development support programs and focused on employment, competitiveness, and innovation in rural areas. The fifth IPA component relates to rural development and is intended to prepare candidate countries for the implementation and management of CAP (Janković, 2009).

The EU's rural development policy helps rural areas across the Union address a wide range of economic, environmental, and social challenges of the 21st century. Often referred to as the "second pillar" of the Common Agricultural Policy (CAP), it complements direct payment systems for farmers and agricultural market management measures (the so-called "first pillar").

Member states and regions design their own rural development programs based on the specific needs of their territories while addressing at least four out of the six common EU priorities (http://www.ruralsrbija.rs/srl/strana/ruralni-razvoj):

- Encouraging knowledge transfer and innovation in agriculture, forestry, and rural areas.
- Enhancing the sustainability and competitiveness of all types of agriculture and promoting innovative agricultural technologies and sustainable forest management.
- Promoting food supply chain organization, animal welfare, and risk management in agriculture.
- Restoring, preserving, and enhancing ecosystems related to agriculture and forestry.
- Promoting resource efficiency and supporting the transition to a low-carbon economy and climate-resilient agriculture, food production, and forestry.
- Promoting social inclusion, reducing poverty, and fostering economic development in rural areas.

The priorities of rural development are further broken down into "focus areas". For example, the priority of resource efficiency includes the focus area of reducing greenhouse gas and ammonia emissions from agriculture.

At least 30% of funds for each Rural Development Program (RDP) must be dedicated to measures relevant to environmental protection and climate change, while at least 5% must be allocated to the LEADER initiative.

Additionally, rural development measures support the diversification of the rural economy and the quality of life in rural areas. Economic diversification includes activities for developing rural and eco-tourism, revitalizing and commercializing local crafts, and providing new services based on existing infrastructure. In short, diversification involves shifting towards non-agricultural activities.

The main goal of the Common Agricultural Policy (CAP) is to ensure a stable supply of agricultural products at affordable prices while securing an adequate income for agricultural producers. The funds for these measures are provided through the European Agricultural Fund for Rural Development.

2.1. The Role of Local Administration in Rural Development

The EU's local rural development policy has given local governments a central role in determining the developmental needs, priority objectives, and programs of each local government unit, which will be supported and funded through incentive programs and funds from different levels. In this way, local governments are now able to genuinely and effectively manage the development of their communities.

It is assumed that such a transfer of power from central to local levels leads to greater efficiency in terms of public governance and creates better conditions for economic development. At the same time, such transfers of power align with new expectations from citizens and civil society for much deeper participation in the democratic decision-making process (Bryden, 2006).

Among the motivations for this trend of decentralization, competitiveness is particularly emphasized, as it highlights the importance of knowledge in the economic development process. By involving local governments in the bottom-up approach, central authorities can utilize local knowledge in policy formulation, thereby encouraging transparency in identifying local community priorities, as well as costs, despite the presence of multiple governance levels. At the same time, both sides of the partnership—national and local authorities—must be mindful of the risks arising from insufficient knowledge exchange or, at the local government level, a lack of sufficient capacity to properly interpret and utilize sometimes complex information coming from the central government.
Trends in decentralization certainly pose substantial challenges in implementation. These processes involve the formal inclusion of subnational actors and social partners in the decision-making process, where their role was previously often only consultative. Experiences in implementing territorial rural development policies have highlighted some difficulties in achieving effective multi-level coordination.

Coordination and governance between those "above" and those "below" is a particularly challenging task for authorities and requires overcoming significant structural obstacles. The key issues include whether and how actors manage to address coordination challenges in their relationships and what roles actors at different levels can play in designing and implementing rural development policies (Bryden, J. M., 2006).

The desired outcome is to develop a genuine and effective partnership between national and subnational authorities through the use of vertical governance models in rural policy. The overarching goal is to make the subnational level of government accountable for the state of rural areas, based on its participation in decision-making and implementation of rural development policies.

The central government, in terms of rural development policy, has the obligation to coordinate its own sectors in alignment with rural interests while also harmonizing and promoting the coordination of rural policies at other levels of government (the role of "meta-governance"). Some of the key issues concerning the role of central government include
(https://otvorenavlada.rs/strategija-poljoprivreda-ruralni-razvoj037-lat-docx-2/):

(a) what each ministry or agency should be responsible for,

(b) what mechanisms are needed to coordinate different ministries and agencies at the central level, and

(c) what the main obstacles are to developing a legal framework for cross-sectoral cooperation at different levels of government.

3. RURAL DEVELOPMENT OF SERBIA

The Republic of Serbia is a predominantly rural country, with agriculture as its dominant economic sector. There are various classifications and data, but approximately 70-80% of the Republic of Serbia's territory is considered rural (Glavaš-Trbić et al., 2010). Rural areas face long-term challenges such as an aging population, migration to urban areas, insufficient investments, the dominance of agriculture as the primary economic activity, employment issues, education, remoteness from potential markets, and more. Properly addressing these rural challenges could enable a shift toward an integrated approach to sustainable development, as opposed to the previously dominant sectoral approach (Đekić et al., 2011).

According to Janković (2012), the approach to rural development must, above all, recognize that it is a long-term social process, distinct from previous rather simplified centralized rural development planning models. It is closely related to issues that social theory today attempts to address, including regional development and decentralization, (neo)endogenous and territorial development, sustainable development in socio-economic, environmental, and other aspects, networks of relevant institutions and actors, various strategies for life and work in agricultural households and farms (farming systems), levels and methods of participation, the role of civil society, social capital, the importance of social inclusion, and the fight against (rural) poverty, among others.

The following tables present the state of Serbia's rural economy, according to the Draft Strategy for Rural Development 2010-2013.

Considering that rural areas occupy approximately 85% of Serbia's territory and that rural populations make up more than half of the total population, the need for further investment in these areas is evident. This investment aims to improve social and economic conditions both in isolated rural areas, which face depopulation trends, and in suburban areas. Investing in rural economic development and local communities is a vital factor in improving the quality of life in rural areas through better access to public services, infrastructure development, and the creation of a more favorable business environment (Kostić-Stanković, 2013).

Table 1. Strengths and weaknesses of the rural economy of Serbia (according to the Draft Rural Development Strategy 2010-2013).

Advantages	Weaknesses
Natural/Climatic • Serbia is one of the five biodiversity centers in Europe. • It borders four EU member states. • It has landscapes of exceptional natural features. • A large number of spas and thermal springs. • Forests, rivers, lakes, with opportunities for hunting and fishing. **Trade/Commercial** • Agricultural holdings are export-oriented. • Raw materials are secured through domestic production. **Structural/Societal** • Presence of some strong domestic companies.	**Natural/Climatic** • Inadequate waste management. • Extreme climatic events in recent years (droughts, floods, etc.). • Aging population and depopulation of rural areas. **Trade/Commercial** • Unresolved property and legal issues in rural households (lack of cadastral records). • Lack of entrepreneurship and expertise in rural areas. • Weak research and development sector in many companies. • Small domestic market. • Low diversification of activities within the rural economy. • High inflation rate compared to the EU.

• Potential for rural tourism and other specialized forms of tourism. • Dynamic producers of specialized products. • Preserved local traditions and rural landscapes. **Regulatory/Political** • Quality designation systems exist for certain products. • Status as a potential candidate country for EU membership.	**Structural/Societal** • Insufficient production volume compared to competitors in the global market. • Lack of a new national spatial plan. • Inadequate infrastructure (especially in rural areas). • Low level of education and training in rural areas. • High unemployment rate in rural areas.

Source: (Kostić – Stanković, 2013)

For Serbia, the process of joining the European Union represents a huge challenge. Factors that degrade Serbia's status are related to the "ad hoc" concept of agricultural policy, the lack of a capital base, a centralized public finance system, and a shortage of financial resources at regional and municipal levels, variability in the scope and quality of raw material production, a weak banking system, slow development of economic infrastructure, and slow adaptation of the legislative framework (Drobnjaković, 2012).

Table 2. Opportunities and Threats to the Rural Economy of Serbia (according to the Draft Rural Development Strategy 2010-2013).

Opportunities	**Threats**
Natural/Climate • Opportunities for better environmental protection, • Incentives for farmers aimed at protecting the environment. **Commercial/Trade** • Growing international tourism market, rural/eco-tourism, etc. • New trends creating new market policies, e.g., increasing demand for organic and national food products and traditional food products with geographical origin labels, • Possible competitive advantage arising from food safety, environmental protection, and animal welfare requirements, • Opportunities for various forms of tourism and recreation, • Development of small and medium-sized enterprises and entrepreneurship in rural areas.	**Natural/Climate** • Reduction of forested areas, • Environmental destruction. **Commercial/Trade** • Rapid changes in consumption trends, • Increasing competition in international markets, • Lack of workforce in certain specialized sectors of the rural economy (e.g., tourism), • Pressure on profit margins from multinational companies, • Costs and difficulties in establishing new businesses, • The emergence of strong international brands in the integrated European market may pose a threat to Serbian service industries. **Regulatory/Political** • Increasing delays in infrastructure development,

Structural/Societal Attitudes • Business cooperation creates a good opportunity to increase production, processing, and product placement/trade, • Better diversification of rural areas, • Availability of IPA funds for appropriate investments, • Cross-border cooperation and international projects.	• Stricter environmental protection regulations, • Market access issues due to concerns about safety and hygiene.

Source: (Kostić – Stanković, 2013)

The starting basis and solid foundation of measures that will be further applied to improve rural development, provide support for rural development, outline the direction of future agricultural sector reforms, as well as other important activities in these areas, are the current legal texts, but also the development goals and priorities set with full respect for the principles of sustainable development. (Ministry of Agriculture, Forestry, and Water Management of the Republic of Serbia, 2014).

3.1. The Importance of Rural Development for Serbia

Decades of neglect of agriculture and the natural and demographic exhaustion of rural areas have resulted in very negative economic and social trends and the current unfavorable situation, characterized by numerous problems. The most important of these include small and uncompetitive farms, a large number of elderly farms, fragmented agricultural land, small production plots, extensiveness, and a low technological level of production, insufficient or inadequate use of agrotechnical measures, weak productivity, poor management of manure and agricultural waste, etc. Such agriculture results in low income, is uncompetitive and unprofitable, and in its current state cannot be a factor in sustainable development.

Rural areas in Serbia are defined as spaces that represent the "remainder" outside urban areas. According to this definition, about 70% of Serbia's territory can be classified as rural, where 43% of the total population lives. However, this definition is not recognizable from the perspective of the European Union. In order to allow comparison with EU statistical data, rural areas in Serbia are defined, according to the criteria of the Organisation for Economic Co-operation and Development (OECD), as areas with a population density of less than 150 inhabitants per km^2. According to this definition, 85% of Serbia's territory belongs to so-called rural areas, with almost 55% of the total population. In rural areas, in addition to significant human resources, are also the majority of the country's natural resources (agricultural land, forests, waters), with rich ecosystems and biodiversity, as well as economic activities, cultural and historical heritage. Planning the comprehensive development of smaller rural units based on the principles of sustainable development has proven to be a successful model for revitalizing and advancing underdeveloped rural areas in the European Union (Janković, 2012).

At the same time, in the absence of a strategy and adequate support for the rural development segment, the following objective obstacles can also be listed: lack of quality road infrastructure, lack of tourism infrastructure (restaurants, accommodations), lack of financial support for the restoration and preservation of historical sites, lack of coordination in development plans and activities, and the absence of marketing for the tourism potential of local rural areas. However, the greatest and most difficult obstacle to the development of this segment of the rural economy, as well as in other areas, is certainly the depopulation of rural areas. The strategy for sustainable rural development must be based on a strong connection with tradition and all its elements. Such a practice would, in the next phase, generate the need for completely new activities and jobs. This would contribute to creating new employment opportunities for the local population and significantly increase the chances of young and educated people remaining in these areas. (Stepanov, et al., 2017)

Developed infrastructure is considered one of the most important prerequisites for quality rural and overall economic development because it contributes to: the economic aspect of life in rural communities by reducing regional inequalities and improving access to markets and, consequently, lower transport and transaction costs, increased trade exchange with other regions, and increased income for the rural population. Finally, well-developed infrastructure also contributes to greater freedom of movement, mobility, and significantly greater access to social services, such as healthcare or schools, for the rural population.

3.2. New Rural Paradigm

Traditional hierarchical administrative structures have proven inadequate for effectively managing rural development policy. The new rural paradigm therefore promotes the so-called multilevel approach in rural development management, i.e., management and adaptation along three key dimensions of authority: horizontally, both at the central and local government levels, and vertically, at all levels of governance. The "new rural paradigm" calls for significant changes in the way rural development policies are designed and implemented. Rural development is viewed as a cross-cutting issue, i.e., a matter of common interest for all other political guidelines of a society.

In recent decades, an important discussion has been underway regarding the mechanisms for managing the economic development of local communities. Cooperation between the public and private sectors is being promoted, where they create their own conventions, codes of conduct, and norms that regulate their economic, institutional, and social relations.
The perspective of rural development management at different levels of government not only reflects changes in the hierarchical order but also confirms that rural policy requires increasing interdependence between a broad range of actors, each bringing a specific set of skills and resources to the partnership.

Designing territorial rural development policies involves several different levels of national and subnational actors. The five main levels to consider are: (1) supranational; (2) national; (3) regional; (4) central or subregional; and (5) local.

The challenges of developing and implementing rural policy have been made more complex by the multiple layers of authority (national, regional, local levels) with different areas of responsibility, as well as the traditional sectoral approach of administrations at all levels. The design and implementation of an integrated rural policy thus require changes in intergovernmental relations and in the relationships between the public and private sectors and civil society.

From an analytical perspective, the relationships between actors in rural and other segments of local development form two distinct dimensions: vertical and horizontal. The vertical dimension encompasses the relationships of authority levels from supranational to regional to local authorities. Within this dimension, the role of different institutional actors can vary significantly. In some countries, the system of governance is centralized around national authorities, making higher coordination even more important, while in most European countries, with stronger subnational authorities, coordination at lower levels becomes more important, and central authorities focus more on broader political strategies, providing the framework and consistency.

The result of aligning the regulations of the Republic of Serbia with those of the European Union in the fields of agriculture and rural development will be access to the EU market with more than 500 million consumers, the regulation of production, processing, and sale of agricultural products on the common market, as well as in third countries. EU membership will enable farmers to use funds from agricultural and rural development funds, improve product quality, and thereby significantly increase their competitiveness in the EU market. For all these reasons, negotiations in the areas of agriculture and rural development will be extremely demanding.

4. CONCLUSION

The goal of quality rural development involves accelerating and unifying the development of rural areas in municipalities and regions, through the engagement, building, and improvement of local community capacities and ensuring a two-way flow of information between the central and local levels. Improving the quality of rural development achieves several goals. First and foremost, it ensures access to information relevant to rural areas about agricultural and rural development policies, as well as other state and EU policies that affect rural populations. Then, it involves continuously informing and showcasing good practices and successful initiatives across Serbia to gain knowledge and encourage creativity and new ideas for utilizing and developing existing potential for rural development at the local level. Furthermore, it is necessary to ensure full equality for all rural areas in terms of accessing funds for agricultural development. The educational aspect holds a special place, as it is essential to provide continuous training for participants in rural development processes and improve the system of its functioning through diverse education in work methodologies and the implementation of projects of municipal and regional importance.

This paper focuses on relevant indicators of rural areas' development (economic, ecological, socio-demographic, developmental, etc.), highlighting the importance of competent institutions aligning Serbia's agricultural policy with the EU and organizations at the local level in solving key issues and creating favorable conditions for the agricultural sector and rural development until 2030. Harmonizing Serbia's agricultural policy with the Common Agricultural Policy (CAP) is very important, primarily because it will provide a more secure environment for agricultural production and the more intensive development of the agricultural sector.

Interest in effective environmental management at the regional and local levels is much greater than at the global level due to the clear interest and potential direct threat to the population living in a specific area. If there are adequate macro-frameworks and the possibility to influence competitiveness at the local and regional levels, then the other side of the rural development quality issue concerns the ability of actors to best use their environment (making it a distinctive element of their area while increasing its territorial competitiveness), while ensuring that their natural resources and heritage are preserved and revitalized.

Regional quality of rural development uncovers the issue of the heterogeneity of rural areas in relation to their potentials but also the challenges they face. In this regard, for the success of regional rural development quality, it is crucial to adapt (transform) existing and build (new) institutions, strengthen their overall capacities, responsibility, and efficiency, which implies a complex relationship between human, economic, ecological, social, and other forms of capital. In the context of the ecological dimension of regional rural development, the institutional framework – which essentially represents the value-normative dimension – is one of the key factors for sustainable natural resource management, as well as their valorization in a developmental sense.

All the mentioned factors within these and other dimensions highlight the significant latent functions that each achieved competitiveness of a given area can produce. If we accept that sustainable development largely depends on social actors – people and institutions – then, in the context of ecological dimensions of rural development quality, it involves strengthening cohesion, solidarity, identity, motivation, and a different approach of the local population to these issues, as well as facilitating collective initiatives and systems of responsibility. In this sense, it is clear that the social dimension of local rural communities' functioning (which is usually the most interesting for sociologists) appears in strong correlation with the other dimensions, partly as a potential condition for their achievement and partly as a result of certain activities and actions of actors in a given area. This further emphasizes the complexity of rural development quality issues, which in previous policies have often been declaratively mentioned but essentially disregarded.

For the quality of rural development, it is crucial to strengthen human capital, develop entrepreneurial abilities, modernize agriculture, and invest in new initiatives and implement positive practical examples..

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THE APPLICATION OF ZEOLITES FOR IMPROVING STANDARDS AND CONDITIONS IN MODERN LIVING

ПРИМЕНА НА ЗЕОЛИТИТЕ ВО ФУНКЦИЈА НА ПОДОБРУВАЊЕ НА СТАНДАРДОТ И СОСТОЈБАТА ВО УСЛОВИ НА СОВРЕМЕНОТО ЖИВЕЕЊЕ

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Abstract: *The application of zeolites depends on their basic physical and chemical properties and their potential for economic exploitation. These properties are directly dependent on their chemical composition and crystal structure, as well as on the topography of the zeolitic mineral in the tuff as the zeolite raw material. The paper discusses solutions aimed at improving the production of safe and health-conscious food. These solutions are based on products and preparations derived from natural zeolite, with a high participation of clinoptilolite. These agents are used for the reclamation of degraded land, binding of heavy metals and radionuclides, as donors of micro and macroelements for plant production, as adsorbents of mycotoxins, correctors of environmental conditions, and other purposes.*

Key words: *natural zeolite, clinoptilolite, agriculture, food, ecology.*

Апстракт: *Примената на зеолитите зависи од нивните основни физички и хемиски особини и нивната можност за економска експлоатација. Овие особини директно се зависни од нивниот хемиски состав и кристалната структура, односно од топогтафијата на зеоллитскиот минерал во туфот како зеолиотска суровина. Во трудот се разгледувани решенијата кои допиримесуваат за унапредување на производството на исправна и здравствено безбедна храна. Тие се базираат на производи и препарати на база на природниот зеолит, со високо учество на клиноптиолитот. Овие средства се користат за рекултивација на деградирано земјиште, врзување на тешки метали и радиониклуиди, донори на микро и макроелементи за потребите на растителното производство, како адсорбенти на микотоксиди, коректори на амбиенталните услови и други намени.*

Клучни зборови: *природен зеолит, клиноптиолит, храна , екологија, земјоделство.*

1. INTRODUCTION

Zeolites are, by definition, crystalline, hydrated aluminosilicates of alkali and alkaline-earth cations, possessing an infinite three-dimensional crystalline structure. They are microporous

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crystals with a structure composed of well-defined pores interconnected by channels where cations and water molecules are located (Jovanovic, 2016).

The primary or fundamental structural unit of zeolites is the TO_4 tetrahedron (T - Si, Al) (Figure 2a), where Si and/or Al atoms are positioned in the center, while oxygen atoms are located at the corners. These units are connected through shared oxygen atoms in space (Figure 2b), forming secondary polyhedral units, which, when linked together, create the crystalline (aluminosilicate) lattice (Figure 1).

Zeolites have the ability to lose and absorb water, as well as exchange some of their constituent cations without significant structural changes. They were discovered in 1756 by F. Axel Frederic Cronstedt, a Swedish mineralogist, who named them based on the Greek words **"zein"** and **"lithos"**, meaning **"boiling stone."**
The general formula of zeolites is: **$(Ca, Sr, Ba, Na_2, K_2)\ Al_2Si_{2\text{-}10}O_{8\text{-}24} \bullet 2\text{-}8\ H_2O$** (Table 1).

The water molecule content depends on the **Al:Si ratio** and the characteristics of the crystalline structure. This ratio varies within certain limits, and changes in silicon content lead to structural modifications, affecting the connectivity of silicon-oxygen and aluminum-oxygen tetrahedra.

- **Zeolites with low silicon content** are characterized by rings composed of 4 tetrahedra.
- **Zeolites with moderate silicon content** feature rings of 6 tetrahedra.
- **Zeolites rich in silicon** have rings of 5 tetrahedra.

Zeolites with **higher silicon content** contain more water molecules, which they release at around **150°C**, whereas zeolites with **lower silicon content** have fewer water molecules and release them at a **higher temperature of about 500°C**. The release and absorption of water occur gradually, allowing observation of changes in physical and optical properties caused by variations in water content.

This structural characteristic enables **cation exchange**, where **Ca and Na** can be replaced by **K, Mg, and Fe**.

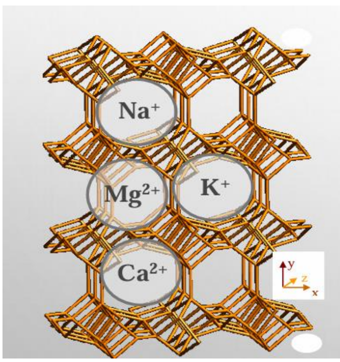

Figure 1. Spatial structure of clinoptilolite with embedded exchangeable cations.

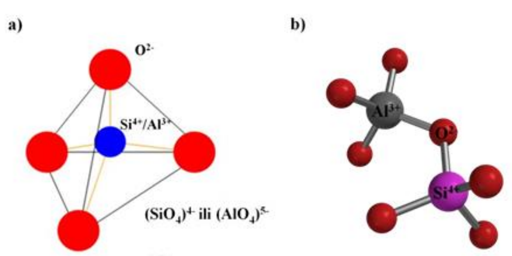

Figure 2. Tetrahedral structure of $(SiO_4)^{4-}$ and $(AlO_4)^{5+}$ as main units (a), connected by a shared oxygen atom (b).

They are characterized by a large unit cell volume and a specific crystalline structure, which gives them distinctive physicochemical properties that make them widely applicable in various technical fields. Zeolites with a rigid structure have the greatest application, as they exhibit stability under high temperatures and mineral influences. This group includes chabazite, erionite, mordenite, and others.

The second group consists of platy and fibrous zeolites with a layered structure, which have low stability and irreversibly lose water, resulting in the loss of their specific properties for practical use. This group includes natrolite, phillipsite, heulandite, and others (Figures 4, 7, and 8).
Zeolites are found in the composition of many rock complexes and can form through various processes. The primary classification of their formation is divided into endogenous (magmatic and hydrothermal) and exogenous (volcanogenic-sedimentary and sedimentary) origins.
Table 1. Presents the structural and chemical characteristics of some natural zeolites

Table 1. Chemical and Structural Characteristics of Some Natural Zeolites

Zeolite	Structural characteristics		Chemical characteristics	
	Channel size nm	Free volume	Typical composition for zeolite	Selectivities
Chabazite	0,37 - 0,42	0,47	$Ca_2[(AlO_2)4(SiO_2)8].13H_2O$	Cs>K>Rb>Na>Li>Sr>Ca>Mg
Clinoptilolite	0,44 - 0,72	0,34	$Na_6[(AlO_2)6(SiO_2)30].24H_2O$	Cs>Rb>K>Na>LiBa>Sr>Ca >Mg
Mordenite	0,67 - 0,70	0,28	$Na_8[(AlO_2)8(SiO_2)_{40}].24H_2O$	Cs>Rb>K>Na>Li>Ba>Sr>C a>Mg
Erionite	0,36 - 0,52	0,35	$(Ca,Mg,K,Na_2)_{4,5}[(AlO_2)_9(SiO_2)_{27}].27H_2O$	Rb>Cs>K>Na>LiBa>Sr>Ca >Mg
Holandite	0,40 - 0,72	0,39	$Ca_4[(AlO_2)_8(SiO_2)_{28}].24H_2O$	K>Rb>Na>Li>Sr>Ba>Ca
Philipsite	0,42 - 0,44	0,31	$(K,Na)_{10}[(AlO_2)_{10}(SiO_2)_{22}]20H_2O$	Cs>K>Rb>Na>LiBa>Sr>Ca

Zeolites are usually colorless or white (Figures 3 and 5). They can sometimes be red, pink, green, or brown. Their luster is vitreous, pearly, or earthy. The hardness is between 3½ and 5½, and the density is from 2.0 to 2.5.

Figure 3. Natural zeolite (clinoptiolite) from Greenland

Figure 4. Combined sample of four types of zeolite (Radiant natrolite crystals, associated with stilbite, small pink alumonite crystals, crystalline hevlandite is also present on the back side

Figure 5. Mordenite - Stilbite (India)

Figure 6. Heulandite (New South Wales, Australia)

Figure 7. Erionite (Veneto, Italy)

Figure 8. Phillipsite (Kola Peninsula)

According to experimental data, zeolites form as metastable phases within the stability field of feldspars and quartz, and as stabile phases they are fixed outside this field within a temperature range of 100° to 250°C. In sedimentary rocks, they can also form at ordinary temperatures. They may develop in the later stages of the pegmatitic process and in contact metasomatic deposits. Zeolites regularly appear in the cavities of volcanic rocks in association with calcite, dolomite, mica, and quartz. They can also be the product of hydrothermal alteration of other tectosilicates. In marine or lacustrine environments, they form through the devitrification of volcanic glass and the alteration of plagioclase found in tuffs and volcanic ash. Because of this, they are often found in bentonites.

2. RESULTS AND DISCUSSION

Producers of safe food today face several requirements: to produce a sufficient quantity of food, to ensure it is healthy, and to keep it affordable. The production of safe food limits and/or excludes the use of pesticides, herbicides, fungicides, artificial fertilizers, antibiotics, hormones, and other chemical agents, as regulated by EU documents and regulations (178/2002; 852/2004; 882/2004; 183/20). At the World Summit in Rio in 1992, a global action plan for sustainable development-Agenda 21-was adopted, which includes an integrated approach to land resource planning and management as a key factor in the production of safe food.

Human activities in the fields of industry, energy production, mineral extraction, agriculture, military engagements, transportation, and urbanization generate primary and secondary organic, inorganic, and radioactive pollutants that contribute to the permanent degradation of soil, with long-term consequences for biodiversity (Sekulić, P., Kastori, R., Hadžić, V., 2003).

The commercial use of natural zeolites is currently lower compared to synthetically produced zeolites. However, at the current level of application, approximately 500,000 tons of zeolite tuff are exploited annually in the USA, Japan, Mexico, Korea, China, and Russia. In most cases, these quantities are used as construction material or as raw material for the cement industry. However, with advancements in processing and application technologies, especially for sedimentary zeolites, their use is increasing in various fields. They are increasingly being utilized as fillers in the paper industry, as ion exchangers for water purification, for nitrogen separation from the air, as catalysts in petrochemicals, as fertilizers and soil regenerators, as acid-resistant adsorbents, and as adsorbents for radioactive nuclides, etc.

Zeolites are considered fully useful and widely used minerals, and their use is expected to increase in the future. As monomineral deposits in tuffaceous sedimentary rocks in the USA and other countries, they have opened a new chapter for these valuable industrial minerals, whose characteristics are utilized in industry, agriculture, and the environment.

Zeolites in construction: Many buildings in Zapotec - Mexico are made from blocks of massive clinoptilolite tuff, which is still used for constructing residential houses in the region. The easily cut and fabricated tuffo giallo napolitano, rich in habasit and philipsite, in central Italy has been used since the Roman Empire, and the entire city of Naples is built from it (Aiello 1995). Numerous cathedrals in Central Europe were built from zeolite tuff extracted from quarries in the Laacher See region in Germany. The high silicon content in tuffo giallo napolitano neutralizes the excess limestone in cement, which hardens. In the past, houses in the American West were built with local erionite, which was resistant to the arid climate. In the USA, nearly one million dollars were saved during the construction of the 240-mile-long aqueduct in Los Angeles by replacing 25% of the required Portland cement with inexpensive tuff rich in clinoptilolite. Zeolite is used as an anticorrosive additive in cement and in the production of lightweight constructions and insulating building materials.

Zeolites for treatment of urban wastewater: Ames, Mercer et al. demonstrated the effectiveness of clinoptilolite in removing NH_4^+ from urban and agricultural wastewater. Clinoptilolite removed 97 % of NH_4^+ from sewage water in Tahoe-Truckee. Adding powdered clinoptilolite to wastewater before aeration increases O_2 consumption and sedimentation, resulting in sludge from which water can be much more easily removed, and the dry residue can then be used as fertilizer. Nitrification of the sludge is accelerated with clinoptilolite, which selectively exchanges NH_4^+ from the wastewater and provides an ideal environment for the growth of nitrifying bacteria, which then oxidize NH_4^+ to nitrate. Liberti et al. described a nutrient removal process called RIM-NUT, which uses selective exchange of clinoptilolite and an organic residue to remove N_2 and P from sewage water. Zeolites are also used for the removal of Pb^{2+} and Cd^{2+} from wastewater (Colella et al. 1995, Petruzzeelli et al. 1999, Peterson 1993). They are also used as subsurface permeable barriers for the migration of pollutants in groundwater (Bowman et al. 2000).

Zeolites for decontamination of radioactive wastewater: Tuffs rich in clinoptilolite, chabazite, and philipsite are used for the removal of cesium and strontium isotopes from wastewater (Robinson et al. 1995). During the Chernobyl disaster, 30-40 times more radioactivity was released than that of the atomic bombs dropped on Hiroshima and Nagasaki. To remove the radioactive isotopes ^{137}Cs, ^{134}Cs, ^{89}Sr, and ^{90}Sr, about 500,000 tons of zeolitized rocks, primarily containing clinoptilolite, were used during the Chernobyl disaster. Decontamination of drinking water from the Dnieper River was carried out using finely powdered clinoptilolite and aluminum sulfate.

Zeolites in animal waste treatment: When treating animal waste, natural zeolites can contribute to reducing odor and increasing nitrogen retention in the waste, controlling moisture content for easier handling of manure, and purifying methane gas produced by the anaerobic digestion of manure. In Bulgaria, adding 10% clinoptilolite to cow's milk has reduced the concentration of cesium radionuclides by 30%. Mixed with waste or packed in boxes hanging from the ceiling, clinoptilolite is used to purify the air in poultry houses. When added to feed boxes for livestock, clinoptilolite significantly reduces the development of NH_3 and odor.

Zeolites in medicine: In recent decades, more scientists prefer natural zeolite species such as heulandite, clinoptilolite, and chabazite in the biochemistry and biomedical industry. They are used as detoxifiers, decontaminants, and antibacterial agents. They are also used in hemodialysis. It has been found that philipsite and some synthetic zeolites provide a good filtration medium for removing NH_4 from devices during hemodialysis, allowing the purified solution to be reused for dialysis. Natural zeolites are much cheaper compared to the zirconium phosphate ion exchanger currently in use. In Cuba, natural zeolites are used as acid neutralizers in the stomach, which are a threat to stomach ulcers. Zeolites are also used to stop acute diarrhea caused by food poisoning.

They bind mycotoxins, creating stable compounds. They increase antioxidant levels in the body. They stop external bleeding. They bind free radicals in the body. They reduce muscle pain caused by lactic acid. They stabilize and regulate the immune system. The use of zeolites is also effective in the treatment of athlete's foot. In Cuba, it is a common practice to use zeolite dust to powder horses and cows in case of wounds. Although a systematic study has not been conducted in mines and mills where workers are directly exposed to zeolite, in the case of injuries, wounds heal much faster.

Zeolites in the paper industry: In the paper production industry, zeolites are used as fillers to reduce odor and stickiness. In industrial plants producing packaging paper, large quantities of wastewater are generated. Wastewater represents a threat to the environment; when recycled, suspended organic and inorganic particles and bacteria concentrate, and when the wastewater is reused, it can cause spoilage and an unpleasant odor in the paper. Tests have been conducted on pH, turbidity, color, and bacterial count in wastewater with zeolite, and a high degree of removal of suspended particles has been achieved. It is also necessary to remove bacteria present in the wastewater. These activities would enable successful recycling of wastewater, thereby protecting the environment, while the resulting paper remains of high quality for packaging material.

Zeolites in the plastic industry: Zeolites are also used in the plastic industry. They help reduce odor, decrease volatile organic compounds, and increase permeability.

Zeolites in tire production: In tire manufacturing, zeolites are used to increase hardness, elongation at break, density, tensile strength, and the ignition point.

Zeolites as ornamental stones: Thomsonite, one of the rarer zeolites, is used as an ornamental stone. Its nodules can accumulate on the seabed or beaches. Thomsonite nodules have concentric rings in colors such as black, white, orange, pink, red, and various shades of green. Some nodules contain copper inclusions.

Natural zeolite in agriculture: In agriculture, clinoptilolite serves as a source for slow-release potassium. Zeolites improve plant growth, enhance water infiltration, improve soil quality over time, reduce salt loss, and retain nutrients in the root zone for plants to use when needed. This leads to more efficient use of sodium and potassium. Zeolites, with their alkalinity, help maintain the required pH level. They are mainly used in K- or NH_4-saturated clinoptilolites (Allen and Ming 1995). The term "zeoponic" can be applied to plant cultivation in any artificial soil where zeolite minerals are a significant component, e.g., in microgravity environments or lunar habitats (Ming et al. 1995). Using zeolite increases yields in: cereals, especially wheat by 6 to 15% and even up to 20%, barley by 5 to 15%, rice by up to 23%, oats, alfalfa, millet, and corn, with yields increasing by 20 to even 30%.

Along with increased yields, an improvement in quality has also been observed, such as in potatoes, where the yield increased by 12%, with better storage and maintenance of potato quality. The most significant positive impact of zeolite has been noted in crops grown in controlled environments (hotbeds, greenhouses), where zeolite acts as a mineral substrate containing magnesium and potassium. Experiments conducted in field and controlled conditions (glass gardens, greenhouses) indicate the justification for using zeolite both individually and in combination with mineral and organic fertilizers. The increase in yield averaged between 20 - 60 %, with simultaneous improvement in product quality. In field conditions where corn, wheat, and barley were grown on sandy and poor soils, the use of zeolite increased production by 22-51%. Zeolite, used as an environmental conditioner in storage facilities, can also be used for producing organic-mineral mixtures (OMG). The use of such an OMG mixture is highly justified in vegetable production, particularly tomatoes and cucumbers. Refined zeolite in seedling production positively affects germination and seedling emergence, resulting in uniform seedlings and contributing to earlier fruit ripening. In viticulture, the production of vine cuttings showed a 10-20% increase in first-category cuttings (Grubišić, M., 2002).

The ameliorative properties of zeolite in degraded agricultural soils are reflected in: improvements in physical and chemical properties, the absorption capacity of light, sandy, peat, infertile, and forest soils increases about tenfold with the use of zeolitic tuff, with the composition of zeolitic water in clinoptilolite making up about 13% of its mass.

Natural zeolite in mushroom cultivation. The addition of organozeolite to the compost for growing oyster mushrooms in an amount of 0.2% influenced the increase in yield (30%) and the presence of minerals (P, Mg, Fe), proteins, sugars, and fibers in them. A lower fiber content (3%) was found in the spent compost, indicating increased enzymatic activity in the zeolite-enriched substrate (Milenković, I., Adamović, M., Tomáševic-Čanović, M., 2001).

Natural zeolite in livestock farming. The harmful effects of mycotoxins can cause disorders in animals, known as mycotoxicoses, as well as the occurrence of pathomorphological changes in tissues and organs (liver, kidneys, etc.). In some cases, these effects can be carcinogenic. The most common disorders include reduced food intake and utilization, decreased production of milk, meat, and eggs, and disturbances in reproduction and health. Some animal species (ruminants) may be tolerant to small doses of certain mycotoxins, however, after prolonged use of such feed, mycotoxins can accumulate in meat, milk, or eggs and pose a threat to the health of consumers of these products. By processing zeolite, preparations are obtained that have the ability to adsorb mycotoxins ingested through food in the digestive tract of animals. The inclusion of these preparations, in relatively small amounts (0.2-0.5%), in the feed mixtures for cattle, pigs, and sheep contributed to reducing or eliminating mycotoxicosis, improving production and reproductive results. In certain studies, lower amounts of mycotoxin residues were found in milk and meat (Grubišić, M., 2002). In research with newborn calves and piglets, it was found that the addition of zeolite in small quantities significantly increased the absorption rate (over 50%) and boosted the animals' immunity. Natural zeolite-based preparations have the ability to bind the radioactive element Cs-137. In the meat of broilers that received Cs-137 with the addition of clinoptilolite, a lower amount (70-80%) of this element was found.

Zeolites help regulate the acidity of the liquid content in the rumen and increase the fat content in milk. A mixture of bentonite, magnesium oxide, and sodium bicarbonate, with the addition of zeolite in the diet of cows, affects an increase in milk fat by 0.06-0.29%. Zeolite has the ability to bind NH_4^+, CO_2, and moisture in the barns. The greatest reduction in CO_2 and NH_4^+ (over 30%) occurred in the barn where zeolite was added to the animal feed (2%) and bedding (50 kg/100 m2) once a week. Similar results were found in pig farming. Zeolite, in the form of a preparation, added to the feed and water for rainbow trout farming, contributes to an increase in the body weight of the fish and the concentration of certain minerals in the meat. It was found that the zeolite preparation contributes to reducing water hardness and the amount of NH_4^+ and nitrates in conditions of intensive farming of California trout (Grubišić, M., 2002).

Natural zeolite in mining. The biggest problem is the landfills, i.e., ash dumps from thermal power plants, as well as various flotation tailings. These damaged, degraded soils, due to the technological process, contain significant amounts of heavy metals (Pb, Cu, Zn, Cd, Co) and negligible amounts of biogenic nutrients (N, P, K) as well as organic components, and as such, they represent very sterile surfaces for any vegetation development. Such heterogeneous materials represent an even greater problem because they spread through wind and water, contaminating the surrounding fertile lands, and therefore represent an environmental issue.

3. CONCLUSION

Zeolite minerals enable adsorption, cation exchange, dehydration-rehydration, and other processes, which contribute to their use in separating oxygen from air, removing NH_3 from drinking water and municipal wastewater, eliminating Cs and Sr from nuclear waste, as an additive in livestock feed, as a soil amendment to improve CEC (cation exchange capacity), as a deodorant in stables, ashtrays, refrigerators, and sports equipment, as a bactericide, insecticide, and antacid for humans and animals, and as decorative stones.

Natural zeolites possess properties that allow their wide application in agriculture. The technology for their processing has been mastered, enabling the production of various products and preparations that can be used as micronutrient donors, adsorbents of mycotoxins and heavy metals, for improving environmental conditions in buildings, binding radionuclides, and other purposes. Thanks to these properties, zeolites can make a significant contribution to the better utilization of resources for the production of hygienically safe and healthy food.

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IS THE NEW ERA - THE TIME FOR RURAL TOURISM?

DA LI JE NOVO VREME - VREME ZA RURALNI TURIZAM?

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Abstract: *Rural tourism is becoming an increasingly significant segment of the tourism industry, especially in the context of modern social and economic changes. Faced with the fast pace of life, urbanization, and ecological challenges, people are increasingly seeking a return to nature, authentic experiences, and sustainable lifestyles. Rural areas offer rich cultural heritage, gastronomic specialties, traditional crafts, and direct contact with nature, making them ideal destinations for the modern traveler in search of rest and spiritual fulfillment.*

Rural tourism can not only be a source of additional income for the agricultural economy but also a significant factor in the preservation and revitalization of rural communities in Serbia. In the field of rural tourism, greater effects can be achieved through collaboration, and rural tourism can have an even more significant share in domestic tourism revenues. Currently, more than a thousand family farms engaged in rural tourism in Serbia generate nearly ten percent of total domestic tourism income, and the interest in staying at rural households grows year by year. This paper explores the potential of rural tourism as a response to contemporary trends, analyzing the key factors contributing to its popularity, including ecological awareness, the need for authentic experiences, and the economic sustainability of rural communities. It also considers the challenges of developing rural tourism, such as infrastructure, digitalization, and adapting tourism offerings to new generations of travelers. The conclusion of the paper emphasizes that the new era, shaped by technological innovations and changes in lifestyle, has favored the strengthening of rural tourism. With strategic initiatives and support, rural tourism can become a key factor in the sustainable development and revitalization of villages, offering a unique symbiosis between tradition and the modern needs of tourists.

Key words: *rural tourism, healthy food, village survival, sustainable development*

Apstrakt: *Seoski turizam postaje sve značajniji segment turističke privrede, posebno u kontekstu savremenih društvenih i ekonomskih promena. Suočeni sa ubrzanim tempom života, urbanizacijom i ekološkim izazovima, ljudi sve više teže povratku prirodi, autentičnim iskustvima i održivom načinu života. Ruralna područja nude bogato kulturno nasleđe, gastronomske specijalitete, tradicionalne zanate i direktan kontakt sa prirodom, što ih čini idealnim destinacijama za savremenog turistu u potrazi za odmorom i duhovnim ispunjenjem.*

Seoski turizam može biti ne samo izvor dopune budžeta poljoprivredne privrede, već i značajan faktor u očuvanju i revitalizaciji seoskih zajednica u Srbiji. U oblasti seoskog turizma veći efekti se mogu postići udruživanjem, a seoski turizam može imati još značajnije učešće u prihodima domaćeg turizma. Trenutno više od hiljadu porodičnih gazdinstava koja se bave seoskim turizmom u Srbiji ostvaruje skoro deset odsto ukupnih prihoda od domaćeg turizma, a interesovanje za boravak u seoskim domaćinstvima raste iz godine

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u godinu. Ovaj rad istražuje potencijale ruralnog turizma kao odgovora na savremene trendove, analizirajući ključne faktore koji doprinose njegovoj popularnosti, uključujući ekološku svest, potrebu za autentičnim iskustvima i ekonomsku održivost ruralnih zajednica. Takođe, razmatraju se izazovi razvoja ruralnog turizma, kao što su infrastruktura, digitalizacija i prilagođavanje turističke ponude novim generacijama putnika. U zaključku rada se ističe da je novo vreme, oblikovano tehnološkim inovacijama i promenama u načinu života, pogodovalo jačanju seoskog turizma. Uz strateške inicijative i podršku, seoski turizam može postati ključni faktor u održivom razvoju i revitalizaciji sela, nudeći jedinstvenu simbiozu između tradicije i savremenih potreba turista.

Ključne reči: *ruralni turizam, zdrava hrana, opstanak sela, održivi razvoj,*

1. INTRODUCTION

Rural tourism in Serbia has been recognized as a factor in the revitalization of villages in order to solve economic and demographic problems. However, rural tourism still does not have clearly defined elements of the marketing mix (product, price, promotion and distribution), nor is its development based on the principles of sustainable development.

The current offer in rural tourism in Serbia is based on the great geographical diversity of rural areas and rich rural heritage, and we emphasize that there are many areas in Serbia without a single hotel or accommodation capacity, is that a chance? This is precisely what opens up a real opportunity to expand the circle of interested parties with returnees from abroad, to invest their own funds, with full understanding and support from both the state and local governments. All this can be achieved by building infrastructure in the villages of Serbia, given that this is currently a limiting factor in the development of rural tourism. Also, we should look with encouragement at all the moves that the Government of Serbia is implementing to help the village through various incentive measures, and within the framework of the cooperative renewal program as a chance for the population to stay in their homes and the action "500 cooperatives in 500 villages" and the allocation of incentives to interested agricultural and tourist cooperatives.
(https://kt.gov.rs/en/call-for-grants-to-members-of-cooperatives-issued)

Rural tourism is a complex form of tourism, as it integrates all types of tourism in rural areas, such as agritourism, agricultural, cultural, wine, gastronomic, garden, craft, camping, hunting, fishing, event (music, literary, film), ethno, mountain, lake, and river tourism.

Healthy and tasty, mostly organically produced food, local products, fruits of old and new crafts, promotion of cultural, historical and natural heritage, along with the famous hospitality of our hosts, are some of the recognizable advantages in the fierce competition for the affection of domestic, and especially foreign guests.

The basis of the tourist offer in rural tourism is diversity, because there are plains, hills, mountains, rivers, lakes and other areas with preserved original nature, exceptional recreational properties, and Serbia has a rich rural cultural heritage with traditional ethnic characteristics of the rural population.

2. WHAT IS RURAL TOURISM?

Rural tourism is a specific form of tourism that includes a range of activities, services and additional facilities provided by rural residents on family farms, with the aim of attracting tourists and generating additional income. In this context, the term rural tourism is used in a broader sense as a synonym for rural tourism. Travelers are motivated not only by vacation, but increasingly by experience, adventure and escape from everyday life. Rural tourism meets the expectations of both young and old throughout the year, providing an authentic experience through direct communication, hospitality of the hosts and a rich offer of traditional local cuisine.

Key elements for the development of rural tourism include preserving tradition, cultural values, the specificities of a particular area (traditional rituals, gastronomic specialties, natural landmarks, habitats of rare plant and animal species), historical heritage, as well as museum and local collections that preserve traces of the past. At the center of the interpretation of all these values are the hosts themselves, who contribute to the authenticity of the tourist experience with their knowledge and experience. (Stepanov, et al., 2015)

The tourist offer in rural tourism most often relies on existing resources – real estate, agricultural production, traditional skills and knowledge of the local population. The way in which these potentials will be used and shaped into a unique tourist offer depends on many factors, including the engagement of individuals, institutions, state authorities and businessmen. The sustainable development of rural tourism requires coordinated efforts and strategic planning in order to preserve authenticity, improve infrastructure and enable long-term economic prosperity of rural communities.

2.1 Sustainable development of rural tourism?

Sustainable rural tourism relies on a preserved environment, rich natural and cultural heritage, which is the basis for attracting visitors. Its development involves cooperation between local tourism service providers, which contributes to more efficient use of resources, improvement of the tourist offer and improvement of the quality of life of the local population. The development of rural tourism increases the standard of living, creates new jobs and encourages the population to stay in rural areas.

When planning a business idea in the field of rural tourism, it is important to consider the key success factors:

- What are the short-term and long-term development goals?
- What are the specific steps needed to achieve these goals?
- In what period of time can the plan be implemented?
- How much financial investment is needed and how can it be secured?
- Is there a sufficient qualified workforce or are retraining and additional education programs needed?

Existing tourism service providers can significantly improve their offer through additional education and adaptation to modern tourism trends. Potential stakeholders in the development of rural tourism include individuals and legal entities, associations, rural tourist households, caterers, artisans, tourism agencies, local communities, state institutions, business people and educational institutions. Their mutual cooperation is key to creating an attractive and competitive tourism offer, which will transform rural areas into sustainable destinations with long-term growth potential.

3. BUSINESS IN RURAL TOURISM

Rural tourism was initiated by an entrepreneurial spirit, because life in the countryside, in addition to the production of agricultural goods, offers numerous opportunities for tourist activities. The most common activities offered to tourists include accommodation, entertainment and recreation. Some specific services often used in this business are:

- Providing accommodation to visitors and facilitating various activities that allow them to experience an authentic agricultural and rural lifestyle.

- Providing entertainment in the household or the surrounding area, such as horse riding, mountain biking, hiking, visiting abandoned parts of the village, bird watching, wine tasting and other activities.
- Organizing formal and informal education through tours and seminars, where visitors can learn about local cuisine and traditional food preparation, visit natural and cultural attractions, participate in workshops of old crafts or get acquainted with the local cultural heritage.

These services can be available throughout the year or depending on the seasons, which allows for different thematic offers that follow seasonal specificities. (Đorđevič-Milošević, Milovanović, 2010)

Rural tourism businesses typically employ a small number of people, often relying on family members or a few people from the local community. However, engaging local people and working with local suppliers adds value, as it builds loyalty to the community. This approach allows tourists to experience an authentic, local experience, which is especially important for visitors to rural areas. When it comes to seasonal businesses, hiring seasonal or temporary workers makes it easier to adapt to market changes.

The first step in starting a rural tourism business is to conduct a detailed analysis of the available resources and potential, both your own and the natural and cultural ones in the area. In the second phase, the structure of the products and services that will be offered to tourists is formed.

3.1. Motives and challenges in rural tourism

The motivation for engaging in rural tourism varies from entrepreneur to entrepreneur, and some of the main motives include: (Arsenov, 2000)

- Personal business success, the desire to build one's own entrepreneurial path.
- Activation during retirement, enabling continued engagement in a productive life.
- Commitment to different lifestyles, such as sustainable and environmentally friendly lifestyles, or a return to traditional values.
- Transfer of knowledge about the rural environment, the desire to preserve and share cultural heritage and rural traditions.

When the motivation is focused on achieving the highest possible profit, expectations include:

- Positive cash flow, which allows the business to operate without financial difficulties.
- Income sufficient to invest in equipment and cover current business costs.

Financial success is also a relative goal:

- providing employment for family members and neighbors or friends, or covering the costs of maintaining equipment, can be someone's success.

The fact is that few rural tourism businesses make significant profits, and those that do have been doing so for many years. It is widely believed that it takes three to five years for a business to stabilize and start making serious profits. But until that moment comes, the business may not be profitable.

3.2. The economic effect of rural tourism

The employment situation in rural areas of Serbia is very difficult, and unemployment remains one of the key problems affecting both the economic and social and political situation. This problem has been going on for many years, and the consequence of high unemployment is the increasingly present appearance of employees in the sphere of the "grey" economy. Although the unemployment rate among the working-age population in rural areas remains high, the personal income of employees is among the lowest compared to the rest of the region, which creates even greater economic challenges. (Košić, 2006)

Therefore, there is a need to maximize the use of tourism potential that small, underdeveloped rural areas can offer. Rural tourism is an opportunity to solve this problem, as it can significantly contribute to reducing unemployment. Many people in rural areas see a way out in rural tourism and agriculture, because engaging in tourism as a primary or additional occupation not only increases income, but also improves the quality of life. Through rural tourism, the population can work in their own homes, which reduces the need for migration to cities and eases the pressure on urban infrastructure. (Rosić, 2001)

The development of rural tourism could accelerate the economic and social development of villages, reduce depopulation and slow down migration to cities. In order to achieve sustainable development of rural areas, it is necessary to design strategies and measures that will strengthen the demographic and functional component of settlements. These measures should include improving infrastructure, supporting the development of local businesses, as well as stimulating the return and retention of young people in the countryside.

Rural tourism is of particular importance because it creates opportunities for self-employment within households, providing them with additional income. Households engaged in rural tourism can sell their surplus agricultural products at higher prices than is the case in the traditional market. In addition, rural tourism has a long-term impact on the demographic structure, as it contributes to the retention of young people in the countryside, slows down the aging of the population and reduces the departure of young people to cities. Tourism also encourages the development of infrastructure systems, such as roads, water supply and sewage, which further improves the quality of life in the countryside. (Arsenov, 2000)

Despite all the potential it offers, investments in the development of rural tourism, especially in underdeveloped municipalities, are still insufficient. In order to create the right conditions for the successful development of this sector, it is necessary to ensure greater investments in infrastructure, promotion and education of local entrepreneurs. In addition, it is important for local and regional authorities to support rural tourism through favorable subsidies and incentives, in order to enable its sustainable growth and contribution to the economy.

The greatest economic effect is achieved when rural households are engaged in both agriculture and tourism, because in this way they can combine production with the tourist offer. Household members can actively engage in tourism activities, sell their products as final products or services, which brings them significantly higher profits. The integration of agricultural production and rural tourism contributes to the diversification of sources of income, reduces dependence on seasonal agricultural work and increases the financial stability of households. (Đorđevič-Milošević, Milovanović, 2010)

3.3. How to get started?

Start with an idea and education. While a business idea that seems original and innovative to you can be the foundation of a successful business, it alone is not enough to achieve long-term success. If that were the case, anyone who woke up with a great idea would have already become rich. The key to success lies in the ability to improve, develop and finally implement your idea into a real business venture. In today's environment, with great competition and a saturated market, success is achieved through hard work, acquiring the necessary knowledge and incredible perseverance.

We may have already seen someone else making a solid income from rural tourism and thought: "Why shouldn't we do it too? It seems simple." However, the real challenge comes when we decide to follow the path of those successful entrepreneurs whose businesses we have observed and admired. What should we do first? It is crucial to analyze the internal strengths and weaknesses of our business plan, in order to recognize potential obstacles and external influences that can make our work more difficult, but also easier.

The first step is a detailed market analysis. We should research existing competitors, identify the specific needs of potential tourists and develop a range of products and services that we can offer. This includes not only the specific tourist activities, but also the quality of services and experiences that we want to provide. Quality should be consistent and recognizable, as this will lay the foundation for long-term guest trust and stable business growth. At the same time, it is important to develop a market presence plan, i.e. a marketing and promotion strategy, in order to reach the target group as best as possible. We must also not forget that profit can only be achieved if the relationship between price and quality of services is aligned with market conditions and needs. (Šunjka, 2018)

Given that tourism is one of the fastest growing sectors, in which new trends and niches are constantly emerging, with a well-thought-out idea based on real resources and market analysis, there is a great chance of creating a profitable business. However, it is important to keep in mind that just having an idea is not enough - the real challenge lies in implementing it. To succeed, knowledge, education, strategy and good organization are needed.

The first goal should be to create as many satisfied guests as possible, because they are the best advertisement. A satisfied guest not only returns, but also recommends you to others, which can significantly increase the number of tourists and the profitability of your business. High quality service and attention to the needs of guests should be at the heart of your business model. When a guest is satisfied, he becomes an ambassador for your brand, which leads to positive word of mouth and a constant increase in visits.

In the long term, the biggest challenge lies in the sustainability of the business and its ability to survive the competition. Commitment to continuous improvement, constant education, and careful management of resources and finances are key to long-term success. Getting started is just the first step on this path - the most important thing is to remain consistent with your vision and constantly work on improving your services, so that your idea becomes and remains a successful business venture.

4. FACTORS THAT AFFECT THE DEVELOPMENT OF A TOURIST DESTINATION

The most important factors influencing the development of a particular tourist destination include public perception, its market positioning and its ability to differentiate itself from competing destinations with similar characteristics. Destination perception encompasses a set of visual and mental impressions, ideas and beliefs that the public, and especially potential tourists, have about that destination. This perception plays a key role in the decision-making process and greatly influences the choice of tourists, as well as the ability of the destination to stand out among competing destinations. Destination perception can be understood as a very important element of destination branding and its long-term success in the tourism market. (Đekić, 2001)
Destination perception consists of two basic components:

- organic and
- induced.

The organic component of perception is created based on the personal experiences of tourists or the experiences of their friends and acquaintances, as well as information obtained from objective sources. These sources can include news, reports, newspaper articles, documentaries, books, school lessons, and the like. Such sources often have a long-lasting and stable influence on the formation of the image of the destination, because they are based on real experiences and things that have been verified in the eyes of consumers.

On the other hand, the induced component of perception is created through marketing activities, advertisements, promotions, and other externally produced information. This component is formed based on information that is designed to influence the attitudes and opinions of consumers, and that comes from the media, advertising messages, promotional campaigns, and other channels that aim to create a positive image of the destination. In this context, marketing communication and promotion strategies play a key role. The effective use of these strategies can significantly contribute to shaping awareness of the destination and create interest among potential tourists who have not yet visited the destination. This information and strategies can be key to attracting specific target groups, as well as developing recognition in the market. (Popesku, 2012)

One of the important phenomena in tourism is the trend of tourists who consciously orient themselves towards trips that involve a certain level of risk. These tourists, who voluntarily take risks, often opt for types of tourism such as backpacking, adventure tourism, tourism in unexplored areas, as well as specific activities such as gambling or summer resorts with certain types of sports or challenges. Such tourists see their trip as an opportunity for excitement, adventure and exploration of new frontiers. This type of tourism offers them the opportunity to step outside the framework of everyday life and experience something new and different, with a certain level of risk that makes the trip more exciting and challenging.

Tourism based on voluntary risk-taking often attracts a specific group of tourists, who can be described as free, always looking for new experiences and ready to face challenges and uncertainties. These tourists take risk less seriously when it comes to tourism, because it is seen as an opportunity for fun, learning and self-discovery, rather than as something dangerous or negative. This market segment includes tourists who are inclined to explore unknown destinations, participate in extreme sports and adventures, and seek unique, authentic experiences that are often not available in traditional tourist destinations.

Given that these tourists seek extraordinary experiences, destinations that want to attract this group must be prepared to offer challenges, adventures and unexplored landscapes, while maintaining an element of safety and responsibility, to ensure a positive perception and repeat visits. This type of tourism places high demands on infrastructure, safety protocols and appropriate training for guides, but can be very lucrative and sustainable in the long term if managed carefully and responsibly.

5. SWOT ANALYSIS OF RURAL TOURISM

In order to develop a clear strategy for rural tourism development, it is necessary to conduct precisely targeted research and a detailed analysis of the current situation. Based on this information, it is possible to set specific goals and get a clear picture of what is wanted to be achieved, as well as the steps that need to be taken in order to achieve the desired success. This process allows for targeted action and optimal use of resources on the way to achieving goals.

A prerequisite for the correct selection of a rural tourism development strategy is a thorough analysis of the current situation. This analysis must include all relevant external (external factors) and internal (internal characteristics) factors that influence the development of rural areas. Only through an understanding of these factors can it be possible to identify a better path to achieving goals. The use of tools such as SWOT analysis, which provides a systematic approach to considering strengths, weaknesses, opportunities and threats, is crucial for defining a strategy. (https://mto.gov.rs › extfile › strategija)

SWOT analysis is used as one of the most important tools for creating strategy because it allows for an overview of four key factors that can shape future development: (https://mto.gov.rs › extfile › strategija)

- Strengths
- Weaknesses
- Opportunities
- Threats

By conducting a SWOT analysis of rural areas, with a systematic approach to analyzing positive and negative events, trends in their environment, as well as considering internal resources, it is possible to formulate specific policies, strategies and decisions. It is important to note that SWOT analysis is not a process that can be carried out independently - it should be a group technique that includes the cooperation of experts, educated and experienced participants who have a deep understanding of the specificities of their region, city, its strengths, weaknesses, resources, but also the problems it faces.

After a detailed analysis is carried out, the next step is to define specific quantitative and qualitative goals. These goals should be clearly set in order to direct activities and resources towards their implementation. Identifying the market and potential partners with whom cooperation will be established is also an important step in defining a strategy. Through clearly set goals, it is easier to determine specific programs and initiatives that will contribute to their implementation, thereby improving efficiency and focusing attention on key aspects of development.

Table 2. SWOT analysis of rural tourism

ADVANTAGES	WEAKNESSES
• Natural/climatic - Serbia is one of the five European centers of biodiversity - Borders four EU member states - Has landscapes of exceptional natural features - Large number of spas and thermal springs - Forests, rivers, lakes, hunting and fishing opportunities • Trade/commercial - Export orientation of agricultural holdings - Raw materials secured by domestic production • Structural/attitude of society - Some strong domestic companies - Potential for rural tourism and other specialized forms of tourism - Dynamic producers of specialized products - Preserved local traditions and rural landscapes • Regulatory/Political - There are quality label systems for some products - Status of the country as a potential candidate for EU accession	• Natural/climatic - Inadequate waste management - Extreme climatic events in recent years (droughts, floods, etc.) - Aging population and depopulation of rural areas • Trade/commercial - Unresolved property and legal relations in rural households (lack of cadastres) - Lack of entrepreneurship and expertise in rural areas - Weak research and development in many companies - Small domestic market - Weak diversification of activities in terms of the rural economy • Structural/attitude of society - Lack of production volume compared to competitors in the world market - Lack of a new national spatial plan - Inadequate infrastructure (especially in rural areas) - Low level of education and training in rural areas - High unemployment rate in rural areas

CHANCES	THREATS
• Natural/climatic - Opportunities for better environmental protection - Incentives for farmers to protect the environment • Trade/commercial - Growing international tourism market, rural/eco-tourism etc. - New trends are creating new market policies, e.g. increasing demand for organic and national food products and traditional processed products with geographical indications - Possible competitive advantage arising from requirements regarding food safety, environmental protection and animal welfare - Opportunities for different forms of tourism and recreation - Development of small and medium-sized enterprises and entrepreneurship in rural areas • Structural/attitude of society - Business mergers create a good opportunity to increase the volume in the field of production, processing and product placement/trade - Better diversification of rural areas - Availability of IPA funds for adequate investments - Cross-border cooperation and international project	• Natural/climatic - Decreasing forest area - Destruction of the environment • Trade/commercial - Rapid changes in consumption trends - Increasing competition in international markets - Labor shortages in some specialized sectors of the rural economy (e.g., tourism) - Pressure on profit margins by multinational companies - Costs and difficulties of starting new businesses - The emergence of strong international brands in the integrated European market may pose a threat to Serbian service industries • Regulatorne/političke - Increasing delays in infrastructure development - Increasing environmental restrictions - Market access issues due to safety and hygiene concerns

In short, a rural tourism development strategy must be based on a thorough analysis of the current situation, the use of tools such as SWOT analysis and the setting of clear objectives. This approach allows for targeted action and maximum use of resources, thereby creating sustainable and competitive tourism in rural areas.

SWOT analysis is a strategic planning tool that summarizes the key aspects of the development of a particular project, economic sector or area in a concise and concise manner. In planning procedures, SWOT analysis serves as a sublimation of all analytical findings for the purpose of determining strategic starting points, vision and guiding strategies for further development.

6. SERBIA ON THE TOURIST MAP: SUCCESS AND DIRECTION

Tourism is one of the key factors in the development of tourist destinations, countries and economies on a global level. After the oil and automotive industries, tourism activities are the leading branches of the world economy. Taking into account modern trends in the field of tourism, which are evident on a global level, real opportunities for the development of tourism in Serbia are also seen. (Ristić, 2013)

There is an argument that tourist travel can be a form of escape from life at home and an attempt to temporarily achieve a different, inverse existence. The search for something new and different can be related to the individual's lifestyle or to the characteristics of the environment. Individuals differ in the degree to which they seek something new and different, and this search is based on the psychological characteristics of individuals. In this sense, research into the needs of users should be conducted in an adequate manner in order to discover the true motivation. For certain people, unexperienced, unseen, new experiences are a factor that attracts them to certain destinations, while some tourists are looking for a return to their roots, faith and tradition.

It is undeniable that Serbia has great potential for tourism development, but it is also clear that this potential is being developed with minimal investment. However, the lack of financial resources should not be an excuse for the lack of creative investment in communication activities that would position a certain tourist destination highly. In the marketing context, in addition to communication activities, it is also necessary to develop the tourist product, improve services and quality, as well as continue to ensure price competitiveness. The weakness of Serbia's tourist offer is reflected in poor infrastructural support, as well as inadequate positioning in the global market. On the other hand, diplomatic activities aimed at attracting foreign investors represent a good input element for planning a tourism strategy. The structure of global demand is also changing. World attractions are no longer so inaccessible, and the average tourist can visit them in a relatively short period of time. Increasing demand is directed towards destinations that offer relaxation, a healthy environment and organic food. Serbia possesses precisely these values, but in order to effectively shape them into a competitive tourist product, investments are necessary. (Stepanov, et al., 2017)

A particularly important segment of tourism development in Serbia is rural tourism. The results in Serbia's tourism sector for 2024 are encouraging and provide grounds for optimism. According to the National Bank of Serbia, tourism revenues amounted to over 2.4 billion euros, which represents an increase of 11 percent compared to the previous year. The Statistical Office of the Republic of Serbia states that 3.8 million tourists visited Serbia, which is an increase of 5.3 percent compared to 2023. Foreign tourists achieved 2 million arrivals, which represents an increase of 12.4 percent. The total number of overnight stays reached 10.9 million, while foreign tourists recorded 5.2 million overnight stays, which is an increase of 9 percent. In 2024, the European Tourism Commission identified Serbia as the country with the highest percentage growth in the number of foreign tourists compared to 2019, not only in the Western Balkans but also in all of Europe. (https://www.nbs.rs/)

Rural tourism in Serbia is experiencing an expansion, as confirmed by the fact that 1,200 rural tourist households are currently registered, which is an increase of 70 percent compared to the previous year. The state has recognized the potential of this tourism segment, and through a public call, 256 million dinars have been allocated for its further development. The planned projects for 2025 are worth almost 2.1 billion dinars (almost 18 million euros), while the Ministry of Tourism has allocated 830 million dinars for 46 tourism infrastructure projects in over 40 local governments. These investments are crucial for the balanced development of tourism in Serbia. (https://www.nbs.rs/)

The formation of the National Tourism Council represents a significant step towards designing a long-term and sustainable tourism development strategy. The active involvement of social, political and economic entities, as well as individuals, is necessary for the successful development of tourism, especially in rural areas. Also, adequate valuation of cultural and historical heritage requires additional efforts in the restoration of numerous sites and buildings, which can increase the commitment of the local community to its area, customs and heritage. Sustainable development of rural tourism must not be just a phrase, but a strategic plan that will enable Serbia's tourism potential to be used in the best possible way in the long term.

7. CONCLUSION

Tourism is one of the key factors in the development of both individual destinations and national and global economies. After the oil and automotive industries, the tourism industry occupies a leading position in the world economy. Modern global trends in tourism open up real opportunities for its further development in Serbia.

Tourist travel often represents an escape from everyday life and an opportunity to discover new experiences and cultures. The need for something different depends on the personal preferences and lifestyle of the individual, and this search is based on psychological characteristics of the personality. Understanding the motivation of tourists is key to creating attractive offers, where authentic and yet unexplored experiences can play a key role in attracting visitors. Of particular importance is the trend of returning to roots, faith and tradition, which Serbia can successfully use as part of its tourism strategy.

Serbia has significant potential for tourism development, but it requires a strategic approach and creative investments. Although financial resources are limited, this should not be an obstacle to innovative marketing and communication activities that could contribute to a better positioning of Serbia on the world tourism map. In addition to promotion, it is also necessary to improve the quality of tourism products and services, as well as build better infrastructure, which is one of the key challenges.

Global tourism demand is changing—an increasing number of travelers are seeking destinations that offer relaxation, untouched nature and a healthy lifestyle. In this regard, Serbia has a significant comparative advantage, as it is abundant in natural beauty, ecologically clean areas and traditional ways of food production. In order to translate this potential into a sustainable tourism offer, additional investments are necessary, along with strategic planning and a guarantee of return on investment.

The development of rural tourism in Serbia must be based on the principles of sustainability, with the active involvement of social, political and economic stakeholders. Special attention should be paid to the preservation and revitalization of cultural and historical heritage, which can contribute to the strengthening of local identity and the economic sustainability of communities. If rural tourism is developed in a planned and responsible manner, it can become one of the main drivers of regional development, benefiting both tourists and the local population.

In the long term, a smart combination of natural resources, cultural heritage and modern tourism trends can make Serbia a recognizable and competitive destination on the world tourism scene.

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APITURISM AS A DEVELOPMENT OPPORTUNITY FOR RURAL TOURISM AND AGRO-BUSINESS

APITURIZAM KAO RAZVOJNA PRILIKA ZA RURALNI TURIZAM I AGRO-BIZNIS

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Abstract: *In recent years, apitourism or beekeeping tourism has become a modern trend in the tourism market, as well as a development opportunity in the field of agro-business. Originating less than a decade ago in the Republic of Slovenia, after the Government of this country adopted a strategy for integrating beekeeping and tourism, it can be classified as selective, that is, specific or special forms of tourism. Due to the health benefits in the field of apitherapy, it is often associated with health tourism, while its characteristics are inevitably connected to rural tourism.*

Key words: *apitourism, rural tourism, development, chance*

Apstrakt: *U poslednjim godinama, apiturizam ili pčelarski turizam predstavlja savremeni trend na turističkom tržištu, ali i razvojnu priliku u oblasti agro-biznisa. Nastao pre manje od jedne decenije u Republici Sloveniji, nakon što je Vlada ove zemlje usvojila strategiju integracije pčelarstva i turizma, može se svrstati u selektivne, odnosno specifične ili posebne oblike turizma. Zbog zdravstvenih benefita u segmentu apiterapije, često se povezuje sa zdravstvenim turizmom, dok su njegove karakteristike neizbežno povezane sa ruralnim turizmom.*

Ključne reči: *apiturizam, ruralni turizam, razvoj, prilika.*

1. INTRODUCTION

The tourism market has been facing numerous changes in recent years, both in the segment of tourist demand and in the segment of tourist supply. Modern tourists are no longer satisfied with standardized tourist packages designed for mass tourism demand; instead, they seek something new. They are typically experienced travelers, with a higher level of education, digitally literate, and eager to embark on new adventures. In addition to satisfying so-called recreational and cultural needs, i.e., the provision of transportation and accommodation services, the modern tourist seeks something more – a specific experience, an adventure, authenticity, as well as an opportunity to explore local traditions, customs, cuisine, etc.

an effort to meet the demands and satisfy the changing tourist demand in the tourism market, tourism providers are creating tourism products referred to as special or selective, i.e., specific forms of tourism, based on unique resources, attractive values, and the quality of tourist destinations. In this context, in recent years, rural areas have become increasingly interesting, popular, and promising spaces for the development of this specific type of tourism. Designing a

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high-quality program for staying in rural areas surrounded by nature as the core tourism product of rural tourism is an important process that requires analyzing the quality of service provision, as well as the potential to enrich non-accommodation tourism offerings. A significant role in improving rural tourism and agribusiness, with considerable development effects, is played by apitourism or beekeeping tourism, which is becoming an increasingly popular trend in the tourism market.

2. CONCEPT AND CHARACTERISTICS OF APITOURISM

Hosts, through rural tourism services, have the opportunity to sell surplus agricultural products, often at significantly higher prices than market rates. The development of rural tourism is gaining increasing importance due to its potential contribution to the social and economic renewal of rural areas and the revitalization of villages. This form of tourism is based on sustainability principles, offering tourists elements of rural life, nature, and traditional hospitality (Stanić Jovanović, et al, 2025).

Rural tourism leads to agricultural tourism or agro tourism, which also includes beekeeping tourism. Beekeeping tourism positively affects regional development and provides additional income to beekeepers in countries where environmental protection awareness is established (Suna, et al, 2020).

Apitourism is an innovative form of agritourism where tourists learn about the life and work of bees, bee products, and everything related to beekeeping. It also offers special services such as inhaling air from the beehive, honey massages, honey baths, cosmetics based on bee products, and more. In short, apitourism focuses on raising awareness about the importance of bees in the ecosystem, beekeeping, and educating visitors about the life and work of bees, the functioning of the bee community, and the production of bee products. Currently, apitourism is becoming increasingly popular due to the growing interest in apitherapy and wellness, which includes bee products (Škaro, 2021).

Apitourism combines sustainable, niche, heritage and health tourism. It is a new tourism product and a new research topic (Tišler & Šuligoj, 2020).
Apitourism is a form of tourism that deals with the culture and traditions of rural communities and can be considered one of the most sustainable methods of development and tourism (Fathi, et al, 2022).

Apitourism is not yet fully utilized and has significant potential for growth and development. It requires a great deal of effort and knowledge, as well as attracting a large number of people who will recognize the importance of apitourism and the healing properties of bee products. Apitourism holds much more potential. Through apitourism, visitors can relax, unwind, have fun, and even learn something new. First and foremost, visitors can participate in a small workshop organized by the local tourism community. After the workshop, they learn how honey is extracted, and at the end, they reap the fruits of their labor, enjoying them through food, massage, wellness treatments, and similar experiences (Bakavić, 2020).

The interest in bee products as well as inhalations of air from the hive, thanks to their good results that they have shown on human health, especially in post-covid recovery, have attracted a lot of attention from both apitherapy service providers and users (Hegić, 2022).

Apiforestry – the combination of forestry and beekeeping, especially in chestnut forests, provides an opportunity for the development of innovative activities and services based on beekeeping, such as apitherapy, which is a health segment of beekeeping or apitourism (Franić, 2019).

In this context, the emergence of apitourism marks a new trend in tourism with an emphasis on the importance of bees and the numerous opportunities offered by engaging in this centuries-old craft. The use of bee products and apitherapy in daily life has been known since ancient times, but the potential for creating innovative tourism stories has not been sufficiently utilized (Peruško, 2024).

Apiturism offers an excellent opportunity for the development of an economically viable specialization. The idea of the developing apiturism stems from the fact that there is increasing interest in the use of bee products in cuisine, cosmetics, therapy and prevention. Providers of apiturism do not only sell bee products and crops, but its own story. Through their story of specialization and niche tourism, they have the opportunity to create added value to their products. By offering apitourism as competitive advantage, they create experiences. Customers and visitors not only buy their products, but they hear the story of bees, why they are important to humanity, why bee products have so much positive effects on humans, especially through personal presentation in an authentic environment they see, experience and learn about the importance of bees for the existence of humanity (Korošec, 2022).

Unlike classic types of health tourism, such as exploiting water and climate, apitourism is only in the initial stages of development. On the global scale, Slovenia is one of the leading countries in the development of this type of tourism, as the first steps in apitourism were taken there (Šuligoj, 2021).

Beekeeping encourages the socio-economic revitalization of rural areas, diversifies agricultural production, and offers new opportunities for both beekeepers and tourists (Topal, et al, 2021).
It is one of the most popular and rapidly growing types of tourism in the modern world, mostly due to the growing interest of tourists of all ages in spending their holidays enjoying bee products (i.e., honey, propolis, royal jelly). Tourists are interested in learning the secrets of technology, i.e., how make high-quality honey and its related products. Hives become travel objects for tourists. The goods in the manufacture of which tourists personally participate are particularly attractive to them (Aliyeva, et al, 2019).

Apitourism combines sustainable beekeeping, niche, historical heritage, and health tourism as an intersection between tradition, alternative medicine, and the sustainable income-generating activity of the beekeeper (Beigi, 2018; Tišler, Šuligoj, 2020; Wos, 2014).
The increasing interest in beekeeping has led to one of the most sustainable forms of travel. The knowledge of this millenary art and its determining role in the preservation of biodiversity leads to current diverse educational experiences such as: attending the different talks and workshops offered globally, becoming a beekeeper for a day, seeing the live honey collection, acquiring knowledge of local gastronomy, supporting artisan crafts, and taking part in flora and honey routes. These activities are part of Apitourism, a growing concept that thanks to successful and long-lasting examples, such as the case of Slovenia, encourages local and proximity tourism (Izquierdo-Gascón, Rubio-Gil, 2023).

Following modern trends in the international tourism market, in recent years apitourism or beekeeping tourism, as a subtype of health tourism, is getting a chance for accelerated development. This type of tourism is more recent, and it is translated as beekeeping tourism and implies various benefits in health prevention from the consumption of beekeeping products to staying in the immediate environment of bees (Stanić Jovanović, et al, 2023).

This type of tourism is more recent, and is translated as beekeeping tourism, and implies various benefits in the prevention of health, from consuming beekeeping products to staying in the direct vicinity of bees (Jovanović, et al, 2023).

Apitourism is a form of tourism that encompasses activities such as observing, experiencing, and tasting honeybees and beekeeping products. The increasing interest in apitourism has also caught the attention of the scientific community, this situation constitutes a current research area for the scientific world (Dönmez, 2023).

Experiencing apitourism activities creates a more positive opinion in tourists. It is understood that apitourism guides are knowledgeable about bee biology, fun, hospitable, passionate about their job and proficient in foreign languages. Visitors expressed the guides' expertise in this field with expressions such as "bee apiologist", "walking encyclopedia", "bee doctor", "bottomless wealth" and "bee wizard" (Dönmez, 2024).

Apitourism is becoming more popular internationally and internally. It is a niche that if used properly, can be a powerful catalyst for beekeeping in the country (Grigorova, et al, 2016).

3. BEEKEEPING AND THE USE OF HONEY IN THE PAST

Beekeeping, as one of the oldest agricultural professions, has played a significant role throughout history to the present day. The history of bees dates back deeply into the past, and numerous archaeological findings testify to beekeeping as one of the oldest branches of agriculture. Honey, the most well-known bee product, was valued less than beeswax in the past, which had greater value until the end of the 19th century (Đukić, Stubičar, 2023).

The oldest fossil of a bee cited by scientists is a recent discovery of a bee that is 100 million years old, which has been remarkably preserved in amber. This discovery proves that this newly found bee is 35 to 45 million years older than other known bee fossils (Cramp, 2012). So far, there is no reliable evidence regarding when bees first appeared on Earth or when humans began to keep them. It is believed that the homeland of the honeybee is India. In ancient times, bees lived in forests in tree hollows, small caves, underground holes, and various other suitable places that they found themselves and inhabited. Beekeeping emerged in the distant past, starting with the first encounters between humans and bees in nature. Preserved monuments of ancient material culture testify that early humans persistently searched for honey, knowing its delicious and nutritious properties. The first data about the role of bees in the lives of early humans date back to the Paleolithic era, when a drawing was found on the wall of a cave in the Aran Sand Dunes in Valencia (Spain), depicting two "beekeepers" climbing a vertical rock. All known ancient civilizations were interested in bees and greatly benefited from them. The ancient Egyptians and

Assyrians were among the first to keep bees. The ancient Greeks learned the art of beekeeping from the Egyptians, and the Romans from the Greeks. The emblem of Upper Egypt was the lotus flower, while that of Lower Egypt was the bee. Bees were regularly depicted on the tombs of the first dynasty of pharaohs. The ancient Egyptians used propolis for faster wound healing and for embalming the remains of pharaohs. Clay beehives and other items from 3,400 BC have been found on the island of Crete. In the "Odyssey," Homer mentions details about honey, and in the "Iliad," he compares large crowds of people to dense bee swarms. Hippocrates, the most famous Greek physician and founder of medicine, prescribed honey to both healthy and sick people in the 5th century BC (https://spos.info/rad/pcelarstvo-u-praistoriji-i-starom-veku/accessed: 12.03.2025).

Honey holds a special place in the culinary traditions of various cultures around the world. In India, honey is an important ingredient in Ayurvedic medicine and is used in various dishes and beverages. In Middle Eastern cuisine, honey is often drizzled over desserts such as baklava and used in savory dishes like honey-glazed chicken. In China, honey is used both as food and as a traditional medicine. In Western cultures, honey is a popular sweetener and is used in a wide range of recipes, from baked goods to salad dressings. The diverse use of honey in different cultures highlights its universal appeal and versatility as an ingredient https://www.mojakosnica.com/blog/zanimljive-cinjenice-o-medu-koje-mozda-niste-znali/accesed: 12.03.2025).

4. THE ORIGIN OF APITOURISM

Apitourism can be described as an innovative form of agro-tourism and an alternative form of health or spa tourism. It focuses on raising awareness about the importance of bees in the ecosystem and beekeeping, and it is becoming increasingly popular due to the growing interest in apitherapy and wellness. This requires special organization, spatial planning, and specific training of the api-host. Specifically, a beekeeper involved in apitourism must be educated in various fields: biology, zoology, chemistry, and economics. Additionally, apitourism requires knowledge of marketing, hospitality, psychology, foreign languages, as well as the ability to provide first aid in case of bee stings, including potentially life-threatening anaphylactic shock. This type of active vacation is the result of numerous studies showing that beekeepers live longer than their peers in other professions. Apitourism was born in Slovenia in 2016, after the Slovenian government, at the suggestion of the beekeeping association, became the first to adopt a strategy for integrating beekeeping and tourism. Slovenia is the world's leading destination for beekeeping, or "apitourism," with over 10,000 beekeeping farms and more than 17,000 beekeeping colonies, and is one of the first countries to offer certified apitourism services. The Slovenian Tourist Organization and the Slovenian Beekeeping Association have jointly developed a series of initiatives for a sustainable approach to apitourism. They provided support to travel agencies in creating packages that offer tourists interesting combinations of rich eco-content, such as wellness vacations combined with local honey tastings. This trend spread globally, and api-centers began to develop in many countries, from Croatia, Bosnia and Herzegovina, and Serbia to Greece and the United States. Apitourism experienced a boom in Serbia and the region after the outbreak of the COVID-19 pandemic, when people began to turn to nature and a healthier lifestyle. Following the proposal of the Slovenian Beekeeping Association, the United Nations General Assembly declared May 20, 2017, as World Bee Day. Serbia supported this initiative because its beekeeping industry is similar to that of Slovenia. Beekeeping is highly developed in both countries, and it represents an important agricultural sector. World Bee Day has been celebrated worldwide since 2018. The date commemorates the birthday of Anton Janša, the founder and teacher of modern beekeeping in the 18th century (Jovanović, et al., 2023).

Taking into consideration that beekeepers are faced with new trials almost daily, primarily related to climate change, but also infectious and invasive bee diseases, it is evident that beekeeping is quite an insecure occupation if beekeeping production is not developed and the range of products and services is not expanded within the beekeeping household. It is precisely for this reason that apitherapy and apitourism are included in the offer since every beekeeper without excessive initial investments (except for upgrading knowledge) could have a new additional source of income. The business of apitherapy and apitourism should be taken seriously, as well as any other job, with the awareness that knowledge, skill and ability are necessary in addition to desire (Hegić, 2022).

The court beekeeper of Empress Maria Theresa and academic painter was born in Breznica (now Slovenia) in 1734. In his youth, he made a studio in a barn with his brothers. Soon afterwards, although illiterate, they went to Vienna and enrolled in the painting academy. He developed an interest in beekeeping since his father had 100 beehives. In 1770, Maria Theresa appointed him the court beekeeper and the first imperial instructor in the monarchy. He became the first appointed teacher of beekeeping. He kept bees in the imperial gardens and traveled, presenting his observations on the migration of beehives to various pastures. After his death, Maria Theresa published his 'Complete Guide to Beekeeping' and issued a decree obliging all beekeeping teachers to use his book (https://sr.wikipedia.org/sr-el/Anton_Janša/accessed: 12.03.2025.).

Slovenia was the first in the world to develop apitourism - an innovative tourist product that is a combination of tourism and beekeeping. It is a unique travel experience and a form of sustainable and responsible tourism linked to the tradition of beekeeping. Currently, there are already 45 certified providers of apitourism services in Slovenia. We are the only ones in the world to have beekeeping tourist guides (https://sca.kis.si/hr/education/apiturizam-2/accessed: 12.03.2025.).

In California, there are already several api-centers that, in addition to the beekeeping experience, offer their guests enjoyment and relaxation in spa centers that are surrounded by an aerosol of beehives. In addition to honey massages and other health and beauty treatments with bee products, these specialized ranches offer stays in api-chambers, which are the equivalent of living in a beehive and where people breathe air from the hive that is rich in bioactive compounds. Visitors have the opportunity to get to know the world of bees on the spot in the apiary. The technique of honey production is presented to them, they can spin it and taste it. Workshops on the importance of bee products, making ointments, balms, creams, liqueurs and everything else that is obtained by combining honey and medicinal plants are organized (Jovanović, et al, 2023).

5. APITURISM AS A DEVELOPMENT OPPORTUNITY FOR RURAL TOURISM AND AGRO-BUSINESS

Beekeeping tourism, or more commonly known as apitourism, represents one of the newer special, selective, or specific forms of tourism. Often associated with health tourism due to its health benefits for the body, it is primarily linked to health prevention through the use of bee products and the practice of apitherapy. On the other hand, it can be directly connected to rural tourism, as well as agritourism and agro-business, since agricultural farms rich in beehives and apiaries have become attractive apitourism destinations. Following contemporary trends in changing tourist demand and expectations, significant effects and accelerated development are anticipated for this form of tourism. Apitourism could play an important role in improving the guest experience in rural tourism, particularly as a small, often family-run form of agro-business.

Different authors and tourism theorists associate apitourism or beekeeping tourism with both health tourism and rural and agritourism. An undeniable fact is that apitourism, besides being a contemporary trend and a relatively new form of special, selective, or specific tourism, can also contribute to enriching the tourist experience in rural areas, raising the quality of services in rural tourism, and more efficient valorization of rural and agritourism resources. This would ensure the foundation for additional employment in agro-business and the economic empowerment of rural households, through the opportunity to creatively design apitourism products. Ultimately, the attractiveness of rural tourism destinations implies a developed agro-business based on organic, local cuisine of the area and preserved natural surroundings in line with environmental protection principles. In this regard, ecological preservation is a fundamental prerequisite for the development of rural tourism and agro-business, while apitourism represents their developmental opportunity for creating a sustainable tourist destination.

The concept of sustainable development based on preserved natural resources, active participation, and the promotion of tradition, culture, and life in rural communities, along with the integrated tourist offering of rural tourist products expressed through the creativity of rural hosts and beekeepers, forms the basis for the development of apitourism and guarantees the success of agro-business.

The main characteristic of apitourists is that this form of tourism is predominantly chosen by smaller groups, families with children, individual tourists, and so-called weekend tourists, who wish to spend shorter holidays during the year as an escape from city crowds.

This form of tourism was greatly influenced by the active period of the COVID-19 pandemic, during which people began to focus much more on health prevention and staying in undisturbed rural environments. Additionally, apitherapy has proven to be an exceptionally suitable choice for treating so-called "manager's disease" and relieving the daily stress to which we are all exposed.

Api-centers, in this sense, become centers of so-called "slow forms of tourism," which align with green, sustainable, and ecotourism principles. Rural households and ethno-villages, as small, often family-run agro-businesses in rural tourism that have beehives, should base their offerings on educational facilities, active participation, and entertainment for children. A specific zone for receiving tourists, as well as informing them and introducing them to the local apitourism offer, can serve as a welcome info-center, complete with a souvenir shop.

Since active participation is one of the key characteristics of apitourism, organizing lectures, workshops, and courses that include learning about traditions, customs, lifestyle, and daily tasks in rural beekeeping communities, as well as visiting farms, apiaries, and hives, and educating about the life and significance of bees, the use of bee products, honey extraction, making balms and creams, and utilizing apitherapy and additional activities, is of particular importance for the development of this special form of tourism.

The offer of additional content can include: honey massages, cosmetics based on honey and bee products, gastronomic offerings (honey meals, honey wine, honey brandy, etc.), with a special focus on offerings for younger visitors (e.g., making wax souvenirs, painting honey cookies, photographing in front of the "bee hotel," etc.). Children's animation can be achieved through the organization of creative games themed around honey and bees, as well as involving local amateur theater groups, folklore societies, or screening documentaries on beekeeping and the life of bees.

Examples of good practice from the Republic of Slovenia indicate the creation of api-routes, api-itineraries, as well as the education and involvement of api-tourist guides. Networking and cooperation between beekeeping farms and agro-businesses in rural tourist destinations, on one side, and providers of tourist offers and representatives of the public sector and professional associations, on the other side (tourist agencies, hoteliers, rehabilitation centers, health institutions, spas, local tourist organizations, destination management organizations, clusters, pensioners' associations, as well as preschool/school/student institutions and other public institutions), represents an important prerequisite for the development of this type of tourism.

A stay in an api-tourist destination can take the form of: extended weekends or summer vacations in rural households (for families), so-called "schools in nature" (for artists and nature lovers), training (for athletes, recreationalists), camps (for children, students, certain homogeneous visitor groups), team buildings (for companies), as well as congresses, meetings, conferences, and other events (so-called "MICE" industry); of course, depending on the accommodation capacity (number and structure of beds) and the possibilities for full-board and half-board meals.

Directly proportional to the length of stay is the richness of natural (caves, canyons, gorges, mountains, and volcanic cones, as the most sought-after geomorphological tourist motives; lakes, rivers, canals, streams, thermal mineral springs, and marshes, along with seas, as hydrographic tourist motives, among which there is especially great interest in waterfalls, sinkholes, and cascades; as well as attractive flora and fauna, national parks, natural monuments, especially endemics and relics as biogeographical tourist motives) and anthropogenic resources (sacral architecture, museums, galleries, fortresses, castles, industrial heritage objects; as well as objects of folk architecture such as roller mills, watermills, mills, inns, old houses, huts, log cabins, etc.), in the immediate surroundings, as well as the possibility of organizing trips, excursions, and sightseeing programs.

Enriching the stay by including attractive rural activities in the apitourism offer, such as: organizing local beekeeping, gastronomic, and/or village festivals (fairs, markets, events, etc.); tractor/wagon/sledge rides; donkey/horse riding (depending on the season and the host's agro-business possibilities); hiking/adventure tours; collecting forest fruits, and more, contributes to an extended stay, repeated visits, and the creation of an authentic experience, thus elevating the quality level and visibility of rural and api-tourism products and agro-business on the tourist market.

6. CONCLUSION

Following contemporary trends in the rural tourism market and the agro-business sector, beekeeping tourism or apitourism has become an increasingly sought-after part of the offer in recent years, both in terms of health prevention and as a way of enriching the stay. The consequences of the coronavirus pandemic, along with modern diseases such as the "manager's disease" and the impact of stress in people's daily lives, have contributed to the increased demand for products and services in rural and agrotourism. In addition to organic production and environmental sustainability as the fundamental prerequisites for the development of tourism in rural areas, a specific offer such as apitourism can represent a development opportunity in the sector of small, mostly family-owned agro-businesses.

Tourist interest in rural and agrotourism, specifically beekeeping tourism and the use of various beekeeping products, needs to be promoted through continuous education for both rural hosts and tourists. The creation of special api-tourism products and services could also incorporate local gastronomy, tradition, customs, and folklore; introducing visitors to the richness and multiculturalism of folk crafts, as well as the use of old trades and tools. All of these elements together, in the era of globalization, represent a segment of highly valued, unique, and authentic tourism products that are especially exotic for foreign tourists and domestic visitors from large cities.

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HARNESSING GASTRONOMY: THE ROLE OF SUSTAINABLE TOURISM AND LOCAL PRODUCTS IN RURAL DEVELOPMENT

ИСКОРИШТАВАЊЕ ГАСТРОНОМИЈЕ: УЛОГА ОДРЖИВОГ ТУРИЗМА И ЛОКАЛНИХ ПРОИЗВОДА У РУРАЛНОМ РАЗВОЈУ

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Abstract: *This paper explores the pivotal role of gastronomy in fostering sustainable tourism and driving rural development through the promotion of local products. By examining the intersection of culinary traditions, sustainable practices, and tourism, the study highlights how local food systems can serve as powerful tools for economic growth, cultural preservation, and environmental sustainability in rural areas. Sustainable tourism, when integrated with local gastronomic products, not only enhances the visitor experience but also provides opportunities for local communities to thrive through the promotion of indigenous food traditions, sustainable agricultural practices, and responsible tourism. The paper discusses the ways in which rural areas can leverage their unique culinary offerings as both cultural assets and economic drivers, emphasizing the importance of innovation in marketing and product development. Through case studies and survey conducted among 209 guests of a restaurant that serves local food, this paper demonstrates how the synergy between gastronomy, local products, and sustainable tourism contributes to the resilience and long-term prosperity of rural regions. Ultimately, it argues that harnessing the potential of gastronomy within the sustainable tourism framework is key to achieving inclusive rural development that benefits both the local communities and the global traveler.*

Key words: *sustainable tourism, local products, tradition, innovation, rural developmet*

Апстракт: *Овај рад истражује кључну улогу гастрономије у неговању одрживог туризма и покретању руралног развоја кроз промоцију локалних производа. Испитујући пресек кулинарских традиција, одрживих пракси и туризма, студија наглашава како локални системи исхране могу послужити као моћно оруђе за економски раст, очување културе и одрживост животне средине у руралним областима. Одрживи туризам, када се интегрише са локалним гастрономским производима, не само да побољшава искуство посетилаца, већ и пружа могућности локалним заједницама да напредују кроз промоцију аутохтоних прехрамбених традиција, одрживих пољопривредних пракси и одговорног туризма. У раду се разматрају начини на које рурална подручја могу искористити своју јединствену кулинарску понуду као културна добра и економске покретаче, наглашавајући важност иновација у маркетингу и развоју производа. Кроз студије случаја и анкету спроведену међу 209 гостију ресторана који послужује локалну храну, овај рад показује како*

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синергија између гастрономије, локалних производа и одрживог туризма доприноси отпорности и дугорочном просперитету руралних региона. На крају, он тврди да је искориштавање потенцијала гастрономије у оквиру одрживог туризма кључно за постизање инклузивног руралног развоја који користи и локалним заједницама и глобалним путницима.

Кључне речи: *одрживи туризам, локални производи, традиција, иновација, рурални развој*

1. INTRODUCTION

The impact of sustainable tourism on local economies is profound, as it generates increased revenue for communities that embrace environmentally and socially responsible practices (Assai et al., 2024). Sustainable tourism encourages visitors to engage with local businesses, leading to a rise in income for small-scale enterprises, which are often the backbone of local economies (Knežević et al., 2024). According to Panić et al. (2024a) sustainable tourism creates job opportunities in various sectors, including hospitality, transportation, and guiding services. Furthermore, sustainable tourism practices often prioritize fair trade, supporting local artisans and producers. By featuring local crafts and goods, tourists contribute to the preservation of traditional skills and promote economic equity (Deb et al., 2024). This support not only elevates local artisans but also enriches the overall tourism experience, as visitors gain access to unique products that reflect the region's culture and heritage.

Sustainable tourism significantly impacts rural development by promoting economic growth and fostering social cohesion (Gao & Wu, 2017). At its core, sustainable tourism is predicated on principles that prioritize environmental stewardship, cultural integrity, and economic viability. By attracting visitors who are increasingly seeking authentic experiences, rural communities can experience substantial economic benefits, such as job creation and increased income. According to (Bojović et al., 2024), regions that have embraced sustainable tourism often see a rise in employment opportunities in areas such as hospitality, food production, and guided tours, which can help mitigate rural unemployment. Furthermore, sustainable tourism encourages the preservation of local culture, as communities strive to showcase their unique heritage to visitors. This not only promotes community cohesion but also instills a sense of pride among residents, who become active participants in the narrative of their cultural and historical identity.

Local products play a crucial role in enhancing rural economies by creating a direct link between agricultural practices and culinary experiences (Vujko et al., 2024a). Defined as goods produced within a specific locality, local products embody the unique flavors, traditions, and agricultural practices of the region. Their significance goes beyond mere gastronomy; they are essential for boosting small businesses and supporting local farmers (Han et al., 2024). According to Li et al. (2024), farmers' markets in rural areas not only provide a venue for local producers to sell their goods but also foster a sense of community by connecting consumers directly with the source of their food. This relationship enhances food security as it encourages the consumption of seasonal, locally sourced products, reducing reliance on imported food and promoting sustainable agricultural practices. Additionally, initiatives like farm-to-table restaurants exemplify how local products can elevate culinary offerings while supporting local economies (Nastić et al., 2024). By prioritizing local ingredients, these establishments not only contribute to economic growth but also encourage sustainable farming practices, leading to a more resilient agricultural sector (Vujko et al. 2024). Tourists are increasingly seeking experiences that allow them to engage with the local culture, and local crafts and foods serve as tangible representations of a destination's identity. Additionally, local culinary experiences, such as cooking classes or food tours, offer educational opportunities for tourists to learn about traditional practices and ingredients unique to the region (Marinello et al., 2023). This not only enriches the tourist's experience but also fosters a greater understanding of local customs and traditions. The connection forged between tourists and the local community is further strengthened when visitors participate in cultural events or workshops, creating lasting memories and relationships that transcend the typical tourist experience. By facilitating these interactions, sustainable tourism not only benefits local economies but also cultivates mutual respect and understanding between visitors and residents.

The intersection of gastronomy and sustainable tourism has emerged as a potent catalyst for rural development, presenting unique opportunities for economic growth, cultural preservation, and environmental sustainability. Sustainable tourism, defined as a travel approach that respects local cultures and ecosystems while benefiting local communities, serves as a framework within which rural areas can thrive. By harnessing local culinary traditions and products, rural regions can not only enhance their appeal as tourist destinations but also foster economic resilience and social cohesion. The paper started from the initial hypothesis H that gastronomy represents a motive that has the ability to independently attract tourists, and is therefore an indicator of sustainable development of rural destinations. This research paper will analyze the impact of sustainable tourism on rural development, explore the integral role of local products in promoting rural economies, and discuss the challenges and opportunities that arise in leveraging gastronomy for rural advancement. It was concluded that tourists in most cases recognize the potential that gastronomy represents for rural development

2. MATERIALS AND METHODS

The research was conducted among the guests of the national cuisine restaurant "Banstolka" on Fruška Gora national park, during the summer season of 2024. The authors visited the restaurant on several occasions, asked for the email addresses of guests who were willing to participate in the research, and then forwarded them a link with questions. Out of the 300 questionnaires sent, 209 were returned to the address and the authors processed them with the SPSS program. In order to check the statistical significance of the answers of the respondents, their answers were compared in relation to the gender of the respondents. Statistically significant differences are those with p greater than 0.05. When Pearson Chi-Square (p) is greater than 0.05, it indicates no statistical significance in respondents' answers concerning age; smaller values indicate differences in responses.

Fruška Gora, recognized as one of Serbia's five national parks, holds remarkable natural and cultural-historical importance. It accommodates a diverse array of tourism types, including sports and recreation, health and wellness, cultural and event-driven activities, scientific pursuits, and nautical ventures. Its potential for the growth of business tourism is substantial, attributed to its stunning landscapes, numerous hiking and trekking paths, proximity to the capital, well-developed infrastructure, and rich cultural-historical sites.

3. RESULTS AND DISCUSSION

Total number of 108 male respondents and 101 female respondents participated in the research. The data in Table 1 show that the respondents did not show a statistically significant difference in the answer regarding the opinion about the importance of gastronomy for the development and promotion of a sustainable form of tourism, in relation to gender. The integration of **gastronomy** into **sustainable tourism** strategies for rural destinations not only boosts economic development but also helps to preserve cultural traditions, promote environmental sustainability, and offer tourists enriching, authentic experiences. By emphasizing local food and sustainable practices, rural areas can create a thriving, sustainable tourism model that benefits both the local community and the visitors. The data in Table 1 provide an insight into the complete agreement of respondents on the importance and synergy of gastronomy and sustainable tourism.

Table 1. Importance of gastronomy in promoting sustainable tourism

		Gender		Total
		Male	Female	
How important is gastronomy in promoting sustainable tourism?	Not important	1	1	2
	Somewhat unimportant	1	1	2
	Neutral	14	6	20
	Somewhat important	56	39	95
	Important	36	54	90
Total		108	101	209
	Value	df	Asymptotic Significance (2-sided)	
Pearson Chi-Square	9,618[a]	4	,047	

Also, as with the first table I regarding the synergy between gastronomy and tourism, there is no statistically significant difference in the answers of the respondents. Local food is not just about eating—it's about sustaining rural communities, protecting the environment, and enriching tourist experiences. By promoting local food, rural tourism can become more sustainable, culturally rich, and economically beneficial.

Table 2. Role of local food

		Gender		Total
		Male	Female	
What role do local food traditions play in tourism experiences for you?	No role	1	2	3
	Minor role	3	2	5
	Neutral	7	8	15
	Moderate role	32	45	77
	Major role	65	44	109
Total		108	101	209
	Value	df	Asymptotic Significance (2-sided)	
Pearson Chi-Square		6,614[a]	4	,158

Table 3 shows similar tendencies as the previous ones, i.e. that there are no disagreements when it comes to the answers to this question either. Each rural destination carries a distinct culinary fingerprint, one that reflects its land, history, and traditions. Tourists who seek an escape from urban life often crave authenticity—something they find in the farm-to-table meals served in quaint countryside inns or at bustling farmers' markets overflowing with seasonal produce. The demand for local food not only benefits tourists but also breathes life into rural economies. Small-scale farmers, artisanal producers, and local restaurateurs thrive as travelers bring new business to the region.

When visitors choose to dine in locally owned establishments rather than generic chain restaurants, the revenue circulates within the community, fostering sustainable economic growth. In many cases, food festivals—celebrating everything from truffles to seafood—become major annual attractions, drawing thousands of visitors eager to indulge in a region's culinary specialties.

Table 3. Impact of Local Food on Rural Destination Visitation

			Gender		Total
			Male	Female	
Have you ever visited a rural destination specifically because of its local food offerings?	Tottaly disagree		0	2	2
	Disagree		0	4	4
	No opinion		7	13	20
	Agree		44	34	78
	Tottaly agree		57	48	105
Total			108	101	209
	Value	df	Asymptotic Significance (2-sided)		
Pearson Chi-Square			9,630[a]	4	,047

The results that can be seen in table 4 also show that there is no statistical significance in the respondents' answers in relation to gender. In the tranquil embrace of rural landscapes, where vast fields, lush vineyards, and family-run farms shape the scenery, the concept of organic food holds profound significance for both tourists and local communities. The growing preference for organic produce among travelers is not just a trend—it is a reflection of their desire for healthier choices, environmental consciousness, and a deeper connection to the places they visit. For many travelers, rural tourism is an escape from the artificial and mass-produced, a retreat into nature where food is expected to be fresh, wholesome, and untainted by chemicals. Organic food—grown without synthetic pesticides, fertilizers, or genetically modified organisms (GMOs)—is often perceived as a marker of purity. Tourists associate it with unspoiled landscapes, traditional farming methods, and a lifestyle that prioritizes quality over convenience. Whether it's biting into a crisp apple from an organic orchard or savoring farm-fresh eggs at a countryside bed-and-breakfast, the experience reinforces the perception that rural destinations offer food in its most authentic form. Another key factor shaping the perception of organic food in rural tourism is its association with sustainability. Conscious travelers prefer destinations that practice responsible tourism, and organic farming is widely regarded as an environmentally friendly alternative to conventional agriculture. With its focus on soil health, biodiversity, and reduced water pollution, organic farming aligns with the ethos of sustainable tourism. Visitors often perceive rural areas that embrace organic food as being more committed to ecological preservation, enhancing their appeal as destinations that care for both nature and the well-being of future generations.

Table 4. Perceived Importance of Organic Food in Rural Tourism

			Gender		Total
			Male	Female	
How important is it for rural tourism to address the environmental impacts of food production and consumption?	Not important		2	1	3
	Somewhat unimportant		3	0	3
	Neutral		13	4	17
	Somewhat important		43	35	78
	Important		47	61	108
Total			108	101	209
	Value	df	Asymptotic Significance (2-sided)		
Pearson Chi-Square			10,511[a]	4	,033

For many travelers, food is a highlight of their journey. A visit to a rural destination is incomplete without indulging in the regional delicacies that define it. Whether it's savoring the smoky aroma of barbecued meats at a roadside smokehouse or enjoying a picnic made with freshly picked fruits from a local orchard, the flavors of a place leave a lasting impression. More than just a meal, these experiences create memories that linger long after the journey ends, often inspiring visitors to return for another taste of the countryside.

Table 5. Synergy bettwen local product, gastronomy and sustainability

		Gender		Total
		Male	Female	
How can the synergy between local products, gastronomy, and tourism contribute to inclusive rural development?	No contribution	1	2	3
	Minor contribution	1	2	3
	Neutral	1	9	10
	Moderate contribution	20	36	56
	Major contrbution	85	52	137
Total		108	101	209
	Value	df	Asymptotic Significance (2-sided)	
Pearson Chi-Square		19,374[a]	4	,001

In many rural regions, organic farming is not just a modern trend but a continuation of age-old agricultural traditions. Tourists who visit rural areas seek more than just relaxation—they want immersive experiences that connect them with local culture and heritage. Organic food, often linked to heirloom varieties, artisanal production, and traditional farming techniques, offers a gateway into the rich culinary heritage of a place. Whether it's an organic olive oil tasting in a Tuscan village or a meal prepared with pesticide-free vegetables at a countryside retreat, the experience fosters a deeper appreciation for the destination's agrarian roots. The synergy between local products, gastronomy, and sustainability is a cornerstone of responsible tourism. As travelers become more mindful of their food choices, rural destinations that embrace this model stand out as pioneers in eco-conscious hospitality. By valuing what the land provides, celebrating its flavors, and preserving its natural balance, communities can ensure a thriving, sustainable future—one delicious meal at a time.

4. CONCLUSION

The interplay between sustainable tourism and local products is a dynamic and vital relationship that holds the potential to transform local economies, enhance tourist experiences, and preserve cultural integrity. By focusing on the economic benefits of sustainable tourism, emphasizing the role of local products in providing authenticity, and addressing the challenges of integration, stakeholders can develop strategies that foster a thriving tourism industry. This synergy not only benefits local communities and enhances the travel experience but also contributes to the broader goals of sustainability and cultural preservation. As we move forward, embracing sustainable tourism practices that prioritize local products will be essential in crafting a future where tourism serves as a conduit for cultural exchange, economic opportunity, and environmental stewardship.

When local products, gastronomy, and sustainability align, they create a harmonious ecosystem that benefits everyone—producers, businesses, tourists, and the environment:

- For Farmers and producers: Increased demand for local ingredients encourages sustainable agricultural practices, providing stable incomes and preserving traditional knowledge;
- For Restaurants and Tourism Businesses: A focus on local and sustainable gastronomy differentiates the destination, attracting eco-conscious travelers and enhancing its culinary reputation;

- For Visitors: Tourists enjoy fresh, flavorful, and meaningful dining experiences while supporting ethical food systems and
- For the Environment: Sustainable sourcing reduces food miles, lowers carbon emissions, and promotes biodiversity-friendly farming practices.

Despite the benefits of integrating sustainable tourism with local products, several challenges must be addressed to ensure a balanced approach. The growth of tourism can sometimes conflict with environmental conservation efforts, leading to issues such as overcrowding and resource depletion. For instance, the increase in visitors to destinations like the Galápagos Islands has raised concerns about the impact on the delicate ecosystem. Addressing the potential for cultural commodification is another significant challenge; as local traditions become commercialized for tourist consumption, the authenticity of cultural practices may diminish. To mitigate these issues, several strategies can be implemented. Certification programs that promote sustainable practices and community engagement initiatives can help ensure that tourism development aligns with local values and environmental standards. For example, the Global Sustainable Tourism Council has established criteria for sustainable tourism practices that can guide destinations in their development efforts. By addressing challenges through collective efforts, rural areas can harness gastronomy as a powerful tool for sustainable development, fostering economic growth while preserving cultural heritage and environmental integrity.

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HOW LOCAL AGRICULTURAL PRODUCTION REDUCES THE CO_2 FOOTPRINT OF FOOD CONSUMED

КАКО ЛОКАЛНОТО ЗЕМЈОДЕЛСКО ПРОИЗВОДСТВО ГО НАМАЛУВА CO_2 ОТПЕЧАТОКОТ НА КОНСУМИРАНАТА ХРАНА

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Abstract: *Local agricultural production plays a crucial role in reducing the CO_2 footprint of food by minimizing transportation emissions, encouraging seasonal consumption, and fostering sustainable farming practices. The integration of digital technologies in agriculture enhances efficiency, optimizes resource utilization, and improves yield predictions, further reducing environmental impact, as reflected in the ecological (eco) footprint. Smart farming technologies, precision agriculture, and data-driven decision-making strengthen the connection between production and consumption, ensuring a more sustainable and resilient food system. Utilizing available databases to calculate the CO_2 and eco footprint of staple food production, including fruits and vegetables, we have conducted a comparative analysis of organic and conventional agricultural methods. Our findings indicate that organic food, when not locally produced, may have a higher footprint than non-seasonal food, a counterintuitive but significant discovery. Additionally, by analyzing staple food footprints, we have calculated the overall impact of individual vegetarian and omnivorous menus.*
The research underscores that consuming locally sourced and seasonal food results in the smallest ecological footprint. This insight serves as an important driver for supporting small-scale producers and promoting sustainable food consumption patterns. Encouraging policies that strengthen local food networks, investing in digital agriculture, and raising awareness among consumers are essential steps toward reducing the environmental impact of food production. Ultimately, fostering a shift toward localized and sustainable agriculture can contribute significantly to global climate goals and food security for future generations.

Key words: *Local agriculture, Food security, environmental, sustainability, footprints*

Apstrakt: *Локалното земјоделско производство игра клучна улога во намалувањето на CO^2 отпечатокот на храната преку минимизирање на емисиите од транспортот, поттикнување на*

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сезонска потрошувачка и промовирање на одржливи земјоделски практики. Интеграцијата на дигиталните технологии во земјоделството ја подобрува ефикасноста, го оптимизира искористувањето на ресурсите и ги подобрува предвидувањата за приносите, дополнително намалувајќи го влијанието врз животната средина, како што се рефлектира во еколошкиот (еколошки) отпечаток. Технологиите за паметно земјоделство, прецизното земјоделство и донесувањето одлуки базирани на податоци ја зајакнуваат врската помеѓу производството и потрошувачката, обезбедувајќи поодржлив и поотпорен систем на храна. Користејќи ги достапните бази на податоци за пресметување на CO^2 и еколошкиот отпечаток на производството на основни намирници, вклучувајќи овошје и зеленчук, спроведовме компаративна анализа на органските и конвенционалните земјоделски методи. Нашите наоди покажуваат дека органската храна, кога не се произведува локално, може да има поголем отпечаток од несезонската храна, што е контраинтуитивно, но значајно откритие. Дополнително, преку анализа на отпечатоците од основните намирници, го пресметавме целокупното влијание на индивидуалните вегетаријански и сештојади менија.
Истражувањето потврдува дека консумирањето на локално произведена и сезонска храна резултира со најмал еколошки отпечаток. Овој увид служи како важен двигател за поддршка на малите производители и промовирање на одржливи модели на потрошувачка на храна. Поттикнувањето на политиките кои ја засилуваат локалната мрежа за храна, инвестирањето во дигиталното земјоделство и зголемувањето на свеста кај потрошувачите се суштински чекори за намалување на влијанието на производството на храна врз животната средина. На крајот, поттикнувањето на промената кон локализирано и одржливо земјоделство може значително да придонесе за глобалните климатски цели и безбедноста на храната за идните генерации.

Клучни зборови: *Локално земјоделство, безбедност на храна, животна средина, одржливост, отпечатоци*

1. INTRODUCTION

In an era of growing environmental challenges and increasing concerns over food security, the role of local agriculture in promoting sustainability and reducing ecological footprints has never been more critical. There is an urgent need to reduce greenhouse gas emissions, local agricultural production has emerged as a key solution for promoting sustainable food systems (Klapp et al., 2022). By minimizing transportation emissions, encouraging seasonal consumption, and fostering sustainable farming practices, local agriculture plays a crucial role in reducing the CO_2 footprint of food. This approach strengthens the resilience of regional food networks while addressing broader concerns related to climate change, food security, and resource efficiency. Concerning the environmental impacts of food and agriculture, Food systems are responsible for 34% of global greenhouse gas emission (Ritchie et al., 2020). Land use results with 32% of food emission, agricultural production with 39%. The supply chain emissions 18% (included is the Food processing (3.5%); Transport (4.8%); Packaging (5.5%); Retail (4%); Consumer food preparation (2.5%) and finally: food waste (End-of-life: 8.6%), (Ritchie, 2020).

A major advancement in modern agriculture is the integration of digital technologies, which enhances efficiency, optimizes resource use, and improves yield predictions. Through smart farming, precision agriculture, and data-driven decision-making, farmers can reduce their environmental impact while ensuring stable food production. These technologies strengthen the connection between producers and consumers, fostering a more sustainable and resilient food system that adapts to environmental changes and fluctuating market demands (Craig, 2021; Dune et al., 2011). Figure 1 shows how different the CO_2 footprint of protein-rich food can be, which shows the average footprint with a dot, while the range depends on whether a certain type of food is consumed locally or whether transportation creates additional emissions (Crippa et al., 2021).

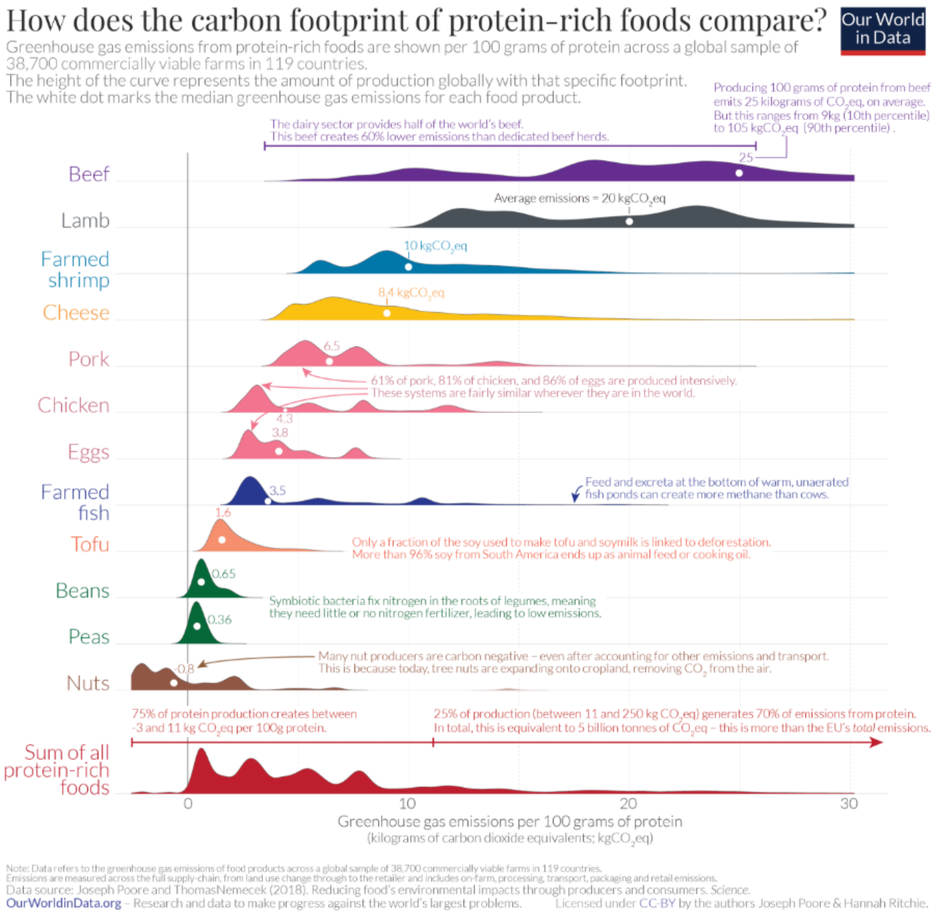

Figure 1. Carbon footprint of protein rich food (Ritchie, 2020)

To assess the true impact of agricultural practices on environmental sustainability, we conducted a comparative analysis of organic and conventional farming methods, using available databases to calculate the CO_2 and ecological (eco) footprint of staple food production, including fruits and vegetables. Our findings reveal a critical insight: while organic farming is often viewed as environmentally superior, non-locally produced organic food can have a higher footprint than non-seasonal, conventionally farmed products. This counterintuitive discovery highlights the importance of supporting local, seasonal food systems rather than relying solely on organic labelling (Poore and Nemecek, 2018 & 2019).

Beyond production methods, food choices also play a vital role in determining environmental impact (Notarnicola et al., 2017). By analysing the footprints of staple foods, we assessed the overall impact of different dietary patterns, comparing vegetarian and omnivorous menus. The results underscore that locally sourced, seasonal food consistently results in the lowest ecological footprint, reinforcing the need to support small-scale producers and promote sustainable consumption habits.

Addressing these challenges requires a multi-faceted approach, including policy support for local food networks, investment in digital agriculture, and consumer education. Encouraging a shift toward localized and sustainable food production is not only beneficial for the environment and food security but is also crucial for meeting global climate goals. By prioritizing regional food systems, reducing reliance on long supply chains, and adopting data-driven agricultural innovations, we can create a more sustainable, equitable, and resilient future for global food production.

According to Figure 1, a diet that includes animal protein is expected to have a significantly higher CO_2 footprint. Therefore, the aim of this paper was to compare menus that are locally and seasonally sourced and include meat with those that are purely vegetarian without local and seasonal sources.

2. MATERIALS AND METHODS

Used were calculators for footprint calculations. For the comparison of organic vs. regular food production we used the http://www.foodemissions.com/foodemissions/Calculator.

In the calculation of omnivore and vegetarian 3-day menus were used the total emission values from the previous source. But for the "distance" of local production, we used the definitions of the American Food, Conservation, and Energy Act of 2008 states that: "(I) the locality or region in which the final product is marketed, so that the total distance that the product is transported is less than 400 miles from the origin of the product; or (II) the State in which the product is produced". A typical vegetarian and omnivorous menu for one day is given in Table 1. All 3-day menus were planned for an adult with and daily recommended energy intake of 2000 kcal.

Table 1. Example of a 2000 kcal daily menu for vegetarian diet and for omnivorous diet

***Vegetarian daily menu** (2000 kcal)*	***Omnivore daily menu** (2000 kcal)*
Breakfast (500 kcal) • 2 slices of whole-grain toast with 2 tbsp peanut butter • 1 medium banana • 1 cup unsweetened almond milk	**Breakfast** (500 kcal) • 2 scrambled eggs with spinach and cheese • 1 slice whole-grain toast • 1 small orange • 1 cup black coffee or tea
Lunch (600 kcal) • Quinoa salad with chickpeas, cherry tomatoes, cucumber, feta cheese, and olive oil dressing • 1 small apple • 1 tbsp walnuts	**Lunch** (600 kcal) • Grilled chicken and avocado sandwich on whole-grain bread • Side salad with mixed greens, olive oil, and balsamic vinegar • 1 tbsp sunflower seeds
Dinner (700 kcal) • Lentil and vegetable curry with 1 cup brown rice • Side of steamed broccoli and carrots with tahini dressing • 1 square (10g) dark chocolate	**Dinner** (700 kcal) • Grilled salmon (150 g) with lemon and herbs • 1 cup roasted sweet potatoes • 1 cup sautéed green beans • 1 tbsp olive oil for cooking
Snack (200 kcal) • Greek yogurt with 1 tbsp honey and 10 almonds	**Snack** (200 kcal) • Cottage cheese with strawberries and 1 tsp chia seeds

USDA tables were used to calculate energy values, while data from OurWorldData (Ritchie, 2020) were used in the calculations of the footprints. Student's t-test was used to compare groups of footprints. Standard tools in MS Excel were used in the data presentation and calculations.

3. RESULTS AND DISCUSION

The primary source of greenhouse gas emissions in food production is agricultural practices (e.g., fertilizer use, irrigation, and energy-intensive processes). For example, tomatoes grown locally in heated greenhouses may have higher emissions than tomatoes imported from warmer regions. Land use and biodiversity: Large-scale agriculture often leads to deforestation and biodiversity loss, while local food systems promote diverse agriculture, which benefits soil health and ecosystems. However, inefficient land use in small-scale agriculture can sometimes offset these benefits. In order to determine the differences in the carbon footprint of organic and conventionally grown food production (Figure 1), the Food Emission Calculator was used. In order to be consistent with the local distance, the higher production emission (0.15 vs. 0.11) of organically grown tomatoes is evident. And in order to compare non-seasonal cultivation, lettuce was taken as an example. However, unlike organically grown tomatoes, which had a slightly higher production emission, lettuce grown in a greenhouse has a production emission almost 75 times higher (4.46 vs. 0.06). One of the most significant environmental concerns regarding protein production is carbon emissions. Animal agriculture contributes heavily to global greenhouse gas (GHG) emissions, particularly methane, a potent greenhouse gas released by ruminant digestion. Additionally, raising livestock requires vast amounts of feed, further increasing emissions through fertilizer use and land conversion.

Protein is a fundamental component of the human diet, necessary for growth, repair, and overall health. However, the source of protein significantly impacts environmental sustainability. Animal-based proteins, such as beef, lamb, and dairy, tend to have higher carbon emissions, land use, and water consumption compared to plant-based alternatives, such as lentils, tofu, and peas (FAO, 2011). Analysing the environmental footprints of different protein sources highlights the urgent need for sustainable dietary choices to mitigate climate change and resource depletion (Sanchez-Sabate and Sabaté, 2019). Beef production is particularly carbon-intensive, generating approximately 50-60 kg of CO_2-equivalent (CO_2e) per kg of protein. Lamb follows closely, with emissions of 20-25 kg CO_2e per kg of protein. Other animal-based proteins such as cheese (13-15 kg CO_2e), pork (7-12 kg CO_2e), and chicken (5-6 kg CO_2e) also contribute significantly to emissions. In contrast, plant-based proteins have considerably lower carbon footprints. Lentils and peas, for instance, produce only 0.9-1.0 kg CO_2e per kg of protein, while tofu generates 2-3 kg CO_2e per kg of protein. The stark difference suggests that replacing animal proteins with plant-based alternatives could drastically reduce global emissions.

The mentioned raises the concerns of the omnivore diets vs vegetarian diets considered as more environmentally friendly solution in a sustainable food system. But what if the local and seasonal supply is concerned? Therefore, to give an answer to this question we proposed 3-day menus for vegetarians and omnivores, however, in one case, local and seasonal foods were used, and in the second case, the same offers were calculated with foods out of season and imported. Accordingly, the results per meal are shown in Table 2. Based on the publications investigating carbon footprints of protein rich foods (Gaillac and Marbach, 2021), diets which include animal proteins are expected to have a significantly higher CO_2 footprint. Therefore, the aim of this paper was to compare menus that are locally and seasonally sourced and include meat with those that are purely vegetarian without local and seasonal sources.

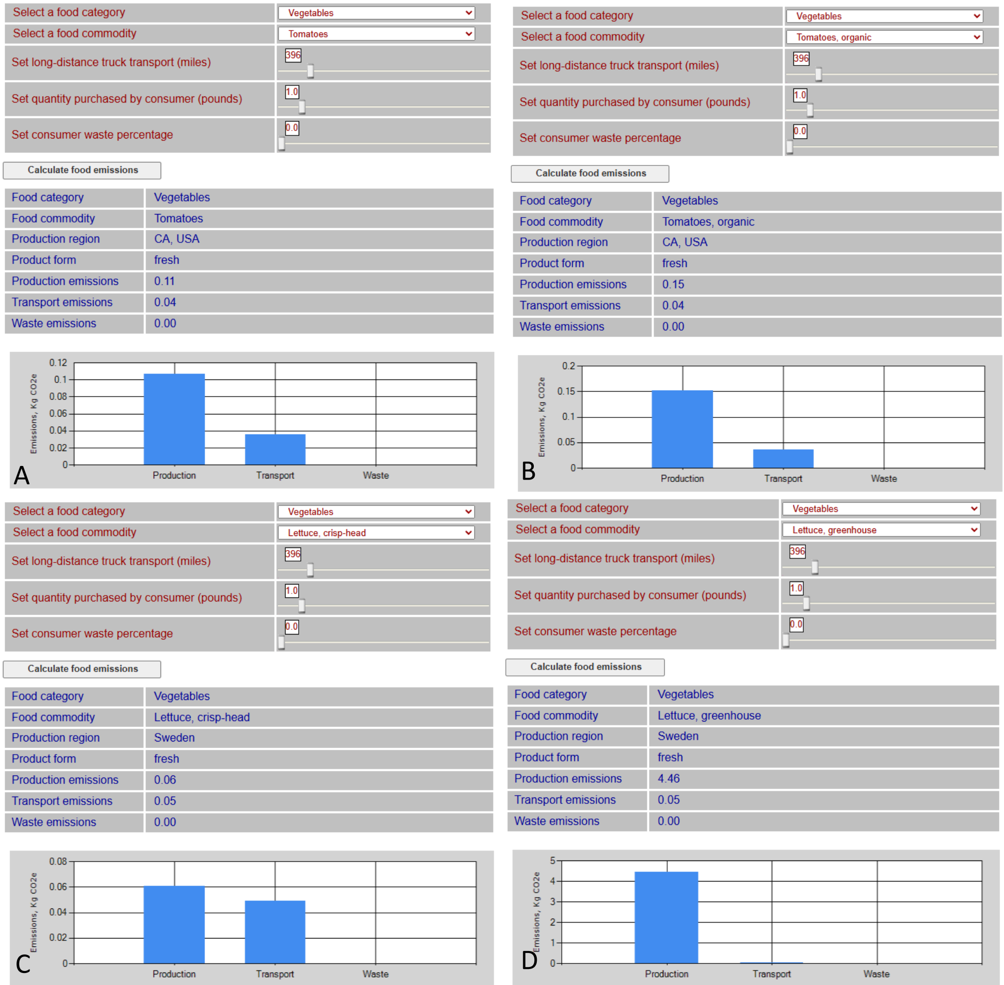

Figure 2. Comparison of the emission of organic vs standard production of tomatoes (A & B) and greenhouse vs standard production of lettuce (C &D), total distance of producing less than 400 miles

In order to determine the differences in the carbon footprint of organic and conventionally grown food production (Figure 2), the Food Emission Calculator was used. In order to be consistent with the local (Martinez et al., 2010) distance, the higher production emission (0.15 vs. 0.11) of organically grown tomatoes is evident. And in order to compare non-seasonal cultivation, lettuce was taken as an example. However, unlike organically grown tomatoes, which had a slightly higher production emission, lettuce grown in a greenhouse has a production emission almost 75 times higher (4.46 vs. 0.06). The above points to the question of how much a vegetarian menu is a more environmentally friendly solution in a sustainable food system, if it is not based on local and seasonal supply. This is why we proposed 3-day menus for vegetarians and omnivores, however, in one case, local and seasonal foods were used, and in the second case, the same offers were calculated with foods out of season and imported. Accordingly, the results per meal are shown in Table 2.

Table 2. Carbon footprint (kg CO_2e) and eco-footprint (m^2) for 3-day vegetarian (VM) and omnivore menus (OM) with local (L) and seasonal (S) food ingredients or with imported (Imp) and non-seasonal (Non-S) food ingredients

Meals	***Carbon footprint (kg CO_2e)***				***eco-footprint (m^2)***			
	VM, L & S	**VM**, Imp & Non-S	**OM**, L & S	**OM**, Imp & Non-S	**VM**, L & S	**VM**, Imp & Non-S	**OM**, L & S	**OM**, Imp & Non-S
Day 1								
Breakfast	0.36	0.91	0.75	1.22	0.71	1.81	1.5	2.44
Lunch	0.43	1.01	1.05	1.69	0.86	2.02	2.1	3.38
Dinner	0.59	1.12	0.9	1.99	1.17	2.24	1.8	3.98
Snack	0.27	0.63	0.27	0.63	0.53	1.26	0.53	1.26
Day 2								
Breakfast	0.36	0.91	0.75	1.22	0.71	1.81	1.5	2.44
Lunch	0.44	1.02	0.75	1.29	0.88	2.04	1.5	2.58
Dinner	0.41	0.87	0.92	2.09	0.81	1.74	1.84	4.18
Snack	0.25	0.6	0.25	0.6	0.5	1.2	0.5	1.2
Day 3								
Breakfast	0.3	0.72	0.3	0.72	0.6	1.44	0.6	1.44
Lunch	0.26	0.77	0.77	1.39	0.52	1.54	1.54	2.78
Dinner	0.59	1.12	0.65	1.49	1.17	2.24	1.3	2.98
Snack	0.08	0.31	0.08	0.31	0.16	0.62	0.16	0.62

Protein consumption is a critical factor in environmental sustainability, with animal-based sources imposing significantly higher ecological costs than plant-based alternatives. Beef, lamb, and dairy have disproportionately large carbon, land, and water footprints compared to legumes, tofu, and nuts. Shifting dietary patterns towards plant-based proteins can substantially reduce global greenhouse gas emissions, conserve natural resources, and contribute to a more sustainable food system (Clark et al., 2020). Through conscious consumer choices and advancements in sustainable agriculture, a balanced approach to protein consumption can help mitigate environmental degradation while ensuring global food security. Beyond carbon emissions, protein sources vary significantly in their land and water usage (Bar-On et al., 2018). Water consumption further amplifies the environmental impact of animal-based protein. Producing 1 kg of beef requires approximately 15,000 litres of water, primarily for irrigation of feed crops. Cheese production follows at 5,000 litres per kg, while chicken requires 4,300 litres per kg. Meanwhile, plant-based proteins require significantly less water; lentils need about 1,250 litres per kg, and tofu requires around 2,000 litres per kg. A dietary shift towards plant-based proteins could significantly alleviate water shortages and reduce pressure on agricultural land (Rosi et al., 2017). However, the impact of "seasonal" and "local" is significant. When different diets (vegan vs. omnivore) are compared, the average daily carbon footprint (kg CO_2e) and the eco footprint will be significantly in favour of vegetarian diet ($p < 0.05$). However, when the omnivorous diet uses locally grown and seasonal foods, the difference in CO_2 emissions is no longer statistically significant ($p=0.08$). The comparison of footprints for different menus is shown in Figure 3. The CO_2 footprint of the omnivorous average compared to the vegetarian menu, which included non-seasonal and imported foods, is framed. Local & Seasonal omnivore diet had average 2.5 kg CO_2e while the vegetarian diet with imported and non-seasonal foods ranged from 2.9-3.7 kg CO_2e (average of 3.3 kg CO_2e).

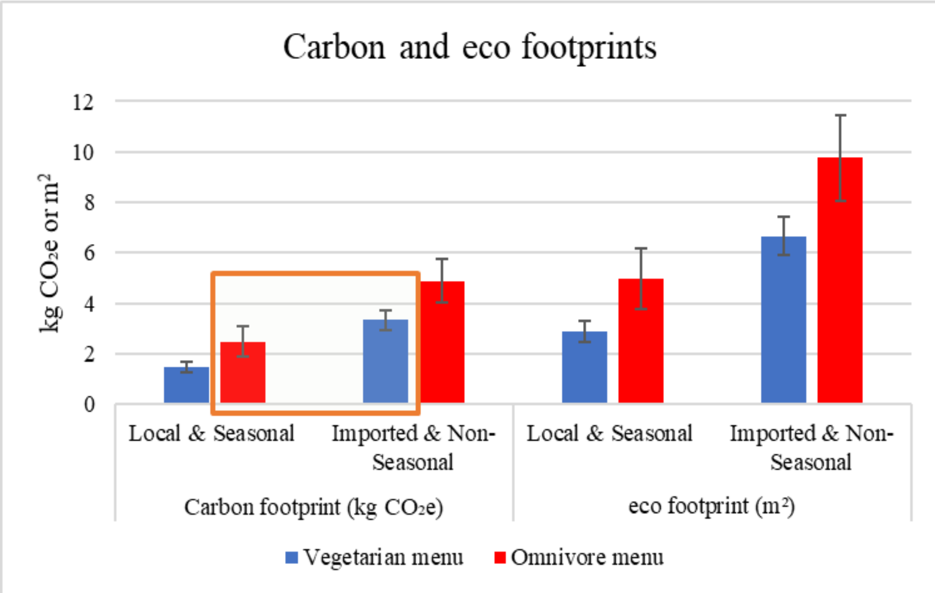

Figure 1. Compared footprints (carbon and eco) for vegetarian and omnivore 3-day menus with and without local and seasonal food ingredients

Local food consumption is often perceived as a sustainable choice that benefits the environment, economy, and society, exploring the impact of local food systems on agriculture, assessing their benefits and limitations (Martinez et al. 2010; Edwards-Jones 2010). Our findings confirm comprehensive analysis of local food systems having an environmental and economic benefit, but having challenges as higher production costs, limited infrastructure, and seasonal availability make it difficult for local food systems to compete with large-scale agricultural supply chains. Consumers also face higher prices compared to conventionally distributed foods (Martinez et al. 2010). Edwards-Jones (2010) investigated if eating local food reduce the environmental impact of food production and enhance consumer health highlighting that while local food systems offer certain advantages, their overall impact depends on multiple factors, including farming practices, transportation logistics, and consumer behaviour.

4. CONCLUSION

The carbon footprint analysis shows that reducing food miles reduces emissions and confirms that one of the solutions is to eat locally grown, which also supports the agro-food sector.
Nutrition and health aspects: Locally grown produce is fresher and can retain higher levels of nutrients, which is beneficial to consumer health. However, the assumption that local food is always healthier depends on production methods (e.g. organic versus conventional farming).
Many consumers believe that local food is inherently sustainable, but its environmental impact varies depending on factors such as season, transportation and production efficiency, as well as dietary patterns, i.e. type of diet.

This paper is a small contribution to the argument for supporting local agriculture because, in addition to supporting the regional economy, it reduces transport emissions and improves biodiversity. In order to maximize environmental benefits, a combination of sustainable agricultural practices, seasonal diets and conscious consumer choices is necessary.

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A ROMANIAN PERSPECTIVE ON THE NEXUS LABOR, ENERGY AND AGRICULTURAL PERFORMANCE IN SOME EUROPEAN UNION COUNTRIES

РОМАНСКА ПЕРСПЕКТИВА НА ПОВРЗАНОСТА НА ТРУДОТ, ЕНЕРГИЈАТА И ЗЕМЈОДЕЛСКИТЕ ИЗВЕДБИ ВО НЕКОИ ЗЕМЈИ – ЧЛЕНКИ НА ЕВРОПСКАТА УНИЈА

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Abstract: *This paper explores the pivotal role of gastronomy in fostering sustainable tourism and driving rural development through the promotion of* ***local products****. By examining the intersection of culinary traditions, sustainable practices, and tourism, the study highlights how local food systems can serve as powerful tools for economic growth, cultural preservation, and environmental sustainability in rural areas. Sustainable tourism, when integrated with local gastronomic products, not only enhances the visitor experience but also provides opportunities for local communities to thrive through the promotion of indigenous food traditions, sustainable agricultural practices, and responsible tourism. The paper discusses the ways in which rural areas can leverage their unique culinary offerings as both cultural assets and economic drivers, emphasizing the importance of innovation in marketing and product development. Through case studies and survey conducted among 209 guests of a restaurant that serves local food, this paper demonstrates how the synergy between gastronomy, local products, and sustainable tourism contributes to the resilience and long-term prosperity of rural regions. Ultimately, it argues that harnessing the potential of gastronomy within the sustainable tourism framework is key to achieving inclusive rural development that benefits both the local communities and the global traveler.*

Key words: *sustainable tourism, local products, tradition, innovation, rural developmet*

Апстракт: *Овај рад истражује кључну улогу гастрономије у неговању одрживог туризма и покретању руралног развоја кроз промоцију локалних производа. Испитујући пресек кулинарских*

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традиција, одрживих пракси и туризма, студија наглашава како локални системи исхране могу послужити као моћно оруђе за економски раст, очување културе и одрживост животне средине у руралним областима. Одрживи туризам, када се интегрише са локалним гастрономским производима, не само да побољшава искуство посетилаца, већ и пружа могућности локалним заједницама да напредују кроз промоцију аутохтоних прехрамбених традиција, одрживих пољопривредних пракси и одговорног туризма. У раду се разматрају начини на које рурална подручја могу искористити своју јединствену кулинарску понуду као културна добра и економске покретаче, наглашавајући важност иновација у маркетингу и развоју производа. Кроз студије случаја и анкету спроведену међу 209 гостију ресторана који послужује локалну храну, овај рад показује како синергија између гастрономије, локалних производа и одрживог туризма доприноси отпорности и дугорочном просперитету руралних региона. На крају, он тврди да је искориштавање потенцијала гастрономије у оквиру одрживог туризма кључно за постизање инклузивног руралног развоја који користи и локалним заједницама и глобалним путницима.

Кључне речи: *одрживи туризам, локални производи, традиција, иновација, рурални развој*

1. INTRODUCTION

Agriculture has long been an integral part of Romanian economy, providing employment opportunities, supporting rural livelihoods, and contributing to national food security and has historically been a cornerstone of the national economy.

Romania holds one of the largest agricultural land areas within the EU as (Andrei et al., 2022; Davidova, 2003) argues but the agricultural productivity is below the EU average. As (Stoica, & Dumitru, 2024) highlights the gap is attributed to several factors, including fragmented land ownership, outdated infrastructure, limited access to modern technologies, and supply chain inefficiencies. Increase in global food demand intensifies the necessity for the adoption of energy-efficient, labor-optimized, and environmentally friendly agricultural practices. Romania's agricultural landscape, characterized by a mix of small-scale subsistence farms and large-scale commercial agribusinesses, presents distinct challenges and opportunities in managing this transition. (Stoica, & Dumitru, 2024).

The linkages between labour, energy and agricultural productivity are complex and multidimensional, with significant implications for sustainable development. The efficient utilisation of labour and energy resources in agricultural activities has a direct impact on productivity levels, economic growth and environmental sustainability. In understanding this nexus, it has become an important area of research, given the increasing global demand for food production and the urgent need to transition to more sustainable energy sources. Fluck (1992) underscores the centrality of energy to farm production, emphasizing how energy inputs drive various agricultural operations. Woods et al. (2010) extend this discussion by illustrating how the food system as a whole is interwoven with energy considerations, highlighting the interdependent nature of agricultural production and energy utilization. Building on these themes, Beckman et al. (2013) examine the supply and demand patterns of energy in agriculture, focusing particularly on how farmers navigate shifting market conditions and evolving policy frameworks. Jebli et al. (2015) investigate how renewable energy sources and agricultural activities influence carbon emissions across different regions, including North Africa and selected ASEAN nations. Carraresi et al. (2015) conducted a comparative analysis of agricultural performance across EU countries in the intra-EU market from 1995 to 2011 and juxtaposed the competitiveness of the agricultural sector with that of the food industry, highlighting the impact of EU enlargement and the financial crisis on national competitiveness. Similarly, Svatoš et al. (2014) examined the development of capital stock value in the agricultural sectors of newly admitted EU member states and focused on key factors such as livestock production, land utilization, and the active agricultural workforce. In another study, Burja et al. (2016) investigated the relationship between farm size and the efficiency of production inputs within Romania’s agricultural sector and suggested that restructuring farm holdings could lead to more effective resource allocation and improved agricultural productivity. Expanding on this theme, Herman (2016) emphasized the importance of enhancing agricultural performance to combat in-work poverty in EU countries. Jaroszewska et al. (2017) conducted a comprehensive study on the convergence of labor productivity in the agricultural sector across the European Union (EU), based on the leveraged data from the Economic Accounts for Agriculture (EAA) and the Agricultural Labour Input (ALI) and examined productivity trends among two distinct groups of countries—those that had been part of the EU-15 prior to 2004 and the newer member states that joined after that year. Turning to the BRICS economies, Liu et al. (2017) explore the nexus between renewable energy, agriculture, and the environment. Their research demonstrates that integrating renewable energy sources into agricultural systems can promote sustainable development by reducing environmental degradation and supporting economic growth. Waheed et al. (2018) and Khan et al. (2018) similarly delve into the relationships among forests, agriculture, renewable energy, and carbon emissions, with a particular focus on Pakistan’s experiences and policy implications.

A different perspective on agricultural sustainability was offered by Rybaczewska-Błażejowska et al. (2018), who assessed the eco-efficiency of agricultural production across the EU-28, by integrating life cycle assessment with data envelopment analysis. Bartová et al. (2018) explored the concept of eco-efficiency in agriculture among EU member states, employing a dataset that encompassed key indicators such as agricultural output, labor input, cultivated land area, fertilizer usage, and greenhouse gas emissions. Expanding on the theme of regional disparities, Pawlewicz et al. (2018) investigated differences in agricultural production potential across EU member states highlighting significant differences in resource efficiency across regions, shedding light on the structural inequalities that shape agricultural performance within the EU. In a country-specific analysis, Bozsik et al. (2018) evaluated the efficiency of agricultural production in Hungary, focusing on the effectiveness of key production factors such as labor and land. Additionally, Gołaś (2019) extended this research to examine labor productivity growth patterns in EU agriculture, reinforcing his findings on sigma and beta convergence. Meanwhile, Ionescu et al. (2020) developed a theoretical framework based on catastrophe theory to assess agricultural competitiveness both at national and regional levels. Pishgar-Komleh et al. (2021) applied a Window Slack-Based Measurement Data Envelopment Analysis model to examine the dynamic eco-efficiency of the agricultural sector in EU-27 countries. Furthermore, Usman et al. (2021) analyze the factors shaping the ecological footprint in the BRICS-T region, emphasizing the roles of renewable and non-renewable energy, agricultural activities, forest area, and financial development. A more macroeconomic approach was taken by Rađenović et al. (2022), who classified EU countries based on their economic performance in agriculture and using a newly developed set of indicators, their research identified clusters of countries exhibiting similar economic progress, providing a clearer understanding of the disparities within EU agricultural development. Lastly, Zafeiriou et al. (2022) explored the intricate relationship between environmental and economic performance in EU agriculture, with a particular emphasis on carbon emissions and their effects on agricultural income.

This article explores the interplay between labor, energy, and agricultural performance in Romania, contextualizing its position within the EU framework and discussing potential pathways for future development.

2. DATA AND METHODOLOGY

This study employs a statistical analysis approach to examine Romania's perspective on the interconnected dynamics of labor, energy consumption, and agricultural performance across selected European Union countries. A key focus is the evolution of final energy consumption per hectare in agriculture over the period 2018–2023. To identify patterns and relationships between different national contexts, a correlation matrix is applied, highlighting both convergences and divergences in energy utilization trends. The findings are interpreted within the broader framework of agricultural policies, energy efficiency initiatives, and labor market dynamics. Additionally, the study considers the influence of external economic factors, particularly the energy crisis of 2021–2023, on these variables. The dataset utilized includes Gross Value Added (GVA) at basic prices (measured in million euros) for the EU-27 and selected individual countries from 2018 to 2024. This data set enables an in-depth exploration of both macroeconomic developments at the European level and more granular, country-specific trends. By distinguishing between the pre-pandemic period (2018–2019), the pandemic years (2020–2021), and the post-pandemic recovery phase (2022–2024), the study assesses the resilience of the agricultural sector in response to economic disruptions and policy shifts. The employment statistics is extracted also from Eurostat database, which provides annual data on agricultural employment (expressed in thousands) for 18 EU countries and the EU-27 aggregate from 2020 onward.

3. RESULTS AND DISCUSSIONS

In the broader European Union (EU) context, Romanian agricultural sector is undergoing a significant transformative shift, influenced by technological innovationists, sustainability goals, and economic convergence and over time, agriculture has contributed significantly to Romania's GDP and also shaped the social and cultural fabric of rural communities as it is remarked in (Andrei et al., 2020). Within the broader European Union (EU) framework, Romania's agricultural sector is experiencing a significant transformative shift, driven by three interrelated forces: technological innovation, sustainability imperatives, and economic integration (Andrei et al., 2020). These factors are transforming the framework of agricultural practice, highlighting the importance of efficiency, environmental responsibility, and economic competitiveness. Understanding the complex relationships among these dimensions has implications for improving agricultural productivity, promoting economic growth, and securing long-term ecological sustainability.

Table 1: Evolution of the Gross value added at basic prices (Million euro) in some EU countries, 2018-2024

Country	2018	2019	2020	2021	2022	2023	2024
EU - 27	176,153.90	182,870.35	180,127.52	190,654.99	222,883.10	223,749.13	233,646.74
Bulgaria	1,732.50	1,767.81	1,748.41	2,663.26	3,023.42	2,156.13	1,942.39
Czechia	1,700.29	1,752.15	1,935.11	2,317.00	2,608.17	2,319.77	2,367.78
Denmark	2,501.26	3,007.35	3,622.12	3,014.54	3,425.10	3,154.29	3,039.42
Germany	18,709.31	23,847.31	21,576.65	22,468.53	31,812.25	30,567.89	31,944.05
Estonia	205.91	281.81	256.73	271.68	488.45	246.86	244.41
Ireland	2,632.24	2,901.12	3,347.83	4,018.98	5,041.87	3,545.88	4,315.70
Greece	5,613.96	5,998.40	5,812.64	5,739.19	6,712.02	6,368.87	7,560.93
Spain	28,742.91	27,944.46	27,841.39	30,287.02	29,380.95	34,020.13	39,516.84
France	33,576.12	31,660.38	31,039.84	31,818.10	40,160.32	37,878.89	35,133.51
Italy	34,014.69	33,384.59	32,556.66	33,757.36	37,540.26	38,915.68	42,411.59
Latvia	346.49	573.41	590.11	613.67	825.86	454.32	651.17
Lithuania	990.06	1,232.12	1,499.79	1,543.99	2,031.07	1,270.57	1,423.34
Hungary	3,449.77	3,532.92	3,420.35	3,814.51	3,450.69	4,132.10	3,589.32
Poland	8,820.34	9,642.86	10,305.62	9,916.09	14,253.27	13,916.27	13,406.18
Portugal	2,974.93	3,295.88	3,289.98	3,660.73	3,385.66	4,339.24	4,383.01
Romania	8,328.45	8,790.05	8,273.04	10,123.67	9,929.62	10,018.76	9,379.11
Slovenia	619.62	560.44	583.94	425.31	523.19	585.34	692.17
Slovakia	541.09	521.05	641.83	702.57	888.74	755.96	737.65

Source: authors based on Eurostat (2025). [code: aact_eaa01__custom_15670113]

As it is shown in Table 1 the overall GVA for the EU-27 increased significantly from €176,153.90 million in 2018 to €233,646.74 million in 2024, demonstrating an upward trajectory despite the disruptions caused by the COVID-19 pandemic. A sharp drop occurred in 2020 (€180,127.52 million), but by 2021, recovery had commenced, culminating in substantial growth in 2022 (€222,883.10 million). This suggests that while the EU economy was affected by the pandemic, recovery policies, digital transformation, and government interventions played a significant role in stabilizing economic performance. While the EU as a whole shows a strong recovery, individual member states exhibit varying degrees of resilience and economic adaptation. As the largest EU economy, Germany experienced a significant dip in 2020 (€21,576.65 million) but rebounded strongly, reaching €31,944.05 million in 2024. Germany's industrial and technological sectors played a key role in economic stabilization. France and Italy are the two major economies followed different recovery paths. France peaked at €40,160.32 million in 2022, followed by a slight decline, while Italy showed consistent growth, reaching €42,411.59 million in 2024. This indicates Italy's post-pandemic economic restructuring was more sustainable. After stagnation between 2018 and 2020, Spain's GVA had growth from €27,841.39 million (2020) to €39,516.84 million (2024). Eastern European Economies like Poland, Romania, and Hungary showed varied trends. Poland had a sharp rise from €8,820.34 million in 2018 to €14,253.27 million in 2022, though a decline in 2024 (€13,406.18 million) suggests economic challenges such as inflation or structural rigidities. Romania followed a similar pattern but exhibited a slight contraction after 2022.Baltic and Nordic Countries, Estonia, Latvia, and Lithuania experienced volatility in their GVA trends.

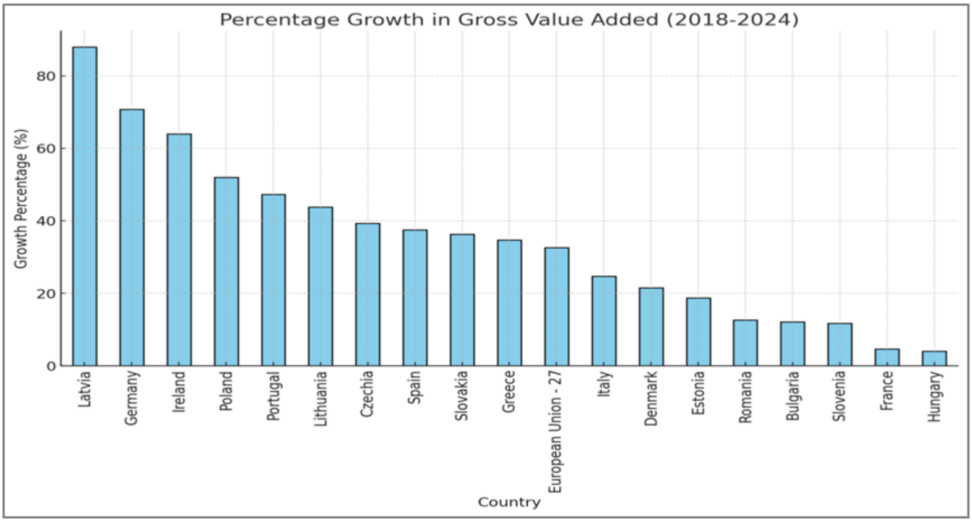

Figure 1. Gross valued added in agriculture in some EU-27 countries
Source: authors computations based on Table 1.

The pandemic's impact in 2020 led to widespread economic contractions, but the degree of resilience varied. Countries with diversified economies, strong digital infrastructure, and proactive fiscal policies (e.g., Germany, Ireland, and Denmark) rebounded more quickly than those with more traditional economic structures (e.g., Bulgaria, Greece). Post-pandemic recovery was particularly notable in 2022 when most EU countries witnessed a sharp increase in GVA. However, 2023 and 2024 exhibit mixed trends—some economies continued expanding, while others (e.g., France and Romania) faced mild contractions, indicating external economic pressures such as energy price volatility, inflation, and geopolitical uncertainties. The correlation matrix highlights a robust economic interconnection among the core economies of the European Union, underscoring the necessity of coordinated EU economic policies.

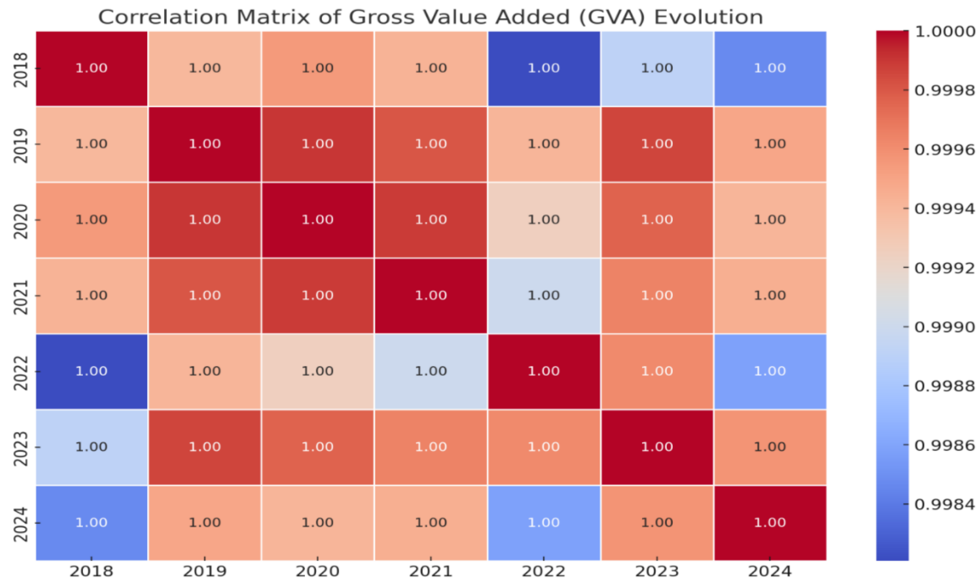

Figure 2. The correlation matrix on gross value added in agriculture, 2018-204
Source: author's computations

As it could be remarked in Figure 2, Germany, France, Italy, and Spain demonstrate high correlations in their economic performance, with values exceeding 0.8 in most cases. This indicates significant interdependence, likely driven by strong trade relations, comparable economic structures, and common macroeconomic policies within the EU framework. The particularly high correlation between Germany and France suggests that their economic cycles move in close alignment, especially in their responses to crises such as the COVID-19 pandemic. Italy follows a similar trend but exhibits slight deviations, possibly due to structural differences in its industrial and service sectors.

As for the emerging Economies Poland and Romania display a strong correlation with each other, reflecting parallel economic growth trajectories. Their correlations with major Western European economies, such as Germany and France, remain moderate. Denmark shows moderate correlations with major EU economies, suggesting a degree of economic independence. Ireland, despite its role as a major financial and technology hub, exhibits only moderate economic correlation with other EU economies. While pre-pandemic trends showed strong economic synchronization across the EU, the recovery trajectories post-pandemic have varied significantly, leading to weaker correlations in some cases. For example, Spain and Poland, or Ireland and Eastern European economies, exhibit lower economic alignment. Countries that implemented substantial fiscal stimulus measures—such as Germany, France, and Italy—tended to recover in a more synchronized manner, whereas those with more limited government support, such as Bulgaria and Estonia, experienced greater economic volatility. The strong economic correlations among Germany, France, Italy, and Spain indicate that economic shocks in any of these major economies could have far-reaching consequences across the EU. At the same time, Eastern European nations like Poland and Romania are becoming increasingly integrated into the broader EU economy but still retain some independent growth characteristics. On the other hand, countries with unique economic structures—such as Ireland, Denmark, and Estonia—exhibit lower synchronization with the larger EU economies.

Energy consumption in agriculture has a determinative role in the productivity and sustainability of the sector. The subsequent table (2) undertakes an analysis of the trends in final energy consumption per hectare in agriculture and forestry across a selection of EU countries from 2018 to 2023.

Table 2. Final energy consumption by agriculture/forestry per hectare of utilised agricultural area in some EU countries.

TIME	2018	2019	2020	2021	2022	2023
EU- 27 (from 2020)	171.22	172.38	175.60	178.37	166.51	164.33
Bulgaria	36.83	37.21	37.27	38.40	38.49	38.65
Czechia	176.08	180.29	181.01	181.89	173.68	170.29
Denmark	226.23	221.41	216.78	215.62	213.06	209.74
Germany	198.39	214.41	216.37	222.47	222.91	220.34
Estonia	126.12	114.12	110.98	89.30	98.18	82.74
Ireland	49.48	50.61	51.28	53.40	73.05	64.81
Spain	101.51	106.84	111.12	113.89	106.84	95.31
France	143.90	141.87	152.26	150.08	143.88	143.99
Italy	216.77	206.79	210.25	229.93	225.27	213.32
Latvia	93.24	102.90	104.13	97.26	98.06	95.85
Lithuania	36.53	37.21	38.64	41.45	43.41	39.76
Hungary	121.11	126.72	140.75	131.90	117.44	111.25
Poland	269.54	262.08	262.14	264.06	232.61	244.60
Portugal	102.36	95.79	103.62	109.05	100.57	107.02
Romania	42.18	40.30	40.67	43.32	43.76	42.42
Slovenia	155.92	152.65	148.61	153.43	154.25	153.61
Slovakia	69.12	67.53	69.00	70.98	67.04	65.40

Source: authors based on Eurostat (2025a). [code:tai04__custom_15675550]

As it could be noticed form the data in Table 2 during 2018 to 2023, the EU-27 average for final energy consumption in agriculture fluctuated, with an initial upward trend from 171.22 GJ/ha in 2018 to 178.37 GJ/ha in 2021, followed by a sharp decline to 164.33 GJ/ha in 2023. Notably, countries such as Poland, Denmark, Germany, and Sweden have among the highest levels of energy consumption per hectare, whereas Bulgaria, Lithuania, and Romania remain at the lower end of the spectrum. Unlike many other EU countries, Romania’s agricultural energy consumption has remained relatively low and stable, ranging between 40-44 GJ/ha. Romania has a high percentage of small farms that still rely on traditional or less energy-intensive agricultural methods and Unlike Western European countries, where intensive farming practices require significant energy, Romanian agriculture still relies on mixed or extensive farming models. Countries such as Denmark (209.74 GJ/ha in 2023), Italy (213.32 GJ/ha), and Germany (220.34 GJ/ha) exhibit much higher energy consumption, often driven by intensive farming practices and reliance on high-tech agricultural machinery. Romania’s energy consumption aligns more closely with Bulgaria (38.65 GJ/ha) and Lithuania (39.76 GJ/ha), countries that share similar agricultural structures characterized by smaller farms and lower levels of mechanization. Some countries, such as Estonia, experienced a drastic reduction in energy consumption (from 126.12 GJ/ha in 2018 to 82.74 GJ/ha in 2023), likely due to shifts towards sustainable agriculture, energy efficiency improvements, or structural changes in farming practices. Romania’s final energy consumption in agriculture has remained relatively low and stable over the past six years compared to the EU average.

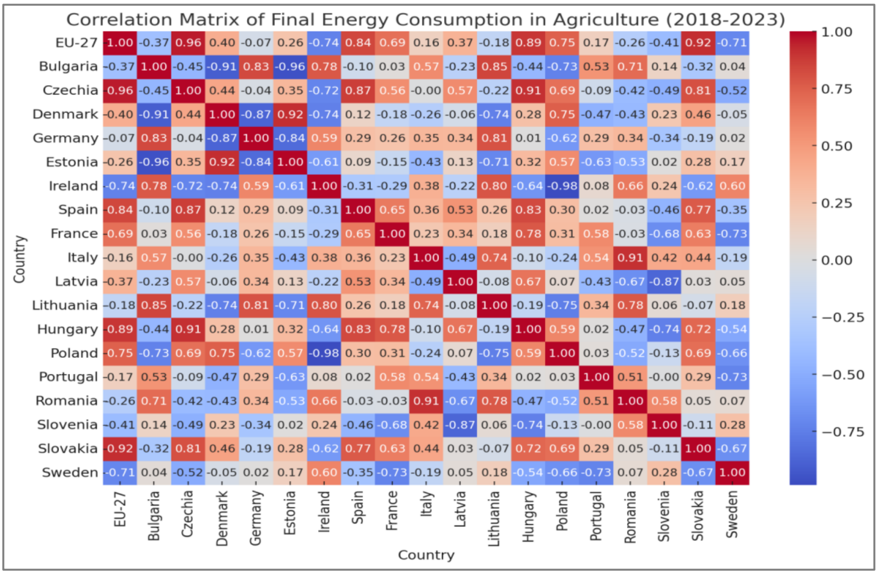

Figure 3. Correlation matrix of energy consumption in some EU agriculture, 2018-2024
Source: author's computations.

Romania presents a unique profile in the correlation matrix, showing a mix of positive and negative correlations with other EU countries. Romania and Italy (r=0.91r = 0.91r=0.91) present strong correlation suggests that Romania and Italy follow similar energy consumption trends because both countries have large agricultural sectors with mixed levels of mechanization and have policy alignment, possibly influenced by EU funding mechanisms, may have driven similar trends. Romania and Lithuania (r=0.77r = 0.77r=0.77) present similarities in agricultural energy consumption indicate that both countries may share structural characteristics, such as farm size distribution or energy policy dependence.

Negative Correlations or divergent trends are registered between Romania and Hungary (r=−0.47r = -0.47r=−0.47) which suggests that while Hungary increased or optimized energy use, Romania maintained a more stable trajectory and between Romania and Denmark (r=−0.42r = -0.42r=−0.42). Denmark's decline in energy use, due to efficiency policies, contrasts with Romania's relatively steady pattern. Its strong correlation with Italy suggests that Romania's energy trends are influenced more by Southern European agricultural practices than by Central or Northern European models. Weak correlations with leading EU energy-efficient countries (Denmark, Germany, Sweden) indicate Romania is not yet fully aligned with the EU's energy transition policies.

Employment in agriculture continues to be an essential component of the European Union (EU), as it makes a substantial contribution to the development of rural areas, the maintenance of food security, and the preservation of the environment. However, the employment dynamics within this industry have been subject to significant transformation in the wake of recent global concerns, including the emergence of the novel Coronavirus (SARS-CoV-2) pandemic, the ongoing climate change crisis, and the digital revolution. Table 3 and Figure 4 analyze employment trends in agriculture across selected EU countries from 2018 to 2023 based on Eurostat (2025, [nama_10_a64_e__custom_15676595]) , highlighting variations in national trajectories, the impact of external shocks, and the role of structural changes in shaping employment dynamics.

Table 3: Employment in agriculture in some EU countries, 218-2023

TIME	2018	2019	2020	2021	2022	2023
EU-27	207,290.41	209,858.13	207,101.67	210,398.06	215,052.91	217,478.67
Bulgaria	3,521.64	3,467.68	3,406.13	3,408.42	3,444.40	3,481.41
Czechia	5,359.13	5,351.37	5,227.23	5,279.24	5,333.08	5,387.92
Germany	44,878.00	45,291.00	44,966.00	45,053.00	45,675.00	46,011.00
Estonia	649.51	646.96	644.09	648.23	665.45	682.95
Ireland	2,264.14	2,335.31	2,277.13	2,426.53	2,594.53	2,684.20
Greece	4,650.30	4,752.00	4,629.80	4,865.60	4,983.60	5,044.00
Spain	19,938.40	20,467.10	19,567.00	20,072.50	20,773.60	21,399.20
France	28,327.80	28,662.00	28,645.30	29,395.20	30,102.90	30,423.60
Italy	25,194.00	25,349.00	24,830.10	25,069.40	25,554.30	26,030.00
Latvia	903.88	922.19	915.93	904.31	906.07	907.42
Lithuania	1,383.18	1,390.43	1,368.88	1,386.61	1,454.98	1,475.80
Hungary	4,605.93	4,651.67	4,615.80	4,681.18	4,755.84	4,765.29
Poland	16,403.70	16,798.90	16,831.90	17,317.50	17,512.00	17,528.90
Portugal	4,942.32	4,983.27	4,884.37	4,952.93	5,137.90	5,191.78
Romania	8,638.80	8,649.50	8,472.10	8,535.80	8,599.50	8,471.10
Slovenia	1,020.88	1,045.71	1,038.44	1,051.92	1,082.44	1,100.19
Slovakia	2,419.90	2,445.19	2,399.07	2,385.12	2,427.30	2,434.06
Sweden	5,186.00	5,219.00	5,153.00	5,218.00	5,400.00	5,462.00

Source: authors based Eurostat, (2025b) [code: nama_10_a64_e__custom_15676595

At the EU-27 level, agricultural employment increased from 207,290.41 thousand in 2018 to 217,478.67 thousand in 2023. This growth suggests that despite modernization and mechanization, the sector remains an important source of jobs. The increase could be attributed to sustainable agricultural policies, rural employment incentives, and the expansion of organic farming. Germany, France, Italy, Spain, and Poland showed steady employment growth in agriculture. For instance, Germany's agricultural workforce rose from 44,878 in 2018 to 46,011 in 2023. France exhibited a similar pattern, with employment increasing from 28,327.8 in 2018 to 30,423.6 in 2023. Bulgaria and Romania showed relatively stable or slightly decreasing employment figures. Romania's agricultural employment fell from 8,638.8 in 2018 to 8,471.1 in 2023, reflecting ongoing structural shifts and rural depopulation.

Countries such as Estonia, Latvia, and Lithuania experienced modest employment increases, likely due to small-scale farming resilience and EU-funded agricultural programs.

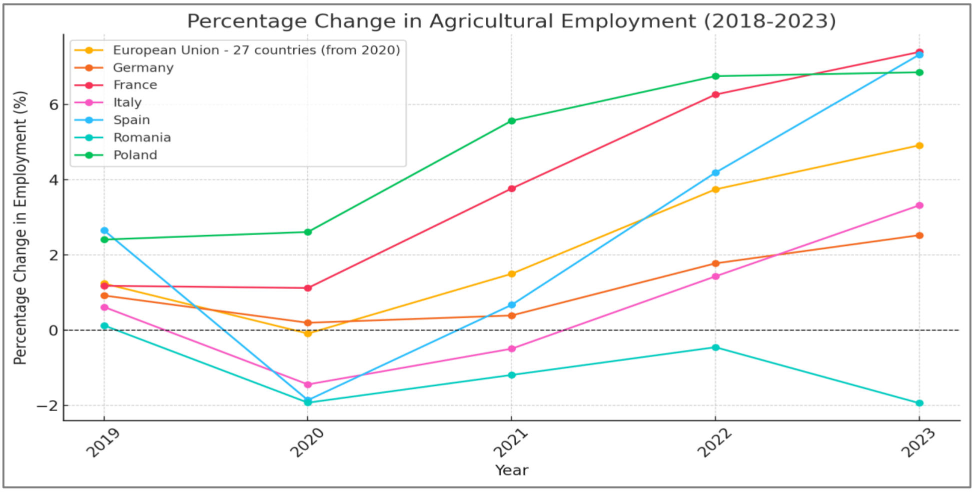

Figure 4. Evolution of the agricultural employment in some EU countries, 2018-2023
Source: author's computations based on Table 3.

4. CONCLUSION

The relationship between labor, energy, and agricultural performance is a critical aspect of Romania's agricultural development within the European Union. While the country faces challenges such as labor shortages, energy dependency, and lower-than-average productivity, it also possesses significant opportunities for growth through modernization, technological adoption, and renewable energy integration. The evolution of GVA across EU countries reflects broader economic cycles, external shocks, and recovery patterns. The COVID-19 pandemic led to a sharp decline in economic activity in 2020, but most economies demonstrated resilience and recovery by 2022. Germany, France, Italy, and Spain showed relatively stable post-pandemic growth, whereas smaller economies displayed higher volatility. Successfully adapting to these changes requires a strategic approach that balances labor inputs, energy consumption, and productivity gains. Embracing digital technologies such as precision farming, automation, and data-driven decision-making can help increase efficiency while reducing resource waste. At the same time, sustainability policies, including carbon footprint reduction and soil conservation measures, must be integrated into agricultural practices to align with EU climate goals. By striking a balance between tradition and innovation, Romania can position its agricultural sector for long-term resilience, competitiveness, and sustainability in an evolving global and European landscape. Romania's agricultural sector is distinctly situated during this transformative era, as the country's farming landscape is characterized by both small-scale, traditional operations and large-scale, industrialized agribusinesses. This arrangement brings forth distinctive challenges as well as significant opportunities for sustainable development and innovation.

Agricultural employment within the EU demonstrates heterogeneous but overall positive trends. Notwithstanding the short-term disruption from the COVID-19 pandemic, the general upward employment trajectory reflects the resilience and strategic adaptation of European agriculture. Member states such as Germany, France, Spain, Italy, and Poland exemplify effective adaptation strategies, incorporating digital transformation and robust policy support. In contrast, countries facing stagnation, like Romania, require targeted policy adjustments, infrastructural modernization, workforce development, and digital adoption strategies to enhance employment sustainability and growth.

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IMPACT OF ECONOMY, ENERGY AND ECOLOGY ON SUSTAINABLE DEVELOPMENT

UTICAJ EKONOMIJE, ENERGETIKE I EKOLOGIJE NA ODRŽIVI RAZVOJ

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Abstract: *The implementation of sustainable development involves defining a sustainable development policy and using adequate economic, energy, environmental and other instruments for the implementation and control of strategic solutions. By adopting sustainable development strategies, the governing bodies of countries in the modern world order should promote the use of economic instruments in financing the environment and ensuring the implementation of the basic principles of sustainability. Respect for the principles of sustainable development, at the national, regional, local and enterprise levels, implies the application of economic instruments in the field of environment, general and sectoral policies. The connection of quality management systems, new technologies and environmental and energy management systems are the basic conditions for sustainable development, which is based on enterprise management ready to find a compromise between economic, energy and environmental requirements. Their connection is direct and mutually conditioned, and is therefore the subject of simultaneous consideration from the standpoint of causes, consequences, and possible overcoming.*

Key words: *Economy, Energy, Ecology, sustainable development, environment.*

Apstrakt: *Primena održivog razvoja podrazumeva definisanje politike održivog razvoja i korišćenje adekvatnih ekonomskh, nergetskih, ekoloških i drugh instrumenata za primenu i kontrolu strategijskih rešenja. Organi rukovođenja, u državama savremenog svetskog poretka, usvajanjem strategija održivog razvoja trebalo bi da unaprede korišćenje ekonomskih instrumenata u finansiranju životne sredine i obezbeđivanju sprovođenja osnovnih načela održivosti. Poštovanje načela održivog razvoja, na nacionalnom, regionalnom, lokalnom i nivou preduzeća, podrazumeva primenu ekonomskih instrumenata u oblasti životne sredine, opšte i sektorskih politika. Povezivanje sistema upravljanja kvalitetom, novih tehnologija i sistema upravljanja zaštitom životne sredine i energetikom, osnovni su uslovi održivog razvoja, koji je zasnovan na menadžmentu preduzeća spremnom da nađe kompromis između ekonomskih, energetskih i ekoloških zahteva. Njihova veza je direktna i međusobno uslovljena, pa je zbog toga predmet istovremenog sagledavanja sa stanovišta uzroka, posledica i mogućih prevazilaženja.*

Ključne reči: *Ekonomija. Energetika. Ekologija, održivi razvoj, životna sredina.*

1. INTRODUCTION

The living and working conditions of modern generations can be said to be characterized by a general state of crisis and uncertainty. In fact, old problems related to insufficient energy, food

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and water supplies have not yet been resolved. However, new problems have emerged: general exposure to terrorist acts, mass migration of the population from war-torn areas, etc.
Classical theorists of economic growth emphasize several of its economic policy factors, such as: the importance of savings and investment, education, technological innovation – research and development, population growth and free trade. Today, a new economic paradigm – sustainable development – is increasingly dominant, encompassing economic growth but also important aspects of environmental protection and corporate responsibility.

The concept of sustainability is not new. Its roots can be found in the works of classical economics, in early attempts to answer the question of what the prospects for the development of human society are. An extensive overview of the development of economic thought on the environment was given by E. Kula (1998). Smith and Ricardo, and especially Malthus, sought answers to questions related to the limitation of natural resources, primarily land, then to demographic growth, and to diminishing returns to production.

The main goal, in this regard, is to point out the unequivocally strong correlation between the economics of ecology and energy.
The interaction of the three main branches in terms of resolving the accumulated contradictions should lead to the goal that is being pursued – sustainable development, in the sense of the imperative that today's economic prosperity is not based on the ruthless exploitation of nature and its capacities for the benefit of contemporary generations, but rather to leave to future generations at least that part of the natural resources that today's generations inherited from their ancestors. The green economy aims, therefore, to solve the main identified problems of today: shortages of food, drinking water and energy, along with drastic environmental pollution. Of course, solutions are offered in the form of sustainable agriculture and the food industry, which should reduce negative impacts on the environment.

Events in the environmental and energy sectors, both locally and globally, simply require every country and every individual to act in a way that saves energy, while protecting the environment at all levels, while actively participating in the fight against climate change. The ever-increasing need for energy, which practically drives the world, but also the growing problems of environmental protection, require environmentally and economically efficient energy production. The areas of energy production, distribution and consumption have been identified as the main environmental pollutants. The explanation lies in the fact that every business is made up of energy flows that are directed towards material production and the provision of services, and focused on energy that opens up new possibilities.

Because, if energy is the main driver of economic activities, then the economy should be viewed as an energy system consisting of energy flows and conversions that culminate in the production of goods and services, and energy as a key source of economic growth, industrialization and urbanization (Ayres, Warr, 2010).

2. ECONOMY AND SUSTAINABLE DEVELOPMENT

The neoclassical growth theory, which emerged in the 20th century, completely denies any need for a stationary state, and the issue of depletion of natural resources loses its importance. Scientific and technological progress becomes the main factor in the development of the economy and society, and it also occupies a central place in the theory. The decades-long period of stable growth of the world economy after World War II supported the belief in the unlimited possibilities of scientific and technological progress. The capitalist world believed that Keynesian economic theory and policy provided answers to the challenges of economic instability. On the other hand, the socialist world firmly believed in the correctness of the fundamental assumptions of scientific socialism that would ensure a secure future for humanity. On the other hand, Milton Friedman, an economist and Nobel Prize winner, believes that the main responsibility of a manager is to run a business in the best interests of shareholders, which is actually financial profit (Robbins, Coulter, 2005). If funds are spent for social good, the costs of doing business increase. Friedman does not believe that it is not necessary to be socially responsible, but rather reduces responsibility to making a profit for the benefit of shareholders.

The crisis of the 1970s, which manifested itself through unemployment, inflation, oil shocks, and rising energy prices, created the need for a new way of thinking about economic policy. A new era was beginning, inspired by the achievements of the natural sciences, primarily physics, as well as the achievements of biology, primarily genetics and ecology. Robert Solow (1974) was the first to emphasize the demand for intergenerational equality in the enjoyment of natural goods. In his famous work from 1974, Solow sets out the demand that each generation of people must have an equal right to reap the benefits of nature, i.e. the environment, and that only a pattern of economic development that enables this over an unlimited period of time can be considered sustainable.

The environment is threatened by human intervention in nature, rapid industrial and technological development, nuclear and other programs. Pollution can cause environmental toxicity. High levels of gas emissions cause air pollution and negatively affect people who suffer from asthma or other respiratory problems, including cancer. Waste materials of organic and inorganic origin have been dumped directly into rivers, lakes or seas for years, which endangers plant and animal life, but also impairs the quality of drinking water. Chemical pesticides, herbicides and other chemicals used in agriculture, as well as the addition of hormones and antibiotics to the food of many animals, can have a detrimental effect on the normal functioning of the human body. Global warming is one of the most serious environmental challenges of our time. Deforestation - unplanned or commercial, threatens the ecosystem. This means that the regulation of water reserves is disrupted, oxygen release into the atmosphere is reduced, and soil erosion is accelerated. The habitats of plant and animal species are put at risk.

Economists and other thinkers increasingly base economic development on intellectual capital (human capital, technology and social capital), and thus knowledge becomes the leading factor of production in relation to physical labor and natural resources (Albijanić, 2011). Numerous activities of state and non-governmental organizations around the world led to the holding of the *UN Conference on Environment and Development*, UNCED, in Rio de Janeiro in 1992. Many important documents were adopted at this conference. In August 2002, the World Summit on Sustainable Development was held in Johannesburg. At this summit, the participating countries agreed to begin developing and adopting national sustainable development strategies as soon as possible. **Today, the concept of sustainable development can be understood as the achievement of three goals:** (1) sustainability through economic growth without inflation and increasing external debt; (2) social sustainability through poverty reduction; and (3) sustainability in terms of the use of natural resources and environmental protection. The concept of sustainability is widely accepted as a roadmap for human development. There are strong moral reasons for today's generation to leave the planet and the possibility of development to posterity as a legacy, at least at the current level. This means that planet Earth, with its potential, must not be degraded by existing people. This position is based on the theory of equity, which emphasizes the fundamental principle of moral justice, contained in the equal right of every person to the broadest basic freedoms, which do not contradict the freedom of others. Therefore, the right of the current generation to exploit resources and the environment must not threaten the same right of future generations. This is analogous to the Golden Rule in economics that current generations cannot consume more than future generations. **The basis of sustainable development is ecologically ethical because nature represents a value in itself and man is only a part of**

nature and it is unacceptable for his activity to destroy the diversity of the living world and the wealth of resources. The economic argument for sustainable development is also important because it is on the side of efficiency against the waste of resources and energy, if we want long-term stability and progress of society as a whole. Hence, it can be concluded that pollution is not a consequence of selfish, frivolous, or short-sighted human behavior, but an inevitable companion of economic activity. The only imperative that humanity can face is that the pace of environmental pollution be optimal, i.e. in line with the possibility of restoring balance in nature and with the principle of economic efficiency (Harris, Jonathan, 2009, p. 456).

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Harris, Jonathan, 2009, p. 458). Sustainable techniques for agricultural production (organic soil restoration, organic healthy food), energy consumption, natural resource management, and industrial production have significant potential but have not yet found widespread application.

Energy is a fundamental input for economic systems. Production depends on fossil fuels, primarily oil, coal, and natural gas. Alternative (renewable) energy sources, such as hydropower, solar power, and wind power, could become significant. The second law of thermodynamics states that in isolated systems, the amount of useful energy and matter decreases over time. This law, known as the law of entropy, has far-reaching significance. The concept of entropy itself refers to the level of organization of matter and energy. The higher the organization of matter and energy, the greater their utility, i.e., the lower the entropy. The opposite is also true; the lower the level of organization, i.e., the higher the entropy, the lower the utility. In order for matter and energy to be biologically and economically useful, they must be organized in highly structured forms. The law itself states that in isolated systems, entropy increases over time, i.e., the level of organization decreases.

2.1. Knowledge economy and ecology

The most important development resource of the world economy of the 21st century is knowledge. The efficient use of knowledge is achieved through an effective business strategy of knowledge management. Knowledge management is the basis for directing the learning and knowledge of an organization towards the realization of set goals and the development of modern society. Accordingly, if environmental protection is a goal that enables the satisfaction of the needs of current and future generations, then knowledge management is a significant opportunity for its realization. In this regard, we especially emphasize the characteristics of a learning organization (LO) and its possible contribution to the improvement and modernization of education for sustainable development and environmental protection.

The modern economy, the knowledge economy, is based on knowledge, which is the basis for creating added value for the organization and prosperity of society as a whole. What characterizes the modern economy is certainly the development of technology, globalization and the creation of a world economy, the emergence of new political and social challenges that are changing society and the economy of today, and, of course, knowledge at the center of the new economy with all its implications for work, leadership and society as a whole (Đorđević Boljanović, 2009). As the intellectual component of products and services is increasingly gaining importance, the possibility of knowledge management is becoming increasingly important in today's business economy.

The creation and dissemination of knowledge within a modern organization is becoming a decisive factor in achieving and maintaining its competitive advantage. In fact, the only sustainable advantage of a modern organization comes from how much a company knows, how effectively it uses what it knows, and how quickly it acquires and uses knowledge (Davenport, and Prusak, 2000, p. xv). In this sense, in order to emphasize the importance of knowledge as their strategic orientation, national economies are increasingly using terms such as the knowledge economy, the ecology of knowledge, smart buildings, and smart cities. This orientation also indicates the necessity of connecting the knowledge-based economy with the environment in which the market competition takes place. With this in mind, and explaining the modern economy, the author Peter Drucker also introduces the concepts of "ecological vision" and "social economy". Namely, in his book Ecological Vision (Drucker, 2000, p. 442) Drucker speaks of the social dimension of the economy, the social function of management, and organizations as social institutions. In this context, according to Drucker, periods of great social change reveal a tension between the need for continuity and the need for innovation. In order to understand this imbalance of these changes as historical, on the one hand, and a roadmap for the future, on the other, Drucker introduced a discipline that he called "social economics", which includes the study of the environment with the idea of its innovation and change, but also active efforts to maintain a balance between change and preservation of that same environment.

Namely, in order for companies to develop their knowledge-based competitiveness, they need to manage knowledge in an optimal and efficient manner, but while respecting the rules of green business. Although knowledge management, as a management concept, is most often associated with the availability of knowledge at all times, or, which is the shortest definition of knowledge management – the right knowledge in the right place at the right time, in itself, the knowledge management program is ecological and focused on sustainability and sustainable development as a whole (Lamonth, 2012). Of course, successful examples of "green" business speak in favor of the fact that this way of thinking of modern organizations is justified and necessary, which leads to sustainability (Čajka, and Jovanović, 2015, pp. 87-89).

Companies that operate in this way certainly reduce costs, increase their positive impact on the environment and its preservation, improve their public image, increase productivity, create a healthier working environment for their employees and create potential business opportunities. Unlike the once-popular view that environmental protection reduces business opportunities, reality speaks in favor of the fact that both the environment and business can win at the same time (Kostić, Knežević, Vukadinović, 2014, pp. 93-95). Doing business "green" is not a cost, but an investment and a catalyst for innovation, new market opportunities and wealth creation. The question arises: how to achieve this? The answer lies in ecology as a strategy and the organization of business systems as ecosystems.
Also, ecological intelligence brings the functioning of ecological systems and its factors closer together. Ecological intelligence enables managers to learn from existing experience and to deal effectively with their environment, i.e. to apply everything learned about how human activity threatens ecosystems, as well as to work with less damage and once again live in harmony not only with their immediate environment, but also with the entire planet (Đoković, 2008, pp. 383-385).

The basic idea of a business or management ecosystem is that each organization influences and is influenced by other elements of the ecosystem, developing mutual relationships in which it must be flexible and adaptable in order to survive – as in a biological ecosystem, and in the aforementioned goal of achieving a comparative advantage that is the result of their symbiosis, and which they could not achieve individually (Lansiti, and Levien, 2004, pp. 67-78).
With all of the above in mind, business ecosystems indicate the dynamics of relationships between their elements. Ecosystems indicate the importance of the way people collaborate, share, trust each other, and grow together. When an ecosystem develops, it also indicates the free flow of ideas, talents, and capital. For these reasons, the term “business ecosystem” is fully justified because it indicates how and in what way a society views economic values, values the individual,

and his or her power to bring about change and make a difference in cooperation with others, which is the ultimate goal of modern management (Hwang, 2014).

2.2. Economic perception of the environmental crisis

The modern era of accelerated scientific and technological changes has confirmed the unsustainability of the quantitative growth model, i.e. the civilizational growth model, which is based on the endless depletion of natural resources. The need to find sustainable paths of social development is being initiated again. The essence of the ecological crisis of modern industrial society and civilization consists in the productivist logic, according to which the production of material goods exists for the purpose of gaining profit and accumulation, and not for the purpose of satisfying authentic human needs; then, obsessive consumption in which the value of "having" (things) takes precedence over "being" (realization of human potential) of a one-dimensional (technical) process that turns both nature and man into its instruments. "The blame for the eruption of the ecological crisis cannot be attributed exclusively to industry, science and politics. Namely, it is necessary to put the entire social consciousness under the microscope of criticism. It is not a question of rejecting all the previous civilizational-social (and technical) tradition as extremely hostile, but rather of the necessity of changing man's established relationship with nature. Successfully overcoming the accumulated ecological problems implies the emergence of a completely new social context, which creates space for mutual rapprochement between man and nature, but also between man and man, which eliminates and mitigates the consequences of the moral and physical decline of the contemporary Ecumene" (Bose, 1985, pp. 479-486).

The modern concept of society originated from the mechanistic vision of the world, accepted for centuries, on whose model modern society is founded, which has continued the further degradation of the environment. André Gorz reveals the connection between the ecological crisis and the crisis of contemporary society. Criticizing the profiteer logic, he claims that both social scenarios (Western and Eastern), by accepting the idea of growth, have condemned themselves only to the persistent accumulation of ecological problems. Although left-wing, Gorz clearly states: "The ecological demand is based on fundamental assumptions. Therefore, it is not subject to bargaining, guessing. Socialism is not worth more than capitalism if it uses the same tools. The complete rule of man over nature inevitably entails that the technique with which this rule is exercised dominates man. In the absence of any other choice, nuclear capitalism is still worth more than nuclear socialism" (Vasović, 2006, pp. 13-15).

A radical critique of the ecological crisis of Western civilization requires a strong critique of its economy because, as Branković argues, "the reason for man's destruction of nature in Western civilization should certainly be sought in the economy. Namely, liberated spirits are precisely in the vortex of the economic perpetuum mobile of that civilization. Nature is an object there because the subject has caused the dizzying acceleration of the economic flywheel and can no longer stop it." (Gorc, 1982).

According to Danilo Z. Marković (1991), "in fact, as is often pointed out, ecology, with its knowledge, should contribute to the creation of more humane living conditions by overcoming the appropriative attitude of society towards nature, which does not take into account the basic ecological principle that there is ecological conditioning, interconnectedness in nature" (Branković, 1989).

3. ENERGY AND SUSTAINABLE DEVELOPMENT

One of the tasks of environmental economics is to identify those economic activities that contribute to sustainability, as well as those that undermine it (Perman, Ma & McGilvray, 1996).

To illustrate the content of the basic principles of sustainability, we will use the codified set of norms and goals provided by the Ontario Round Table on Environment and Economy (ORTEE) of the Canadian state of Ontario and the Dutch National Environmental Action Plan (NEPP). According to ORTEE, a sustainable society can be considered one that (Edwards, 2008): (1) recognizes that economic growth has limits and that these are determined by the carrying capacity of resources in the environment; (2) values cultural diversity; (3) cultivates respect for all forms of life and encourages the diversity of the living world; (4) expands the system of social values through education about sustainability; (5) involves environmental experts in making all development decisions; (6) makes balanced development plans, respecting social, health, economic and environmental needs; (7) uses local resources and capacities in the best long-term way; (8) uses renewable and reliable energy sources; (9) minimizes environmental damage, and (10) strengthens activities in which materials are recycled.

As a result of the application of these principles, a sustainable social community does not undermine the sustainability of other communities, nor does it undermine the sustainability of the lives of future generations (Edwards, 2008).

A similar set of sustainable development principles is provided by the Dutch National Environmental Action Plan NEPP. The Dutch NEPP is one of a series of "green" national documents, first created in 1989, with the aim of linking sustainable development at the local, regional and national levels, primarily through a presentation of planned activities to improve the state of the environment. It is envisaged that this action plan will be updated every four years. NEPP 4 is currently in the advanced implementation phase, and NEPP 5 is being prepared, with a time horizon extending to 2030.

The basic principles of the NEPP are: (1) intergenerational equity, in the sense that the current generation must not reduce the development opportunities of future generations; (2) the precautionary principle, in conditions of global environmental uncertainty; (3) the principle of conservation of natural resources with minimal environmental damage; (4) pollution control at source; (5) the polluter pays principle, through internalization of environmental costs, through fees, taxes and permits; (6) use of best available technologies (BAT); (7) prevention and elimination of unnecessary waste generation; (8) isolation and control of waste that cannot be recycled and reused; (9) inclusion of environmental analyses and assessments in any decision-making in the economy; (10) integral management of the product life cycle, and (11) respect for the capacity of the environment and eco-space.

The above does not represent a complete or definitive content of the principles of sustainable development. Rather, it can be said that the concept of sustainable development is still in the process of being developed and supplemented, and that it is gaining not only relevance but also breadth of scope every day. For example, the "Earth Charter", as a declaration of the basic moral principles of human progress in the 21st century, has been adopted by over 4,500 international organizations, including UNESCO, as well as over 250 universities around the world. After more than ten years of work on its formulation, with extensive support from the Netherlands, the Charter was adopted in March 2000 by UNESCO in Paris.
The Earth Charter (2000) includes key principles grouped into four areas. These are: (I) *Respect and Care for Life*; (II) *Ecological Integrity;* (III) *Social and Economic Justice*; (IV) *Democracy, Nonviolence and Peace*.

All of the above suggests that, today, sustainable development is not just a political slogan or a scientific paradigm. In fact, it is a value orientation based on the view that the primary task of humanity is to preserve life on Earth, which is a prerequisite for its survival and further development.

According to a sustainable economy, *energy is the most important factor of production and the main polluter of the environment.* On a global scale, the situation is such that developing countries are less rich in natural resources, of course with existing exceptions, while in some regions there are not enough natural resources. How to balance the existing differences in the world and preserve natural goods? Ecology deals with the preservation of natural resources, while economics deals with the highest possible profit. Ecological economics represents a new direction in which ecology and economics go hand in hand, with the harmonization of opposing interests. Profit is important, but only to the extent that it does not become destructive to the environment, to humans and to sustainable development (Guy McPhearson, 2002).

Energy, in classical economic doctrines, therefore, did not play an important role as a factor of economic prosperity. This is understandable, because nature and natural resources were treated as an inexhaustible source of input for economic activities. At the same time, with such an exploitative attitude towards nature and its total resources, the theory was developed that people could take everything they needed from nature, in unlimited quantities, and at the same time consider that nature has the capacity for self-renewal of resources. Nature was considered an inexhaustible reservoir of raw materials, necessary for man for survival and further development.

To this should be added the lack of concern regarding the disposal of waste, i.e. residues from economic activities, supported by the view that nature itself is able to neutralize the harmful effects of human activities. Therefore, in economic theory, it was long believed that the amount of energy available to a given economy was endogenously determined, of course under the influence of biophysical and economic constraints (Stern, 2010, pp. 1-13). However, time has shown that such a theory in economic science is simply unsustainable. The first energy crisis, in the early 1970s, showed in its true light the unsustainability of classical theory in economics. Namely, at that time, energy appeared as an important, if not the most important factor of economic growth and development, in all its forms. Economic theory, in accordance with the requirements and problems of practice, finally introduced energy into its research as an important factor of economic activities. Energy is no longer marginalized in modern economic theory.

On the contrary, an increasing number of scientific researches in the field of economic sciences are related precisely to the examination of the impact of energy, forms of energy and energy resources on the economy, not only at the regional and national level, but also worldwide. In this sense, out of the need to solve practical problems, **modern economic theory has included in its research the direct connection that actually exists between *energy*, *economy* and *ecology*** (the so-called 3E). It has even gone a step further, in the direction that the modern economy, still based largely on non-renewable energy sources, is increasingly seen as the main cause of harmful impacts on the environment, and thus on sustainable development. The need to base future economic development on the principles of sustainability has given rise to a new economic doctrine called the "green economy" (Stern, 2010, pp. 1-13).

4. ECOLOGY AND SUSTAINABLE DEVELOPMENT

Environmental management is a modern system of environmental management. The main goal of such a system is to eliminate negative impacts and trends that affect human health. ***The concept of sustainable development implies balanced economic, social and cultural development without endangering the environment.***

Given the fact that the modern world is already largely faced with the need for global, shared responsibility for development in accordance with the needs of people and nature, the moral reasons of today's generation must be strong in terms of adequate chances for future development and survival of offspring. In this way, future generations could be enabled to develop at the same or higher level. Therefore, it can be stated that the essence of the concept of sustainable development is the correlation of economic development and the environment while respecting the legality of ecological systems. This concept is aimed at the rational use of the country's natural wealth and, accordingly, at raising the quality of the environment and the quality of life. *In order to achieve sustainable development, it is also necessary to establish new social values based on knowledge, creativity and human resource capabilities, in a word, on creating quality management with a tendency to transform the current society into a learning society*.

It is necessary to form a Sustainability strategy. An extremely important step in the implementation of a Sustainable Development Strategy is the implementation of a process of continuous data and information collection to measure the process of its success, i.e. timely signaling to responsible institutions about the "points" of success (34). This way of thinking is based on the fundamental principle of moral justice, i.e. that all people have equal rights to the broadest basic freedoms that do not contradict the freedom of others. The right of the current generation to exploit resources and to a healthy environment must not endanger the same right of future generations. Responding to the demands of the current generation without destroying the opportunities for future generations to respond to their demands is sustainable development (30).

Ecomanagement can be defined as the process of allocating natural and artificial resources, but in such a way as to achieve optimum use of the environment in meeting basic human needs at a minimum and, if possible, on a sustainable basis. It also represents a form of control of all human activities that have a significant impact on the environment. In other words, environmental management encompasses the process of making decisions that regulate the impact of human activities on the living space.

At the core of the concept of sustainability, the central place is occupied by the use of the capacity of the environment for human progress and development, but in such a way that it is not damaged and completely exhausted (Milutinović, 2009). Environmental quality management is a complex multidisciplinary task whose strategic basis is the principles of sustainable urban development and which can be successfully achieved if there is a well-conceived eco-management in the environment itself. Environmental protection and management are an integral part of governance - management at all organizational levels and in all business functions.

To this end, management should introduce a continuous process that must be coordinated with social and economic processes (employee safety, health protection, etc.). **The principles and elements of environmental management may include the following strategies** (Milutinović, 2009): (1) environmental policy; (2) planning; (3) implementation and control; (4) monitoring and corrective action, and (5) review, improvement and continuous improvement.

In each of the listed environmental management strategies, or ecological management, there are four basic phases (Milutinović, 2009): (1) identification phase – obtaining information on the basis of which knowledge about the potential effects of pollution would be gained; (2) monitoring phase – direct monitoring and measurements of pollutants, their distribution and localization; (3) valorization phase – ends with the sum of all environmental information obtained in earlier phases and (4) regulation phase – application of various instruments and measures for the purpose of effective environmental management.

To direct the desired state of the environment in the future, prognostic and planning methods and models must be used in order to bring management to an exact level. Therefore, it is necessary to influence the development of environmental management methods, both at the theoretical level and at the level of regulations, standards and instructions. The management model must demonstrate a good relationship between the subjects (competent state bodies) and the object of management (environmental elements), management tools (laws and plans), as well as the position of management instruments (regulations, standards, norms, criteria and information) (Mihajlović, Stošić Mihajlović, 2009). The implementation of planning solutions is based on the coordinated application of instruments and measures in various areas of directing development, construction and use of space and environmental protection.

Strategic planning of environmental management integrates the potential for managing changes in space, but also the long-term time horizon, taking the position of a catalyst for harmonizing public, social and private interests. The concept of environmental management in the function of sustainable socio-economic development, with the goals it seeks to achieve in modern business and living conditions. The basic goals that are at the base of environmental management are the following:[32] (1) prevention and resolution of environmental problems; (2) establishment of boundaries; (3) establishment and maintenance of institutions that effectively support environmental research, monitoring and management; (4) warning of dangers and identifying opportunities for overcoming them; (5) maintenance and, if possible, improvement of existing resources; (6) improvement of the "quality of life", and (7) identification of useful new technologies or policies.

Each of these goals can be discussed in detail, but what they all have in common is their essence, which can be expressed as the desire to preserve the environment. Table 1 shows the so-called "golden rules of ecomanagement", as well as the consequences of not respecting them.
From Table 1, it can be seen that the important rules are substitution, reduction and assimilation. In other words, it is necessary to replace non-renewable resources with renewable ones, to consume natural resources in a planned manner so that they are not exhausted, that is, it is necessary to monitor the period of their regeneration. Finally, the rule of assimilation obliges all participants in economic and other activities to reduce the emission of harmful substances into the environment, that is, to ensure that the rate of environmental pollution does not exceed the optimal level.

Table 1. Golden rules and consequences of environmental management

Golden rules of environmental management	**Consequences**
RULE OF SUBSTITUTION Non-renewable resources can be consumed to the extent that they can be replaced by equivalent (renewable) substitutes.	If the consumption of non-renewable resources is not drastically reduced within the next generation, many will disappear or exist in very limited quantities.
REDUCTION RULE The amount of renewable resources used should not exceed their renewability.	If the growth of renewable resources exceeds regeneration growth, species extinction will follow.
ASSIMILATION RULE Emissions of harmful substances should not exceed the absorption capacity of the environment, i.e. exceed the burden on ecological systems.	If environmental burdens are not drastically reduced, absorption capacity will be exceeded locally and globally.

Source: https://www.google.rs/search?q=http://sewa.sewaweather.com/~ambassadors/new_site/srp/images/stories/Papers+/08-01.pdf&ie=utf-8&oe=utf-8&client=firefo

[32] The golden rules and consequences of environmental management, https://www.google.rs/search?q=http://sewa.sewaweather.com/~ambassadors/new_site/srp/images/stories/Papers+/08-01.pdf&ie=utf-8&oe=utf-8&client=firefo

Environmental management is an increasingly common topic that relates to various areas of organization management, which see it as a way to improve their position in the market. It is related to growth and development, procurement, production, marketing, investments, personnel, etc., or in short, it is related to all areas of business. Miller (2007) defines environmental management as "the shaping, management and development of companies and organizations with responsibility towards the environment". This responsibility means that in all functions of a company or organization, interaction with the natural environment is taken into account when making business decisions. Environmental management is the science and skill of effective and efficient behavior and achieving goals in the right way, but also the true knowledge and practice of achieving the right goals, i.e. goals that concern human survival and the quality of their life. Here, more than in other areas of management application, the dominance of the principle of effectiveness over the principle of efficiency is confirmed, i.e. the inability to compensate for the lack of effectiveness with efficiency. Therefore, environmental management must become a kind of management infrastructure for successful management practices in all sectors, because poorly chosen non-ecological goals cannot be compensated for even by the greatest efficiency.

The main objective of an ecologically protected area is to ensure the quality of life and long-term livelihood of the local population. All areas should be managed in a way that will enable the protection of all natural and cultural resources, while preserving the interests of the owners in achieving appropriate profits, as well as the interests of the local population. Such management is complex and requires different knowledge and skills. Due to increasing public pressure, as well as the potential for cost reduction, legal restrictions and ethical reasons, it is necessary to develop appropriate ecomanagement strategies to create "environmentally friendly" processes and products in the function of sustainable development. Therefore, modifying existing and developing new strategies in the direction of environmentally responsible business is an imperative of modern business in the field of sustainable development.

Sustainable development encompasses three dimensions: environmental sustainability, economic efficiency, and social responsibility. This concept is known as the "three-pillar model" (Giddings, Hopwood, & O'Brien, 2002, p. 190).
The ecological dimension refers to the preservation of biodiversity, the conservation and rational use of natural resources, the reduction of environmental pollution, the care of endangered species, their habitats, ecosystems, and the like (Miltojević, 2011, pp. 639-653).

The social dimension refers to social relations, respect for human rights, the achievement of social well-being, the transparency of social activities, and the involvement of people in decision-making, and is monitored through five areas: health, social justice, education, population, security, and housing.

The economic dimension of sustainable development is based on the principles of harmonization of economic development with resources and production capacities and is observed through two areas: production and economic structure and consumption (Miltojević, 2011, pp. 639-653).

In the 1980s, Dutch statisticians (Konning, 2015) argued that their national development strategy consisted of four dimensions of sustainable development: social, cultural, economic and environmental. According to their thinking, the social dimension requires answering the following questions (Konning, 2015): (1) "how satisfied are we now; (2) to what extent is there safety and security in our environment and social structure; (3) what has been done about people's social connections between the society to which we belong and people outside our society".

When thinking about the social dimensions of sustainable development, we think about a satisfactory level of social sustainability that includes: employment that provides decent living conditions, equitable income, social stability and equitable access to resources. Social sustainability implies social equality and the reduction of social exclusion, as well as the development and inclusion of: equality, social justice and quality of life. Indicators of social sustainability include access to information, connectivity, physical, psychological and reproductive health, availability of activities important for sustaining life, which means: nutrition, household formation, employment, the possibility of accessing land and resources, as well as security inside and outside the home (Becker, E., Jahn, T., Stiess, I., & Wehling, P., 1997).

Social stability as an element of social sustainability is defined as the ability of a human being (individual, household, family) to achieve and maintain adequate living conditions (Becker, et al., 1997). Everything that applies to sustainable development at the macro level (the level of a country's economy) also applies at the micro level when we talk about social enterprises.

4.1. Sustainable and unsustainable development – parallels

Today, the term *sustainable development* is used too often, in different meanings, and the key factors of the concept of sustainable development itself are: the economy, social relations viewed as the degree of realization of freedom and social justice and equality for all people, as well as environmental protection.

In the broadest sense, sustainable development refers to the interdependence of the environment, social and economic systems, as well as the promotion of equality and fairness through the strengthening of public power and a sense of global belonging. It is a concept based on the idea of combining the best aspects of different perspectives and harmonizing the development of humanity with the protection of nature.

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." This definition was formulated by the WCED - World Commission on Environment and Development (38), led by the Norwegian Prime Minister Gro Harlem Brundtland, in 1987. The word "development" in this definition introduces two important aspects of this concept: it is multidisciplinarity, because development cannot be limited to a certain number of disciplines or areas, but is applicable to the whole world, everyone and everything in it, now and in the future. The second aspect is that there is no set goal, but the continuity of development is the goal of development. The definition is based on two principles: (1) the principle of "needs", including the conditions for maintaining an acceptable standard of living for all people, and (2) the principle of "limits" of the capacity of the environment to meet present and future needs, determined by technological development and social organization. **Any development should help meet needs and should not increase restrictions** (Government of Serbia, 2005).

Sustainable development is a harmonious relationship between ecology and economy, in order to preserve the natural wealth of our planet for future generations. It can be said that sustainable development represents a direction, a striving to create a better world, balancing social, economic and natural factors of environmental protection.

Table 2. Comparative presentation of the advantages and disadvantages of two opposing concepts in the relationship of society to the conditions of its own existence

Sustainable development	**Unsustainable development**
Quality of life improvement goals - are based on a general definition including social and environmental factors, as well as monetary ones.	The goals are only to raise the standard of living - they are based on finances which are the foundation of our well-being and happiness

There is an interconnectedness between economic, social and environmental problems. They are addressed in such a way as to achieve lasting solutions based on harmony.	Economy, society, and environment are three distinct, separate groups of problems, and it is held that a healthy economy automatically leads to a healthy society and a safe environment.
It views the needs of future generations as the needs of today's generations and seeks to avoid problems in the future by working on their solutions today.	Things improve in the short term. It's mostly left to future generations to sort them out.
Sustainable development	**Unsustainable development**
The environment and its capacity to support human action are taken into account in all decisions,	The environment is seen as a luxury – it should only be protected if we can afford it.
Balancing the importance of individual rights with collective responsibility.	The focus is mainly on individuals and individual rights.
Collaboration between experts and ordinary people is planned so that plans and proposals meet people's needs.	Experts and specialists plan.

Source: (Bachun, 2005).

Sustainability, as interpreted in Germany, requires an inextricable link between ecology, economy and social security. Sustainable development requires that progress in economic and social living conditions be consistent with the long-term process of preserving the natural foundations of life.

5. CONCLUSION

The ecological crisis implies a crisis of the existing matrix of industrial society in relation to the natural conditions of life. The ecological crisis manifested through various degrees: what kind of pollution, threats, destruction are, in essence, a burning civilizational problem, the solution of which depends on the very future. The developed part of the Planet is faced with the problem of depletion and pollution of resources due to the expansion of energy needs. We now live in a time when renewable energy sources cannot cover all of humanity's energy needs, the use of classical energy sources is unsustainable, because it pollutes the environment to the maximum, and all this is manifested in economic collapses, which seem inevitable, the only question is under what scenario economic collapses will occur.
The meaning of sustainable development policy at all levels of social organization lies in the need to maintain a balance between demand, saving and renewal of natural resources, as an expression of concern for future generations.

Regardless of the evident weakening of the state as an organizer, coordinator and arbiter of social relations in modern society, the key issue of sustainable development, and thus environmental protection, is posed as a relationship between the state and the market. This relationship should be viewed in interaction and should result in meeting people's needs in a way that does not endanger the environment and the right of future generations to live in a preserved environment.

Environmental protection problems are primarily problems of economic societies, or in the broader sense of the word, of the country's economy; with the economy as the material basis, as a condition for the survival and progress of a human community that exists in a certain more or less compact area. Environmental protection is an ambivalent category and has another face. It is about the state having a monitoring and supervisory, control role and the right to intervene in the field of environmental protection. Intervention is usually directed towards the economy and economic organizations that do not respect the established "rules of the game".

The state, also, within its role as the organizer of global society, not only establishes a certain environment through coercive measures and laws that is a prerequisite for a quality environment, but also appears in the role of an investor in infrastructure, where this is not the obligation of the economic sector, with the aim of providing a healthy environment for the population, plant and animal species.

Market mechanisms and state intervention are complementary in terms of providing the conditions for sustainable development. If the market is allowed to develop, the economic effects will be positive. If market mechanisms do not produce the expected results, similar effects can be ensured through state intervention. But only if the market and state policy form an integral whole can a very positive effect and accelerated and sustainable development in accordance with the principle of environmental protection be expected.

Industrialization, in addition to the benefits it has brought to modern man, also brings with it unwanted consequences for the *areal* - the environment in which man lives and works.

Environmental indicators show the quality of the environment, the quantity and quality of natural resources. The state of the environment is the result of environmental pressures and means the quality of different parts of the environment (lithosphere, pedosphere, hydrosphere, atmosphere), basic elements (water, air, soil, surface, etc.) as well as the quality of individual ecosystems (Radej, 1992). Changes in the state of the environment affect the quality and prosperity of humans. Changes in the state of the environment cause ecological and/or economic impacts on ecosystem functions and human health (Plut, 2002). These indicators include the concentration of heavy metals in rivers, exposure of the population to polluted air, and the like. The difference between indicators of environmental pressures and indicators of environmental status and sustainable development is that environmental status indicators show environmental conditions and changes in status over time, rather than pressures. Indicators of environmental pressures can be used in practice as a substitute for status indicators, the collection of which may be difficult and uneconomical.

The changes in today's society, which have occurred in the technical and technological sphere, require a new and fundamentally changed approach in many domains and areas of human life and work, including in the field of environmental protection. Environmental issues have increasing consequences for economic entities and the economy in general. Depending on the reaction of economic entities or organizations, environmental interests can have a positive or negative impact on the extent to which set economic goals are achieved. Economy and ecology have opposing interests, but these interests must be harmonized for the sake of environmental protection and living space. Environmental protection presents risks, but also opportunities. Energy is fundamental for economic development, but at the same time it must serve the function of environmental preservation. Only this approach to energy leads to a sustainable energy system, a more efficient economy and greater social well-being, with sustainable balances and capacities of natural resources and as low levels of pollution as possible.
A new scientific discipline that emerged within the synthesis of social and natural sciences, called *ecological economics*, pays special attention to the importance of the laws of thermodynamics in the process of economic activity, thus ensuring economic activity while preserving the environment within the realistic framework of sustainable development. Energy management is a way and support for reducing environmental threats and economic costs while increasing the quality of life and economic progress.

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STUDY OF CHOLINE CHLORIDE REPLACEMENT WITH BETAINE MOLASSES IN STURGEON GROWING

СТУДИЈА ЗА ЗАМЕНА НА ХОЛИН ХЛОРИД СО МЕЛАСА БЕТАИН ВО ОДГЛЕДУВАЊЕ ОСЛИЌ

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Abstract: *The purpose of the conducted research is to establish the effectiveness of replacing crystalline choline chloride with betaine molasses in sturgeon feeding. In the experiment on yearling sterlet weighing from 1.0 to 1.5 kg, the fish weight increased by 1.02% when fed crystalline choline chloride, and by 1.20% when given betaine molasses compared to the control. The average daily gain when using betaine molasses is 3.5% higher compared to crystalline choline chloride.*

Key words: *betaine, sturgeon fish, feeding, aquaculture, gains, fish farming*

Апстракт: *Целта на спроведеното истражување е да се утврди ефикасноста на замената на кристалниот холин хлорид со бетаин меласа во исхраната на рибата ослиќ.. Во експериментот со едногодишни ослиќи со тежина од 1,0 до 1,5 kg, тежината на рибата се зголемила за 1,02% кога се хранела со кристален холин хлорид и за 1,20% кога била хранета со меласа бетаин во споредба со контролата. Просечниот дневен раст при користење на меласа бетаин е 3,5% поголем во споредба со кристалниот холин хлорид.*

Клучни зборови: *бетаин, риба ослиќ, хранење, аквакултура, добивки, одгледување риби*

1. INTRODUCTION

The relevance of commercial cultivation of sturgeon species is due to the reduction of their reserves in natural reservoirs. Breeding of sturgeon in fish farms is based mainly on the use of complete combined feeds.

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To improve the composition of the feed mixture, vitamins, microelements, synthetic amino acids and many other feed additives are introduced into the diet, among which betaine, obtained from molasses during the processing of sugar beets, is of considerable interest.
Betaine, by its chemical structure, is trimethylglycine containing free methyl groups.

The presence of this substance in tissues is characteristic of living organisms, since betaine is an intermediate product of choline metabolism, necessary for the formation of methionine in cells. Betaine is involved in methylation reactions and also helps maintain the water balance of a living cell.

When ingested with feed, betaine improves the regeneration of intestinal epithelium, the structure of muscle tissue, reduces energy costs for osmoregulation, and increases the body's resistance to stress and coccidia infection.

The biochemical properties of betaine indicate the possibility of its use as a feed additive in fish diets along with choline chloride.
In this regard, the purpose of this study was to study the possibility of replacing the choline chloride additive in sturgeon diets by introducing betaine molasses into the feed mixture.
The main purpose of the study is to establish the effectiveness of replacing crystalline choline chloride with betaine molasses in sturgeon feeding.

2. RESEARCH METHODOLOGY

The experiment was conducted on one-year-old sterlet, with a live weight of 1 to 1.5 kg.
The experiment was conducted according to the scheme presented in Table 1. The first control group received a diet without betaine and choline chloride, the second experimental group received a diet containing 60% choline chloride in the amount of 800 g per 1 ton of feed, and the third experimental group received a diet containing betaine molasses in the amount of 1056 g / t of feed. The duration of the experiment was 60 days.

Table 1. Experimental scheme

Group		Heads in group	Feeding characteristics
1	1 control	5	Compound feed
2	2-experimental	5	Compound feed + 0.08% crystalline choline chloride in 1 kg of compound feed
3	3-experimental	5	Compound feed + 0.1056% (0.08%*1.32) betaine molasses in 1 kg of compound feed

At the end of the feeding period, a balance experiment was conducted to study the digestibility of nutrients in the compound feed using the generally accepted method (Shcherbina M.A. 2006).

All the digital material obtained was statistically processed using the Student's variation statistics method using the Microsoft Excel program within the following significance levels: *- $P<0.05$.

Zootechnical indicators: Measurement of the main fish-breeding indicators: weight, feed coefficient, fatness coefficient, digestibility and assimilation. Measurements and weighing were carried out every ten days. The feed coefficient and fatness coefficient are calculated using generally accepted methods.

Feed indicators: Feed examination in three groups - to determine the correctness of the selected diet.

2.1. Results and discussion

Table 2. Main fish-farming and biological indicators of growing young sterlet (experimental period – 90 days).

Indicators	Group		
	1 control	**2 experimental**	**3 experimental**
Average fish weight, g: initial	1250,00	1251,00	1250,00
Average fish weight, g: final	1430,00	1450,00	1454,60
In % of control	100,00	101,02	101,20
Body length after 90 days of rearing, cm	44,62	44,73	44,69
In % of control	100,00	100,25	100,16
Gross gain of 1 fish in 90 days, g	180,00	199,00	204,60
Average daily gain, g	2,00	2,21	2,27
In % of control	100,00	110,50	113,50
Fish survival rate, %	100,00	100,00	100,00
Condition factor	1,61	1,62	1,63

The initial weight of the fish when they were placed in the experimental tanks was the same, but at the end of the growing period, significant differences were observed.

In the experiment on yearling sterlet weighing from 1.0 to 1.5 kg, the weight of the fish increased in the 2nd experimental group by 1.02%, in the 3rd experimental group - 1.20% in relation to the control.

The average daily gain when using betaine molasses is 3.5% higher compared to crystalline choline chloride.
The fatness coefficient increases by 0.01 indicator when comparing betaine molasses with choline chloride - without use (in the control group - higher by 0.02 units.

The body length of fish in the 2-test group increased by 0.25% compared to the control, in the 3-test group - 0.16%, compared to the control.
The survival rate of fish in all groups was 100%.

The physiological state of fish is consistently better when using betaine molasses.

In the experiment on yearlings of sterlet weighing from 1.0 to 1.5 kg, a decrease in feed costs per 1 kg of gain, when using choline chloride compared to the control, occurred by 0.1 (8.33%) indicator, when using liquid betaine by 0.12 (10.00%) - which characterizes the improvement of feed digestibility when using this additive (table 3.).

Table 3. Consumption and cost of feed by sterlet

Indicators	Group		
	1 control	**2-experimental**	**3-experimental**
Feed consumed per head, g	1440,00	1440,00	1440,00
Feed costs, kg/kg of gain	1,20	1,10	1,08
In % of control	100,00	91,67	90,00

At the end of the study, the economic indicators of betaine use were calculated. Gross gain varied by groups: in the 2-experimental group it increased by 10.56% compared to the control group, in the 3-experimental group by 13.67%.
Production costs increased by 0.83% in the 2-experimental group compared to the control group, and by 0.68% in the 3-experimental group.

The cost of 1 kg of fish weight gain in the 2-experimental group decreased by 8.80%, in the 3-experimental group by 11.43% compared to the control group.
Profit increased by 41.50% in the 2-experimental group compared to the control group, and by 54.99% in the 3-experimental group.

The greatest economic effect was obtained in the 3-experimental group - 37,877.35 rubles, which is 32.50% more than in the 2-experimental group.

3. CONCLUSIONS

The initial weight of the fish when placed in the experimental tanks was the same, but significant differences were observed at the end of the growing period. In the experiment on yearling sterlet weighing from 1.0 to 1.5 kg, the weight of the fish increased in the 2nd experimental group by 1.02%, in the 3rd experimental group - 1.20% in relation to the control.

The average daily gain when using betaine molasses is 3.5% higher compared to crystalline choline chloride.
The body length of the fish in the 2nd experimental group increased by 0.25% in relation to the control, in the 3rd experimental group - 0.16%, in relation to the control.
The survival rate of the fish in all groups was 100%.
The physiological state of the fish is consistently better when using betaine molasses.

The greatest economic effect was obtained in the 3-experimental group – 37,877.35 rubles, which is 32.50% more than in the 2-experimental group.

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INFLUENCE OF ORGANIC VERSUS CONVETIONAL PIG PRODUCTION ON MEAT QUALITY AND FATTY ACID COMPOSITION

ВЛИЈАНИЕ НА ОРГАНСКОТО НАСПРОТИ КОНВЕНЦИОНАЛНОТО ПРОИЗВОДСТВО НА СВИЊИ ВРЗ КВАЛИТЕТОТ НА МЕСОТО И СОСТАВОТ НА МАСНАТА КИСЕЛИНА

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***Abstract**: Studies have shown that organic rearing systems can enhance certain meat quality parameters. To investigate the nutritional processing quality of pork meat from conventional pig farms, the standard physical-chemical analysis was performed. Intramuscular fat content was 4.28%, water content 76.71%, protein 24%, pH=6.02, water binding ability 16.10%, and the brightness L=32.32, redness a=7.76, yellowness b=7.81. The interplay of genetics, nutrition, and production practices ultimately shapes the functional food properties of pork, influencing consumer preferences and market trends.*

***Key words:** pork, nutritional quality, production system*

***Апстракт:** Истражувањата покажаа дека системите за органско одгледување можат да ги подобрат одредени параметри за квалитет на месото. За да се испита квалитетот на нутриционистичката обработка на свинското месо од конвенционалните свињарски фарми, беше извршена стандардна физичко-хемиска анализа. Интрамускулната содржина на маснотии беше 4,28%, содржина на вода 76,71%, протеини 24%, pH=6,02, способност за врзување вода 16,10%, а осветленоста L=32,32, црвенило a=7,76, жолтило b=7,81. Интеракцијата на генетиката, исхраната и производствените практики на крајот ги обликува функционалните прехранбени својства на свинското месо, влијаејќи на преференциите на потрошувачите и трендовите на пазарот.*

***Клучни зборови:** свинско месо, квалитет на исхрана, систем на производство*

1. INTRODUCTION

The influence of organic versus conventional pig production on meat quality and fatty acid composition as a functional food is a significant area of research, particularly as consumer

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demand for healthier and more sustainable food options increases. It is a multifaceted topic encompassing various aspects of animal husbandry, nutritional strategies, and consumer preferences. The differences in production systems significantly affect the physiological and biochemical properties of pork, which in turn influence its quality and health benefits.

Organic pig production is often associated with improved animal welfare and sustainability, as it typically involves outdoor access and a diet free from synthetic additives and antibiotics. Studies have shown that organic rearing systems can enhance certain meat quality parameters, such as oxidative stability and intramuscular fat content, which are crucial for flavor and tenderness. For instance, Martino et al. found that organic crossbred pigs exhibited a different oxidative status compared to conventional breeds, suggesting potential benefits in meat quality attributes like tenderness and flavor (Martino et al., 2014). Furthermore, the inclusion of organic trace elements in pig diets has been linked to enhanced antioxidant capacity, which can reduce lipid peroxidation and improve meat quality (Xu et al., 2024). This is particularly relevant as oxidative stability is a key factor in determining the shelf life and sensory attributes of meat products. This approach often results in pork with higher levels of beneficial fatty acids. For instance, studies have shown that pork from organically raised pigs tends to have a higher concentration of polyunsaturated fatty acids (PUFAs) and a more favorable omega-6 to omega-3 fatty acid ratio compared to conventionally raised pork (Abdullah et al., 2023). This is attributed to the diets of organic pigs, which often include foraged plants and grains that are richer in omega-3 fatty acids. Additionally, the higher lean meat percentage associated with organic production systems can lead to improved fatty acid profiles, enhancing the nutritional quality of the meat (Abdullah et al., 2023).

In contrast, conventional pig production often prioritizes growth rate and feed efficiency, which can lead to differences in meat quality traits with a higher content of saturated fatty acids and lower levels of beneficial unsaturated fatty acids. For example, research indicates that pigs raised in conventional systems may have higher muscle glycogen levels, which can negatively impact meat quality by leading to lower pH and increased susceptibility to spoilage (Liu et al., 2019). Additionally, conventional systems may result in a higher prevalence of certain health issues, which can affect meat quality. Alban et al. (2015) reported that lesions found during meat inspections were more common in pigs raised under conventional conditions, potentially reflecting the stress and health challenges associated with intensive farming practices. Conventional pork typically exhibits higher levels of n-6 fatty acids, which, while essential, can contribute to an imbalanced fatty acid profile when not countered by sufficient omega-3 intake (Almeida et al., 2014). This imbalance is concerning as excessive consumption of n-6 fatty acids relative to n-3 fatty acids has been linked to various health issues, including inflammation and cardiovascular diseases (Da et al., 2021).

Moreover, the nutritional strategies employed in organic versus conventional systems play a critical role in determining meat quality. Organic pigs often receive diets that promote higher intramuscular fat content, which is essential for flavor and tenderness. This is supported by findings that indicate organic systems can lead to a more favorable fatty acid profile in pork, enhancing its nutritional value (Abdullah, 2023). Conversely, conventional systems may focus on maximizing lean meat production, which can compromise flavor and tenderness due to lower intramuscular fat levels (Abdullah et al., 2023).

The genetic background of the pigs also contributes significantly to meat quality. Liu (2023) performed research in which highlighted that different pig breeds exhibit varying meat quality traits, with indigenous breeds often preferred for their superior flavor and tenderness compared to conventional hybrids. Research indicates that certain breeds, such as Duroc, are associated with higher intramuscular fat content, which is positively correlated with desirable sensory traits such as flavor and tenderness (Jiang et al., 2011). The genetic selection for higher intramuscular fat content in organic systems can further enhance the quality of pork, making it not only more palatable but also nutritionally superior due to its higher monounsaturated fatty acid content, particularly oleic acid, which has been shown to have antioxidant properties and potential health benefits (Ros-Freixedes et al., 2016; Da et al., 2021).

2. MATERIALS AND METHODS

Hind leg meat from finisher pigs reared in commercial pig farms was obtained for analysis of physical-chemical meat composition. Surface tendons, membranes and fats were removed, and some of them were used for quality determination such as pH, tenderness, water binding ability, and meat color, and some of them were prepared into dry samples to determine nutritional indicators such as moisture, protein and fatty acids content. Mixed standards of 33 fatty acids were used for chromatographic detection of fatty acids. Before the assay was performed, fat extract was prepared. A test sample of 0.03 g was transferred into a 50 mL centrifuge tube, add 143 mg pyrogallic acid and 2 mL 95% ethanol solution, mixed well, added 10 mL hydrochloric acid solution, and placed in a water bath at 70-80℃ for 40 min for hydrolysis. Then the sample was cooled to room temperature, added 10 mL of 95% ethanol solution and 50 mL of petroleum, shakeed for 5 min, transfered to a separating funnel and allowed to stand for 10 min, collected the ether layer extracted into a 100 mL Erlenmeyer flask, repeated the extraction three times. The extract was left to volatilize overnight to obtain the fat extract, which was dissolved by adding 4 mL of n-hexane, shaken for 30 sec. and allowed to stand until clear, about 1 g of sodium bisulfate was added, shaken to neutralize potassium hydroxide, and after salt precipitation, filtered with a 0.22 μm filter membrane and measured using gas chromatography-mass spectrometer.

3. RESULTS AND DISCUSSION

This study analyzes the nutritional and physical characteristics of pork meat from the hind leg. Table 1 presents the results, showing that this cut has a relatively low fat content of 4.28% and a high water content of 76.71%, contributing to its tenderness. The fat content is lower than what is typically reported in other studies (Pinchen et al., 2020), suggesting variability influenced by factors such as cut type and processing methods. The slightly higher water content compared to some previous research may be due to differences in handling or meat sources. The measured value for water content was 76.71%, which is slightly higher than the 72% water content observed in the study conducted by Pinchen et al. (2020), indicating that variability depends on factors such as processing and cut type.

Table 1. Nutritional quality of pork meat from hind leg parts

Parameter	**Pork meat from the hind legs part**
Fat	4.28
Water	76.71
Ash	1.45
Protein (%)	24.00
pH	6.02
Water bind ability (WBA)	16.10
Color L	32.32
Color a	7.76
Color b	7.81
RGB_red	91.00
RGB_green	71.00
RGB_blue	64.00

Regarding the ash content, the recorded value of 1.45% in this study is consistent with the general understanding that pork, especially lean cuts, tends to have minimal ash content. However, specific ash values for hind leg cuts were not directly mentioned in the available literature. Protein makes up 24% of the meat's composition, reinforcing its nutritional value as a high-quality protein source. Similarly, the measured protein content aligns with the characterization of pork as a rich source of high-quality protein, as noted in various studies on meat composition (Vicente, Pereira, 2024).

The pH level of 6.02 indicates near-neutral acidity, while color measurements reveal a moderately bright, slightly reddish hue, characteristic of this cut. These pH and color values align with general expectations for pork. While the pH value of pork meat can vary depending on breed, diet, and processing methods, detailed pH values for the hind leg part were not explicitly addressed in the literature's sources reviewed. The color parameters obtained, with L = 32.32, a = 7.76, and b = 7.81, are indicative of typical pork color, though specific values for the hind leg part were not directly reported in recent studies. Pork color is influenced by muscle type, pH, and processing methods, which can contribute to some variation. The water binding ability of 16.10% in this study also falls within a typical range for meat, although specific data for hind leg cuts were not readily available in the literature.
Overall, these findings provide insight into the key nutritional and physical properties of pork from the hind leg.

In Table 2, the fatty acid composition of pork meat from the hind leg part is shown. The results show that the major fatty acids in the sample were oleic acid (C18:1), palmitic acid (C16:0), and stearic acid (C18:0), with oleic acid being the predominant monounsaturated fatty acid. These findings are consistent with previous studies, which report that oleic acid is typically one of the most abundant fatty acids in pork fat (Covaciu et al., 2024).

Table 2. Fatty acids content in pork meat

Parameter	Pork meat from the hind legs part
Saturated fatty acid (SFA)	1.46
Caproic acid (C6:0)	0.02
Caprylic acid (C8:0)	0.02
Capric acid (C10:0)	0.02
Undecanoic acid (C11:0)	0.02
Lauric acid (C12:0)	0.02
Tridecanoic acid (C13:0)	0.02
Myristic acid (C14:0)	0.05
Myristoleic acid (C14:1)	0.02
Pentadecanoic acid (C15:0)	0.02
Pentadecenoic acid (C15:1)	0.02
Palmitic acid (C16:0)	0.97
Palmitoleic acid (C16:1)	0.13
Heptadecanoic acid (C17:0)	0.02
Heptadecanoic acid (C17:1)	0.02
Stearic acid (C18:0)	0.44
Oleic acid (C18:1)	2.34
Linoleic acid (C18:2)	0.29
Linolenic acid (C18:3)	0.02

Arachidic acid (C20:0)	0.02
Gondoic acid (C20:1)	0.04
Eicosadienoic acid (C20:2)	0.02
Eicosatrienoic acid (C20:3)	0.02
Arachidonic acid (C20:4)	0.02
Eicosapentaenoic acid (C20:5)	0.02
Heneicosanoic acid (C21:0)	0.02
Behenic acid (C22:0)	0.02
Erucic acid (C22:1)	0.02
Docosadienoic acid (C22:2)	0.02
Docosahexaenoic acid (C22:6)	0.02
Tricosanoic acid (C23:0)	0.02
Lignoceric acid (C24:0)	0.02
Nervonic acid (C24:1)	0.02

The meat contains a variety of both saturated and unsaturated fatty acids, with palmitic acid (C16:0) being the most prevalent saturated fatty acid at 0.97%. Oleic acid (C18:1), a monounsaturated fatty acid, stands out with a higher concentration of 2.34%, which is known for its beneficial health properties. Other fatty acids, like stearic acid (C18:0) and linoleic acid (C18:2), were measured in smaller amounts, contributing to the overall fat profile. This diverse range of fatty acids reflects the complex nutritional content of the pork meat from this specific cut. The concentration of palmitic acid in the current sample was 0.97 g/100g, which is in line with other studies that report palmitic acid as a major saturated fatty acid in pork, constituting approximately 30-35% of the total fatty acids (Covaciu et al., 2024). The level of stearic acid (0.44 g/100g) also falls within the range observed in other studies, where it typically contributes around 10-15% of the total fatty acids in pork fat (Covaciu et al., 2024).

Regarding polyunsaturated fatty acids, linoleic acid (C18:2) was present at 0.29 g/100g, a value that aligns with findings from Fernández et al. (2003), who reported linoleic acid levels in pork ranging from 0.2 to 0.5 g/100g. Interestingly, the concentrations of omega-3 fatty acids, such as linolenic acid (C18:3), were found to be minimal in our sample, which is consistent with the low levels typically observed in conventional pork fat (Covaciu et al., 2024).

In general, the fatty acid profile of pork meat from the hind leg in this study is consistent with existing literature, particularly concerning the dominance of oleic acid and palmitic acid. The observed concentrations of stearic acid and linoleic acid also align with previous reports, while the minimal presence of omega-3 fatty acids supports the general finding that conventional pork fat contains low levels of polyunsaturated fats. Overall, the findings from this study are in line with existing literature, confirming the nutritional value and typical fatty acid profile of pork from the hind leg, while also revealing slight variations that may result from different meat processing techniques.

4. CONCLUSION

Comparison between organic and conventional pig production reveals that while organic systems may enhance certain quality traits through improved welfare and dietary practices, conventional systems often focus on efficiency and growth rates, which can lead to trade-offs in meat quality. Organic production tends to yield pork with a more favorable fatty acid profile, enhanced nutritional benefits, and superior sensory qualities, while conventional methods may lead to less desirable health outcomes due to an imbalance in fatty acid composition. The interplay of genetics, nutrition, and production practices ultimately shapes the functional food properties of pork, influencing consumer preferences and market trends. As consumer awareness of health and sustainability continues to grow, these factors will likely play an increasingly important role in meat purchasing decisions.

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OPPORTUNITIES FOR CULTIVATION OF WILD FLAX - *CAMELINA SATIVA* (L.) CRANTZ IN THE PRILEP PRODUCTION REGION

МОЖНОСТИ ЗА ОДГЛЕДУВАЊЕ НА ДИВ ЛЕН - *CAMELINA SATIVA (L.) CRANTZ* ВО ПРИЛЕПСКИОТ ПРОИЗВОДЕН РЕГИОН

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Abstract: *Camelina sativa* (L.) Crantz*, is an oil-bearing crop of the Brassicaceae family. It is used for the production of biofuels, biolubricants, feed for domestic animals and fish, the cosmetic and pharmaceutical industries. Two varieties ("NS Zlatka" and "NS Slatka"), produced at the State Institute of Field and Vegetable Crops in Novi Sad, Republic of Serbia, were used in the research. The two varieties of wild flax grown in the Prilep production area are characterized with good morphological properties and an average grain yield of 1348 kg/ha for "NS Zlatka" and 1204 kg/ha for "NS Slatka".*

Key words: *wild flax, varieties, morphological properties, yield*

Апстракт: *Camelina sativa (L.) Crantz, е маслодајна култура од семејството Brassicaceae. Се користи за производство на биогорива, биолубриканти, добиточна храна за домашни животни и риби, козметичката и фармацевтската индустрија. Во истражувањето се користени две сорти („НС Златка“ и „НС Слатка“), произведени во Државниот институт за полски и градинарски култури во Нови Сад, Република Србија. Двете сорти див лен што се одгледуваат во прилепското производно подрачје се карактеризираат со добри морфолошки својства и просечен принос на зрно од 1348 kg/ha за „НС Златка“ и 1204 kg/ha за „НС Слатка“.*

Клучни зборови: *див лен, сорти, морфолошки својства, принос*

1. INTRODUCTION

One of the less represented oil plant species is wild flax - *Camelina sativa* (L.) Crantz, which is often recognized as a cultivated plant that can be one of the main candidates for the future European bioeconomy, mainly due to its unique favorable composition of the high content of polyunsaturated fatty acids. Wild or also known as false flax *Camelina sativa* (L.) Crantz, is an annual, self-fertile, oil-bearing plant belonging to the *Brassicaceae* family (Berti et al., 2016). The word *camelina* comes from the Greek word *chamai*, which means short, dwarf, and the word *linion*, which means flax (Cvejić et al., 2016). The products obtained from this plant have been

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used since ancient times in the food, in cosmetic industry for skin care products, soaps, and soft detergents (Ehrensing and Guy 2008), alternative and veterinary medicine, as well as for the production of biofuels and biolubricants (Zubr, 1997). Interest in this crop has increased in recent years due to the possibility of cultivation as a second crop, the short vegetation period 85-100 days from emergence to harvest (Gehringer et al., 2006; Marjanović Jeromela et al., 2021; Kuzmanović et al., 2021), the ability to adapt and grow in stressful conditions, the modest requirements for cultivation on less fertile soils with reduced fertilization and irrigation (Moser 2010; Putnam et al. 1993; Yuan and Li 2020; Zubr 1997), the relatively high seed yield and oil content in it (Gugel and Falk 2006; Krohn and Fripp 2012). This plant species also helps the ecosystem by absorbing plant nutrients in the root system and preventing their loss, then serving as a foraging environment for bees and contributing to reduced weed occurrence due to the dense seeding pattern (Berti et al. 2016, 2017; Eberle et al., 2015; Gesch and Cermak 2011). Wild flax is well suited for production in temperate climates (Cvejić et al., 2016).

Camelina sativa (L.) Crantz is an annual plant species with a spindle-shaped root, which is deep and does not impoverish the soil in terms of moisture. The stem is branched, mostly herbaceous, although it may become woody at maturity. The leaves are arrow-shaped. They are sharp, stationary, 5-10 cm long with smooth edges. The flowers are small with a pale yellow or greenish-yellow color and have 4 petals. Flax belongs to self-fertilizing plant species. The fruit is a pear-shaped shell containing the seed. The seeds are small, mostly yellow, oblong and characterized by an uneven surface. The mass of 1000 flax seeds is about 2-3 g (Marjanović-Jeromela et al., 2016).

In our country, this culture is not yet grown and there are no literary data from official research about it. Keeping this in mind, we set ourselves the goal of performing investigations on some important morphological properties of two introduced varieties of *Camelina sativa* (L.) Crantz in the Prilep production region.

The results of this research helped us to determine the most important morphological characteristics and the average seed yield of the two Novi Sad *camelina* varieties and the tendency for its spread and cultivation in the territory of the Republic of North Macedonia

2. MATERIALS AND METHODS

The research experiment on the wild flax *Camelina sativa* (L.) Crantz was placed on a colluvial-deluvial soil type with a low content of humus and nitrogen and medium availability of phosphorus and potassium. In the experiments, two genotypes of Serbian selection NS Zlatka and NS Slatka, which were created in the Republic of Serbia – Institute of Field and Vegetable Crops in Novi Sad (Marjanović-Jeromela et al. 2016), were tested. The experiment was set up in a randomized block system in three repetitions on the surfaces of the JNU Tobacco Institute - Prilep with coordinates N 41^0 22, 135', E $021^0$30, 707' and an altitude of 677 m. The dimension of the basic plot was 10 m^2, with 8 rows in the plot and an inter-row distance of 0.25 m. All necessary agrotechnical measures and adequate amount of fertilizer were fully applied to manifest the highest genetic potential of the varieties. Autumn basic tillage was carried out at a depth of 0.25 m, and during the vegetation the crop was fed with KAN (+/-27%) at 42 g per row. Sowing was done on April 8, while harvesting on July 8. Harvesting was done at full maturity, manually, by pulling out whole plants with the root, with separate bunches formed on the plot itself for each replicate). During the 90-day vegetation period, total precipitation of 80 mm and an average daily temperature of about 19°C were recorded in the Prilep production region.The following important parameters were analyzed in this paper: plant height, root length, number of branches per plant, number of pods per plant, average number of plants per m^2 and average seed yield per unit area.

3. RESULTS AND DISCUSSION

One of the first morphological characteristics examined was the height of the above-ground part of the plant, which represents the distance from the base of the stem at ground level to its top. The optimal height ensures greater resistance of the plants to lodging, and therefore a higher and more stable yield. In the NS Zlatka variety, the maximum height of the stem was 110 cm, in the three repetitions, while the minimum height was 80 cm. The Novi Sad variety NS Slatka, on the other hand, was distinguished by a maximum height of 101 cm, and a minimum height of 81.5 cm. According to the obtained results, it can be noted that the average height of the variety NS Zlatka is distinguished by a higher height, which on average is 94.45 cm, while the Novi Sad variety NS Slatka is distinguished by a lower stem by 0.86 cm, 93.58 cm.

Table 1. Descriptive s for plant height of used Camelina's varieties: mean, maximum value (max), minimum value (min) and average of three repetition

Researched varieties	***Min***	***Max***	***Average of three repetitions***
NS Zlatka	80 cm	110 cm	94,45 cm
NS Slatka	81,5 cm	101 cm	93,58 cm

The stems of the camellia can be more or less branched depending on the variety and the density of sowing. A second morphological characteristic examined is the number of primary lateral branches originating from the main plant stem. The average number of lateral branches at the variety NS Zlatka from the three repetitions was 7. The variety NS Slatka was also characterized by a maximum average number of 7 branches. According to this morphological characteristic, it can be noted that there are no differences in the number of lateral branches between the two studied varieties.

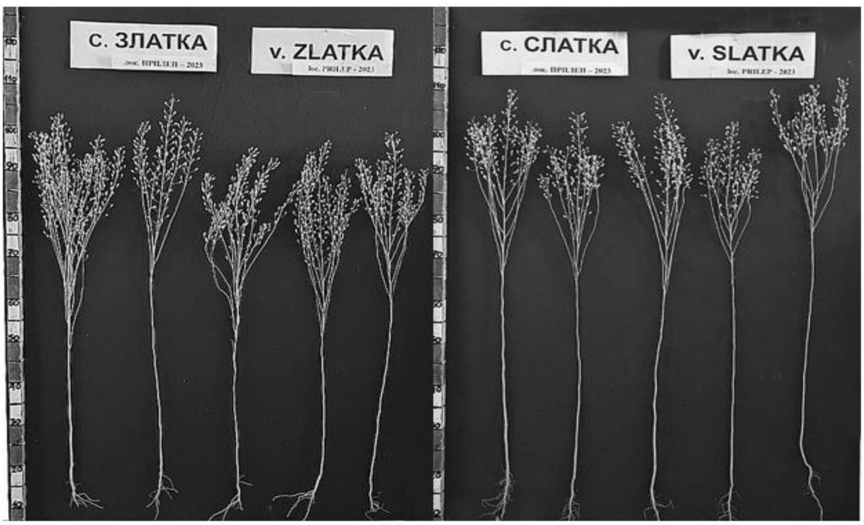
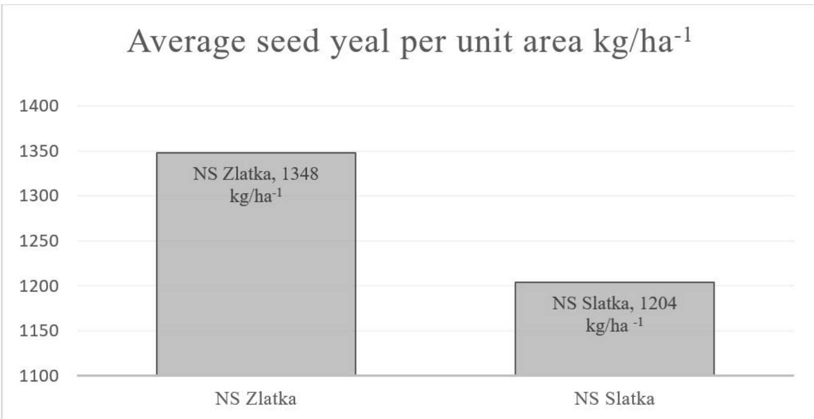


Figure 1. Number of lateral brunches at NS Zlatka and NS Slatka variety

One of the more important indicators that reflect the productivity of Camelina sativa is the number of pods per plant. Depending on the physiology of the plants and the conditions for growth and development, the number of pods in the examined cultivars NS Zlatka and NS Slatka varies from 100 to 300. In the research where the number of pods per plant was manually counted, a maximum number of 289 pods was recorded in both varieties. The average number of pods counted in the variety NS Zlatka was 184, which is 20 pods richer than the variety NS Slatka, which has an average of 164 pods per plant.
The average number of plants per unit area is one of the most significant elements of yield. This property is directly dependent on climatic factors and available moisture during vegetation. The sown seed was tested in the laboratory and was determined that it was characterized by 80% germination. From the obtained results, it can be noted that the variety NS Slatka is distinguished by an average number of 7,014,000 plants per ha^{-1}, while the variety NS Zlatka has 787,000 less plants, which means 6,277,200 plants per ha^{-1} for this variety.

The yield is the most relevant indicator of the success of growing *Camelina sativa* (L.) Crantz in our conditions. The obtained yield depends primarily on the genetic characteristics of the variety, on its adaptation to soil and climatic conditions and on the applied agrotechnical measures. According to research done in the Prilep region, there is no significant difference in seed yield between the two studied varieties. From figure 1, it can be concluded from the calculations that the variety NS Zlatka, as the highest variety, gives the highest seed yield, which is about 1348 $kg/ha^{-1,}$ while the second variety NS Slatka, is distinguished by a significant seed yield, which is 1204 kg/ha^{-1}.



Graph 1. Average seed yield per unit area kg/ha^{-1} of two varieties of *Camelina sativa* (L.) Crantz, (NS Zlatka and NS Slatka) in the Prilep region.

4. CONCLUSION

Camelina sativa (L.) Crantz is an oil-bearing plant with a short vegetation period of 85 – 100 days. Wild flax is a culture that has high environmental adaptability, quickly absorbs water and nutrients from the soil, has little need for mineral and organic fertilizers and is characterized by good tolerance to pests and diseases. Plant height is a significant morphological characteristic that plays a key role in the production of a plant with high lodging and breakage resistance and a high harvest index. In view of the presented morphological characteristics of the investigated varieties of *Camelina sativa* (L.) Crantz, it can be concluded that these varieties are quite adaptable to our climatic conditions and there are no major deviations in terms of the average seed yield. Also, there are several necessary prerequisites for the introduction of this plant species into production, such as: enrichment of collections with new genotypes of wild flax, higher location and more years of practical research in order to assess agronomic and quality properties, crossing in selected varieties for optimal sorting and creating genotypes (Marjanović Jeromela et al., 2022). The obtained results of this research can greatly help for the introduction, testing and development of other more profitable and profitable varieties of this oil-bearing crop in different regions of R. North Macedonia.

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ANALYSIS OF SUCCESSFUL AND UNSUCCESSFUL TECHNOLOGICAL ENTREPRENEURIAL VENTURES

ANALIZA USPEŠNIH I NEUSPEŠNIH TEHNOLOŠKIH PREDUZETNIČKIH PODUHVATA

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Abstract: *Technological entrepreneurship represents one of the most dynamic and challenging sectors of the modern economy. The success of technological entrepreneurial ventures often depends on a variety of factors, including innovation, market demand, access to capital, strategic leadership, and the ability to adapt to rapid changes. While some companies like Apple, Google, and Tesla have become global leaders, many others, despite large investments and ambitious ideas, have failed to survive in the market.*
The analysis of successful and unsuccessful technological ventures provides a better understanding of the key factors contributing to long-term sustainability and growth. By comparing positive and negative examples, we can identify patterns for success and mistakes that entrepreneurs can avoid in the future. This paper explores the main characteristics of technological entrepreneurial initiatives, along with an analysis of the key reasons for their success or failure, offering insights into the challenges and opportunities that modern technological entrepreneurs can expect.

Key words: *entrepreneurship, technological innovations, market sustainability, market adaptation, comparative analysis*

Abstract: *Tehnološko preduzetništvo predstavlja jedan od najdinamičnijih i najizazovnijih sektora savremene ekonomije. Uspeh tehnoloških preduzetničkih poduhvata često zavisi od niza faktora, uključujući inovativnost, tržišnu potražnju, pristup kapitalu, strateško vođenje i sposobnost prilagođavanja brzim promenama. Dok su neka preduzeća poput Apple-a, Google-a i Tesle postala globalni lideri, mnoga druga, i pored velikih investicija i ambicioznih ideja, nisu uspela da opstanu na tržištu.*
Analiza uspešnih i neuspešnih tehnoloških poduhvata omogućava bolje razumevanje ključnih faktora koji doprinose dugoročnoj održivosti i rastu. Kroz poređenje pozitivnih i negativnih primera, možemo identifikovati obrasce uspeha i greške koje preduzetnici mogu izbeći u budućnosti. Ovaj rad istražuje glavne karakteristike tehnoloških preduzetničkih inicijativa, uz analizu ključnih razloga za njihov uspeh ili neuspeh, pružajući uvid u izazove i prilike koje savremeni tehnološki preduzetnici mogu očekivati.

Key words: *preduzetništvo, tehnološke inovacije, tržišna održivost, prilagođavanje tržištu, komparativna analiza*

1. INTRODUCTION

The word entrepreneur is of French origin and essentially refers to a person who acts as an intermediary between individuals or groups. Entrepreneurs are characterized as pragmatic,

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flexible, and adaptable personalities, who strive to adjust entrepreneurial operations to the changing conditions of the market (Leković, 2015).

The field of technological entrepreneurship is in its infancy compared to areas such as economics, traditional entrepreneurship, and management. According to Bailetti (2012), the technological entrepreneurship is defined as an investment in a project that brings together and allocates specialized individuals and heterogeneous resources, closely related to scientific and technological knowledge, with the goal of creating value for the company. As defined in this way, technological entrepreneurship applies equally to both newly formed and well-established companies, which have the same right to engage in technological entrepreneurship as startups.

Technological entrepreneurship involves specialized human resources, utilizing their skills and abilities in the joint exploration of scientific and technological changes, for the benefit of the company. Therefore, the concept of technological entrepreneurship can best be understood as a phenomenon of joint production, relying on a team of specialized individuals from various fields. Some, or all, members of the team become part of the technological path they are attempting to shape in real time (Garud, Karnoe, 2003).

Technological entrepreneurship is not tied to a single individual or the inventions they introduce. It refers to the management of joint research and exploitation, where each member has their role and responsibility in collaboration and collective progress toward achieving common goals. It is characterized by investing in business projects and their implementation, not just recognizing technological or market opportunities (Davis, 2023).

Famous examples of technological entrepreneurial ventures:
Many entrepreneurial ventures originated from the technological sector as small businesses, gradually expanding and eventually becoming global giants (Bhargav, 2023). Some examples of such companies are:

- Apple – Steve Jobs
- Google - Larry Page and Sergey Brin
- Microsoft – Bill Gates
- Facebook – Mark Zuckerberg
- TikTok – Zhang Yiming
- Spotify – Daniel Ek and Martin Lorentzon
- Netflix – Reed Hastings and Marc Randolph
- Airbnb – Brian Chesky, Joe Gebbia, and Nathan Blecharczyk

2. GLOBAL TRENDS IN TECHNOLOGICAL ENTREPRENEURSHIP

Technological startups, often from their inception, target global markets, which is characteristic of the so-called "born-global" companies (Knight, Cavusgil, 2004). Early internationalization of a company is characterized as a significant phenomenon, emphasizing the importance of the "born-global" concept and the need for researchers and practitioners to understand the factors that influence the success of global technological startups (Badzinska, 2017). The born-global concept refers to entrepreneurial startups that, from the very beginning, or shortly after establishment, strive to achieve a significant portion of their revenue through sales of products in international markets (Knight, Cavusgil, 2004). Owners and employees in these companies succeed in transforming interdisciplinary knowledge into practical applications, recognizing market gaps and opportunities, acting proactively, seeking changes, and adapting to them in order to implement innovative solutions across various segments of the global environment (Badzinska, 2017).

Digitization and networking as global trends enable startups to overcome traditional barriers to entering international markets, such as geographical distance and logistical constraints (Badzinska, 2016). By using digital tools like e-commerce, social media, and big data analytics, entrepreneurs can quickly analyze market opportunities and launch their products globally. Global networks not only facilitate communication and collaboration with partners but also provide access to key resources such as finance, expertise, and market information. This digital connectivity plays a crucial role in creating flexible business models that are adaptable to different market demands, allowing startups to grow rapidly on the international stage (Knight, Cavusgil, 2004; Gabrielsson et al., 2012).

The success in global markets depends on the entrepreneur's ability to innovate, adapt to the specifics of different markets, and effectively utilize digital resources and technologies (Knight, Cavusgil, 2004; Badzinska, 2016). Innovations allow companies to stand out in competitive markets, while adapting to various market conditions, including cultural and regulatory differences, helps in creating long-term sustainability on the global stage. The use of digital tools and platforms plays a key role in reducing costs, optimizing business processes, and enabling easier access to new markets (Gabrielsson et al., 2012). Global networks and online communication enable startups to quickly scale their operations and engage consumers worldwide, creating new opportunities for growth and competitiveness.

3. FACTORS AFFECTING THE SUCCESS OF TECHNOLOGICAL ENTREPRENEURIAL VENTURES

There are numerous reasons why entrepreneurs decide to start a business, although the line between success and failure is very thin. Not all entrepreneurs decide to try again after experiencing failure, which is why it is important to explore how individuals who experience failure in startups manage to accumulate the energy for entrepreneurial activities, as well as what motivates them to start a business again (Pan et al., 2022).

Authors Pan, Tsai, Popan, and Chang (2022) conducted a study whose results show that, in the process of starting a business for the third time, the personal motivation of the entrepreneur, as well as the ability to learn from failure, along with family support, were key to continuing their attempts despite the risk of repeated failures.

Indispensable factors also include cultural factors. These encompass social norms, values, as well as the level of tolerance for a risk. In this way, societies that support innovation and entrepreneurship often encourage the development of startups through a more favorable perception of failure and greater willingness to take risks (World Economic Forum, 2024). Cultural intelligence and an understanding of local customs play a significant role in building relationships and adapting products to local needs, which is especially important for global entrepreneurs (Bhargav, 2023).

These are some of the general factors that enable an entrepreneur to maintain positive energy throughout their entrepreneurial journey, with the goal of achieving a successful outcome. General factors of entrepreneurial ventures, in addition to those mentioned above, such as experience, education, and innovation, overlap with factors that affect technological entrepreneurial ventures (Mandal, Diana, 2022).
However, technological ventures stand out due to specific factors, such as their importance for the development of new technologies or disruptive innovations, quick responses to changing market and technological trends, and a focus on research and development as the foundation of competitiveness (Rothaermel, 2012). For technological entrepreneurial ventures, the key success factors are significantly shaped by technological innovations, digital knowledge, and the ability

to adapt to a dynamic business environment. Below, specific factors that influence the initiation of a technological venture are identified (Ardelean, 2021; Oyeyemi et al., 2024).

1. Technological knowledge and innovations – Understanding and implementing modern technologies such as artificial intelligence, block chain technology, and data analytics are crucial for creating a competitive advantage. Technological knowledge, when used creatively, enables the creation of innovative products and services that replace traditional market offerings.
2. Entrepreneurial orientation – A combination of innovation, proactivity, and willingness to take risks contributes to making strategic decisions and exploiting market opportunities. This approach enhances the long-term growth and profitability of technological startups.
3. Adaptability and agility – For business survival in the digital age, successful technological entrepreneurs often focus on flexibility and the ability to adapt quickly to changes in the business environment.
4. Networking and social capital – Connecting with investors, mentors, and other entrepreneurs provides key resources and support to overcome challenges, especially in the IT sector.
5. Government support and infrastructure – The availability of subsidies, training programs, and developed digital infrastructure significantly contribute to creating a favorable ecosystem for technological ventures, especially in countries with a developed economy.

On the other hand, according to (Mandal & Diana, 2022), the three factors linked to the failure of entrepreneurial ventures are fear of failure, economic instability, and corruption.

Fear of failure negatively affects the entrepreneurial intention, creativity, and innovation, as individuals tend to avoid risks that could lead to success. Entrepreneurs with a high level of self-confidence and emotional stability often overcome difficult situations better and continue with their business ventures, as opposed to those without these traits, who may be more prone to abandoning their ideas (VanBockel, 2024).

An unstable economy often limits access to capital, increases operating costs, and reduces consumers' purchasing power. This leads to more difficult conditions for the growth and sustainability of entrepreneurial ventures. For example, during global economic crises such as those in 2008 and 2020, small entrepreneurs faced closures due to reduced consumption and limited access to credit (OECD, 2020). Successful entrepreneurs often adapt to unstable economic conditions through strategies of diversification and flexibility. Additionally, government support through subsidies and grants can be crucial for survival in unstable conditions.

Corruption can limit entrepreneurial activities through informal payments, nepotism, or favoring large companies, which reduces motivation to enter the market and creates unfair competition. In the face of the challenge of corruption, businesses can address it by implementing digital systems, such as electronic company registration. This contributes to transparency, thereby reducing the possibility of corrupt activities, especially in environments with complex administrative procedures. Digital transformation improves efficiency, reduces costs, and increases trust in the business environment (Dobrovolska, Rozhkova, 2024).

4. DIFFERENCES BETWEEN DEVELOPED AND LESS DEVELOPED MARKETS WHEN STARTING A TECHNOLOGICAL STARTUP

As examples of countries with more developed markets, Japan and Germany emerge. Entrepreneurs have access to high-quality infrastructure, advanced technologies, and a favorable financial environment. For example, Japan is known for its high-tech industries, which are based on efficient transportation networks and strong government support for research and development. Similarly, Germany has a system of favorable loans for startups, as well as a high-quality vocational education system that facilitates the finding of skilled labor (GEM, 2023).

Mercari, as one of the most well-known technological startups in Japan, utilizes Japan's advanced infrastructure and digital connectivity to enable seamless online sales for users. Mercari is an e-commerce application that became the first Japanese "unicorn" (GEM, 2023).

As an example of a startup from Germany, the company Celonis was founded in Munich and is known for developing software for process analytics. The company leveraged the availability of government startup programs and proximity to technological universities, which led to rapid growth and global expansion.

On the other hand, countries like Nigeria and Bangladesh face challenges such as the lack of basic infrastructure, limited access to the internet, and the absence of stable legal frameworks. As a result, in Nigeria, entrepreneurs often focus on securing their own energy sources due to the unstable power grid, while in Bangladesh, financing technological innovations is difficult due to the underdeveloped banking system.
The startup Flutterwave, a fintech company founded in Nigeria, facilitates payments between various African countries, as well as countries around the world. Despite facing challenges such as an unstable power grid and regulatory barriers, the startup has managed to attract international investors, thereby expanding the services it offers (African Tech Startups Funding Report, 2023).

The company Pathao from Bangladesh patented an application for transportation and food delivery, and stands out for having leveraged the increasing penetration of smartphones in the country. The app was developed despite the lack of basic infrastructure, using flexible business models and local knowledge (World Economic Forum, 2023).

5. ANALYSIS OF ENTREPRENEURIAL ECOSYSTEMS

In this section, we provide an overview of the entrepreneurial ecosystems in the United States, Israel, and Serbia to identify the key characteristics of these ecosystems. Israel and the United States, with significantly developed economies, implement numerous entrepreneurial practices, for which conditions for improvement also exist in Serbia. Therefore, a comparative analysis of entrepreneurship in the USA, Israel, and Serbia highlights the similarities and differences between the ecosystems, as well as key lessons that explain which practices from the USA and Israel can be applied in Serbia.

5.1. Entrepreneurial ecosystem in the USA

The United States of America has long been recognized as a global leader in entrepreneurship, innovation, and the creation of business opportunities, with a 16% TEA (Total Early-Stage Entrepreneurial Activity) (GEM, 2023). The country boasts the most developed economy in the world, with a gross domestic product exceeding $25.5 trillion in 2022. Therefore, this economic strength provides a solid foundation for entrepreneurs to develop and expand their businesses. The U.S. offers a strong financial infrastructure, including venture capital firms, angel investors, and well-developed capital markets (ResearchFDI, 2024).

Entrepreneurial spirit in the U.S. is fostered by cultural diversity. Diversity encourages creativity and innovation, as entrepreneurs from different backgrounds bring unique perspectives and experiences. Studies have shown that cultural diversity increases the rate of entrepreneurship, as it enables the exchange of ideas and approaches, leading to a greater number of entrepreneurial initiatives (Sobel et al., 2010).

In addition to the above, the U.S. is characterized by a highly educated workforce. According to data from the U.S. Census Bureau, in 2021, 37.9% of individuals over the age of 25 had a bachelor's degree or higher qualification (US Census Bureau, 2022).

The United States has a strong infrastructure that supports the growth and development of startups. This includes world-renowned research institutions such as MIT, Stanford, and Harvard, which not only produce the latest research and innovations but also provide a constant influx of talented graduates who later become successful entrepreneurs (Glasner & Glasner, 2024). In this way, the U.S. is ensured a highly educated workforce that includes a large number of STEM professionals (US Census Bureau, 2022). Collaboration between academia, industry, and government organizations ensures that entrepreneurs have access to cutting-edge research, technological advancements, and a highly skilled workforce (Innovation Centre Denmark, 2019).

Additionally, the U.S. is home to numerous business incubators, accelerators like Y Combinator, and co-working spaces that provide startups with the resources and support that they need in order to succeed. There is also a well-developed network of investors, including angel investors and venture capital funds (CB Insights, 2023).

The U.S. government plays a crucial role in fostering entrepreneurship through various policies and regulations. Programs such as the Small Business Administration (SBA) provide loans, grants, and training (WEF, 2024).
American culture encourages individuals to pursue their dreams and disrupt traditional industries. This cultural sphere is a significant factor in the success of the U.S. entrepreneurial ecosystem, as it allows entrepreneurs to learn from their failures and improve their ideas. Society celebrates success stories and views failures as opportunities for learning. This culture creates an environment where individuals are inspired to follow their entrepreneurial ideas, contributing to the overall dynamism of the ecosystem (Elhajjar, 2024).

The United States is a leader in technological advancements across various fields. The culture of innovation has created favorable conditions for entrepreneurs to develop new products and services that meet market needs and address global challenges. Additionally, the U.S. has a well-developed intellectual property protection system, which encourages innovation by safeguarding the rights of inventors and entrepreneurs (European Commission, 2024).

According to data from 2021, the United States led global investments in research and development, with 238 American companies accounting for 52% of total global investments in healthcare (European Commission, 2024).
Strong economic and political ties with countries around the world allow U.S.-based startups to expand their operations into international markets, giving them relatively easy access to new markets (Plug & Play, 2024).
Some of the most successful examples of U.S. technology startups include "Apple Inc.", "Tesla", "Google", "Amazon".

5.2. Entrepreneurial ecosystem in Israel

Israel is a country that has been characterized by a high level of entrepreneurship, particularly in the high-tech sector, since the 1990s. The government of the country established dozens of incubators to enable entrepreneurs to start businesses in a protected environment. At the same time, the creation of the venture capital industry was encouraged through programs such as Yozma, aimed at promoting financial investments in new startups (Almor & Heilbrunn, 2014). With the highest startup density in the world, Israel has become known as the 'Startup Nation' and represents the second-largest startup ecosystem globally, right after Silicon Valley (INSME, 2020)

At the same time, over the last two decades, Israel has stood out by listing hundreds of entrepreneurial firms on the NASDAQ stock exchange, which specializes in high-tech companies. Additionally, Israeli startups are also listed on other foreign stock exchanges (Sperling, 2005). Israel is home to over 6,600 active technology companies across various sectors, which attracts many multinational companies to either acquire businesses in Israel or open research and development centers, of which there are currently more than 300 (INSME, 2020).

Cultural factors have a significant impact on Israeli entrepreneurship. Military training, particularly in elite technological units such as Unit 8200 and Talpiot, provides young Israelis with technical skills, team dynamics, and leadership, which then reflect on entrepreneurial ventures (Senor & Singer, 2009). Over the years, the military sector has evolved into a high-tech industry, generating numerous spin-off companies (Villasenor, 2018).

In addition, curiosity, innovation, and failure are valued as opportunities for learning, which encourages creativity and a willingness to take risks. In this way, failure is not seen as an obstacle, but rather as part of the path to success (Senor & Singer, 2009).
Historically, Israel has been identified as a country of immigration. Between 1989 and 2006, one million Jews migrated from the former Soviet Union to Israel, bringing with them a rich cultural diversity. They were highly educated, although they were less integrated into the mainstream of society. This migration doubled the size of the scientific and technological community in Israel, which certainly left a significant mark on the entrepreneurial ecosystem (Balachandran, 2019).

Israeli parents often sacrifice personal comfort and place great importance on providing the best possible education for their children. Many Israeli students believe that a strong foundation in mathematics helps them engage in research related to physics, chemistry, biology, and engineering. Preparations for final exams represent a high cost for families, with some spending up to 25,000 shekels annually (1 USD $\approx$ 3.5 shekels). In this way, a skilled workforce is created, ready for technological challenges (Balachandran, 2019).

Researches indicate that collaboration and increased connectivity between universities, research centers, companies, and government entities create an environment that fosters innovation. Even if a person does not have a direct connection with an expert in a desired field, it is likely that someone in their network knows someone with a relevant contact, facilitating the establishment of a connection. Networks are often formed during military service, where people develop close relationships and build mutual trust (Villasenor, 2018).
There is a tendency to assign high-responsibility tasks to newcomers at the start of their careers. For example, one employee was entrusted with a multi-million dollar project, even though they had no prior work experience. Early exposure to such situations greatly influences the type of citizens Israel produces. People mature quickly, and when they face difficult business situations, they are well-prepared to handle stressful and high-risk circumstances (Villasenor, 2018).

Israelis are very informal, which often surprises foreigners. For example, it is a soldier's duty to disobey orders from superiors if they believe the orders are incorrect. They are very direct in expressing their opinions, and this approach makes it easier to question the status quo and rules, which also reflects in the business world. Israeli citizens are also quite competitive with each other, which acts as an incentive for launching startups (Villasenor, 2018).

Israel stands out as the starting point for many successful technological entrepreneurial ventures, such as "Waze," which was acquired by Google in 2013, "Mobileye," which was acquired by

Intel in 2017, and "Fiverr," one of the most successful startups in the digital services field, which had a successful initial public offering (IPO) on the New York Stock Exchange (NYSE) in 2019. As a leader in cybersecurity, "Check Point Software Technologies" stands out, while "SolarEdge Technologies" leads in renewable energy technologies.

5.3. Entrepreneurial ecosystem in Serbia

In the late 1980s, a series of macroeconomic measures influenced the development of the small and medium-sized enterprise (SME) sector in Serbia. The Yugoslav government established the Agency for Small and Medium Enterprises, which laid the foundation for further institutional and legal frameworks. The liberalization of trade regulations created legal conditions for the establishment of joint-stock and private enterprises, while measures were adopted to enhance the competitiveness and economic efficiency of the SME sector, leading to the founding of a large number of private enterprises (Petković & Đukić, 2018).

Since 2003, the government has implemented systemic measures to promote SME development in three key areas: the creation of development policies, the establishment of support institutions (incubators, technology centers, industrial zones), and the development of direct financial support programs (grants, loans), as well as various forms of non-financial assistance (training, consulting, information). The most significant measures include support for research, innovation, development in underdeveloped areas, startups, business infrastructure, and SME networking (Petković & Đukić, 2018).

According to the statistics of the Business Registers Agency (APR) in the Republic of Serbia, there are currently 137,668 business entities in operation, along with more than two and a half times as many entrepreneurs—totaling 351,003. The number of entrepreneurs in Serbia has significantly increased by nearly 50,000 between 2021 and 2023, which is attributed to the transition from the informal to the formal economy. When it comes to entrepreneurial activities, consulting services, restaurants and mobile catering businesses, computer programming, hairdressing and beauty salons, and road freight transport stand out (StarTech, 2024).
Entrepreneurs in Serbia often use their own capital and strive for personal freedom and independence, which allows them greater control over their businesses. However, they face challenges such as bureaucracy, political instability, and economic uncertainty, which tend to hinder the development of entrepreneurial ventures (Radojevich-Kelley, 2011).

Although entrepreneurship in Serbia is developing, it is still in the process of adapting to the market economy of a post-socialist society. Despite the progress in the recent years, entrepreneurs continue to face challenges such as complex administrative procedures, a lack of necessary infrastructure and investment, and an inadequate regulatory framework. Nevertheless, entrepreneurs play a significant role in employment and economic growth by providing creative solutions and contributing to new industrial sectors (Radojevich-Kelley, 2011).
On the other hand, according to Ceves (2018), there are significant potentials for entrepreneurial development in Serbia, particularly in the small and medium-sized enterprise (SME) sector. These potentials are realized through innovation, digitalization, and sustainable development. The key strategies for unlocking this potential include:

- Developing business infrastructure, including business incubators and clusters
- Providing financial support through loans, subsidies, and incentives for innovative projects
- Supporting exports and networking with international markets
- Focusing on rural development and regional potential
- Promoting an entrepreneurial mindset by encouraging women's entrepreneurship, youth entrepreneurship, and social entrepreneurship

Unemployment is often a key motivation for starting a business in Serbia. Additionally, there is a growing segment of individuals who see entrepreneurship as an opportunity for innovation and growth (Ceves, 2018). When it comes to technological entrepreneurship, despite the brain drain, Serbia is characterized by a highly educated IT workforce (Relocation Serbia, 2025).
According to a 2018 study by the Center for Advanced Economic Studies, when it comes to preferred types of employment in Serbia, one-third (30%) of citizens stated that they would like to start their own business, which includes opening a company, agency, or working independently. However, two-thirds (65%) of citizens expressed a preference for salaried employment, primarily in the public sector. Only 5% of respondents stated that they would prefer to work for a salary in the private sector. These findings indicate that the inclination toward risk-taking and entrepreneurship in Serbia is not at a high level (Ceves, 2018).

Serbian citizens recognize that entrepreneurship provides employment opportunities, though they believe that society does not offer sufficient support for entrepreneurs. The study also found that owners of small businesses tend to have relatively low social prestige, whereas employment in the public sector or private companies with foreign capital is considered more prestigious. This perspective is common among entrepreneurs and public opinion leaders, who argue that greater support for entrepreneurship is necessary to ensure economic sustainability (Ceves, 2018).

On the other hand, although limited access to capital remains a challenge, Serbia offers several programs aimed at improving the entrepreneurial landscape. According to StarTech (2024), current support programs in Serbia focus on business modernization, market efficiency enhancement, and entrepreneurship development. These include:

- Advisory support for small and medium-sized enterprises (SMEs) (EBRD): This program fosters SME growth and improvement by encouraging collaboration with domestic and international experts in areas such as strategy, marketing, organization, ICT, financial management, and energy efficiency.
- National cashless payment initiative "A Better Way": This initiative aims to improve and promote cashless payments in both the private and public sectors.

Additionally, several programs support startups in their early stages of development, including: "Smart Start" by the Innovation Fund, "Raising Starts" by the Belgrade Science and Technology Park. Intensive learning, working, and networking programs such as "ParkUP!" by the Belgrade Science and Technology Park and "Startup Weekend" organized by DSI/Preduzmi Ideju have also emerged.
However, for the entrepreneurial ecosystem to mature further, the current number of programs is insufficient. There is a need for broader participation and the creation of new programs to strengthen the ecosystem (Preduzmi Ideju, 2024).

Entrepreneurs in Serbia often face high taxes and administrative costs, which significantly hinder business operations (Zaštitnik preduzetnika i privrednika Srbije, 2024). On the other hand, administrative procedures have been streamlined through digitalization. On May 17, 2023, Serbia introduced a comprehensive digital transformation, requiring all business registration processes to be conducted exclusively through the e-registration application of the Business Registers Agency (APR). This shift has rendered paper applications obsolete, increasing efficiency and convenience in business registration (Eftimov, 2023).

Despite being a smaller country, Serbia has produced several successful tech startups, the most notable being Nordeus, known for the game Top Eleven. Other standout companies include Seven Bridges in bioinformatics, Frame, which is now part of Nutanix, Drytools, now known as Tenderly, and HTEC Group, which provides software and hardware development services to global clients.

5.4. Comparative analysis of entrepreneurial ecosystems in the USA, Israel, and Serbia

Based on the previous overview of the entrepreneurial ecosystems of the USA, Israel, and Serbia from Chapter 5, Table 1 presents a comparative analysis of these ecosystems. Through the criteria: "infrastructure, financial support, cultural factors, education and talent, market access, business costs, main challenges, examples of successful startups," the advantages and disadvantages, key characteristics, as well as the similarities and differences of the given ecosystems, are highlighted.

In this way, the shortcomings of each ecosystem can be observed, particularly the ecosystem of Serbia, which is the least developed compared to the others. The aim of the research is to identify the weaker criteria of the ecosystem so that they can be improved based on best practices, where there is enough room for enhancement with the availability of necessary resources.

Table 1. Comparative Analysis of Entrepreneurial Ecosystems by Criteria

Criteria	the USA	Israel	Serbia
Infrastructure	Developed infrastructure, which includes successful universities (MIT, Stanford), as well as incubators *(Y Combinator).*	The presence of strong incubators and research and development centers, supported and encouraged by the government.	Limited infrastructure, although with investments in the development of business incubators, support programs, and the digitization of part of the administration.
Financial support	A wide network of investors, including *venture capital* funds, *SBA* programs, and angel investors	The *Yozma* program stands out, as it is key to the development of the venture capital sector, along with the presence of multinational companies.	Insufficient access to capital as the biggest challenge
Cultural factors	A culture of innovation and tolerance towards failure is encouraged, while cultural, ethnic, professional, and ideological diversity fosters creativity	Military training is responsible for developing good technical skills and leadership, while failure is valued as a lesson	There is a low tolerance for risk, and entrepreneurship is often driven by necessity, that is, unemployment
Education and talent	The focus is on the STEM fields, and the qualification level of employees is high	There is a significant presence of technical education, along with a strong university system	A highly educated IT workforce, although with a brain drain to foreign countries
Market access	Eased expansion into global markets, due to a developed network of contacts and infrastructure	The domestic market is limited, but with a strong orientation towards global expansion	Focus on the local market, with potential for growth through exports and global networking
Business costs	Business costs are high, including labor and office space expenses	Moderate costs, along with the advantage of government support	High taxes and administrative costs, except for registration fees
Main challenges	A large number of competitors and high business costs	Political instability and dependence on foreign markets	Bureaucracy, corruption, limited access to capital, low risk tolerance
Examples of successful startups	Apple Inc, Google, Tesla, Amazon	Waze, Mobileye, Fiverr, SolarEdge	Nordeus, Tenderly, Seven Bridges

Source: Author,

Serbia's infrastructure in terms of entrepreneurship is limited, although progress is seen in the partially digitized administration. Further development of business incubators and universities is recommended. The biggest identified challenge is the insufficient access to capital. This is confirmed by the European Commission's 2024 report for Serbia, which recommends further increasing funding for financial and technical support for SMEs (StarTech, 2024).
When it comes to the cultural aspect, Serbia, as a country with a low risk tolerance, should look to the cultural characteristics of the USA and Israel. In the USA, the culture of innovation and tolerance encourages entrepreneurs to experiment more freely and promote their ideas, while Israel provides an example of how military training contributes to the development of technical skills and leadership. Therefore, it is crucial for Serbia to encourage similar values, such as tolerance towards failure and an innovative approach, through the education system and public campaigns that promote entrepreneurship as a desirable career choice.

Highly educated IT professionals in Serbia contribute to the launch of technological startups, but there is an issue of talent drain, as these professionals are attracted by better business conditions abroad. To retain talent, it is essential to improve the previously described criteria. However, despite the high outflow of IT professionals, the image of technological entrepreneurship in Serbia is better than that of more traditional entrepreneurial sectors.

Following the examples of the USA and Israel, it is necessary to encourage global networking and business operations. Additionally, Serbia faces the same challenge as the USA in terms of high business costs. It is noted that one of the main reasons for business closures in Serbia is precisely high taxes and administrative business costs, despite the digitized registration process through the Business Registers Agency.

Analyzing the available data from 2022 for all three countries, the following provides a quantitative comparison of key entrepreneurial activity indicators for the USA, Israel, and Serbia, for a more comprehensive comparative analysis (Global Entrepreneurship Monitor (GEM), 2022). It should be emphasized that the data from GEM represent subjective perceptions of the respondents and do not necessarily reflect the broader societal reality or objective economic indicators. However, their relevance for the purpose of this research is not diminished.

5.4.1. Perception of key opportunities and capabilities

Table 2, presents indicators that reflect the perception of key opportunities and capabilities. An interesting fact is the belief in one's own abilities, which in Serbia is almost identical to the USA, and nearly twice as high as in Israel. Also, although failure is generally poorly tolerated in Serbia, it is surprising that the percentage of tolerance is 41.34%, which is lower than in the USA and Israel. Additionally, the intention to start a business in the next three years in Serbia does not lag behind the other two countries.

Table 2. Perception of Key Opportunities and Capabilities

Indicator	USA (%)	Israel (%)	Serbia (%)
Identifying Good Opportunities	46,01	46,75	37,76
Belief in One's Own Abilities	66,80	35,41	66,13
Fear of Failure (among those who see opportunities)	43,06	44,04	41,34
Intent to Start a Business in the next 3 Years	13,58	12,31	12,41

Source: Author,

5.4.2. Entrepreneurial Activity

The acronym TEA (*Total Early-stage Entrepreneurial Activity*) represents the overall entrepreneurial activity in the early stages of starting a business. It is noted that this indicator is highest in the USA at 19.19%, while it is the lowest in Israel at 8.69%.

The rate of ownership of established businesses (Established Business Ownership Rate) refers to the percentage of the adult population (usually aged 18 to 64) who own and actively manage a business that has been in existence for more than 3.5 years. In Serbia, this indicator is the lowest compared to the observed countries.

Table 3. Entrepreneurial Activity

Indicator	USA (%)	Israel (%)	Serbia (%)
Early-stage Entrepreneurial Ventures (TEA)	19,19	8,69	10,48
Established Business Ownership Rate	9,18	3,45	2,94

Source: Author,

5.4.3. Gender equality

The indicator that reflects gender equality is the ratio of female to male total early-stage entrepreneurial activity. It shows the ratio of the number of women and men involved in early-stage entrepreneurial activities. In Serbia, this indicator is the lowest.

Table 4. Gender equality

Indicator	USA (%)	Israel (%)	Serbia (%)
The ratio of female to male total early-stage entrepreneurial activity	0,89	0,67	0,43

Source: Author,

5.4.4. Entrepreneurial impact

When discussing entrepreneurial impact, the focus is on the rate of high expectations related to job creation. This rate measures the percentage of entrepreneurs who expect their business to create a significant number of new jobs. It shows the extent to which entrepreneurs plan or believe that their business will contribute to employment in the labor market. In Serbia, this indicator is lower compared to the USA and Israel.

The business services sector rate refers to the percentage of entrepreneurs whose activities are focused on the business services sector. This includes consulting services, IT services, financial advisory, marketing, legal services, and similar fields. The indicator measures the share of the business services sector in total entrepreneurial activity. In Israel, this rate is by far the highest, at 42.73%, while it is the lowest in Serbia.

Table 5. Entrepreneurial impact

Indicator	USA (%)	Israel (%)	Serbia (%)
The rate of high expectations regarding job creation	24,36	19,58	12,32
The rate of the business services sector	22,27	42,73	13,58

Source: Author,

5.4.5. Social values

The rate of high status for successful entrepreneurs is highlighted, which measures the percentage of people who believe that successful entrepreneurs enjoy high social status and reputation. This rate is highest in Serbia (81.41%), surpassing Israel and the USA.

On the other hand, the rate of perception of entrepreneurship as a good career choice shows the percentage of the population who believe that entrepreneurship is a good option for professional development and career. This rate is lower in Serbia (74.94%) compared to the USA (75.90%), but higher than in Israel (65.34%).

Table 6. Social values

Indicator	USA (%)	Israel (%)	Serbia (%)
The rate of high status for successful entrepreneurs	79,86	81,34	81,41
The rate of perception of entrepreneurship as a good career choice	75,90	65,34	74,94

Source: Author,

Below is the interpretation of the comparison of certain indicators, which seem to be contradictory to the analysis in Table 1.

Namely, belief in one's own abilities, which in Serbia stands at a high percentage of 66.13%, appears as a result of positive perceptions citizens have about their own abilities. However, this does not mean that these abilities are effectively used in practice, due to the lack of support or resources. In the USA, although this percentage is similar, at 66.80%, individuals who believe in their abilities have access to more developed education and support networks, which highlights the difference.

The indicator showing that Serbia has the lowest percentage of fear of failure (41.34%), compared to the USA and Israel, is surprising. This contradiction with the analysis from Table 1 is explained by the fact that failure in Serbia is often associated with existential risks such as unemployment or financial instability. As a result, citizens are less likely to take risks and start a business. Those who do decide to take this step show less fear because they are already "forced" into entrepreneurship. On the other hand, in the USA and Israel, failure is socially accepted, considered part of the learning process. However, the reason respondents expressed greater fear is often due to undertaking more ambitious projects with higher risks.

In Serbia, 12.41% of the respondents stated their intention to start a business in the next three years, which is slightly above Israel with 12.31%, and approximately the same as the USA with 13.58%. This statistic fits into a broader aspect, where entrepreneurship in Serbia is often not a result of opportunities, but rather "necessity." Despite the desire to start a business, conditions favorable for sustainable success are not sufficiently encouraged.

The high percentage of social value indicators in Serbia can be explained by specific socio-cultural and economic circumstances that influence perceptions, rather than necessarily reflecting actual entrepreneurial practice. The perception of successful entrepreneurs in Serbia is explained by the belief that they "succeeded despite everything," which distinguishes them in the labor market. In previous decades, entrepreneurship did not have a positive image, although it has improved over time, particularly in areas like the IT sector and digitalization. Unlike the

technology sector, traditional fields still exhibit resistance to entrepreneurship as a career option (Rilak, 2023).
When it comes to overall early-stage entrepreneurial activity, Serbia shows a moderate TEA percentage of 10.48%, which is higher than Israel's 8.69%. However, the percentage of the adult population that owns and actively manages a business that has existed for more than 3.5 years is the lowest compared to the observed countries, indicating that entrepreneurial ventures in Serbia are considered risky in the long term. Entrepreneurs need more support to maintain stable entrepreneurial activity and success from the initial stages of starting a business.

Considering entrepreneurial impact, entrepreneurs in Serbia are the least likely, compared to the other two observed countries, to believe that their business will contribute to employment in the labor market. Additionally, the rate of the business services sector is the lowest, indicating that Serbia should further invest in and develop business services. Improving these indicators could be achieved if Serbia follows the previously outlined recommendations for enhancing entrepreneurship.

6. CONCLUSION

Technological entrepreneurship stands out as a key driver of economic development and innovation in modern society. The importance of this branch of entrepreneurship is reflected in the creation of disruptive technologies, further market development, and the improvement of existing industries. The role of technological entrepreneurs is particularly characterized by transforming ideas into tangible products and services that change consumers' lifestyles. Examples of startups in the fields of artificial intelligence, green energy, and mobile applications demonstrate how innovative business models can significantly contribute to the competitiveness and sustainability of economies.

Technological entrepreneurship is not a homogeneous field; rather, it develops in line with the trends and specificities of local and global markets. It is rapidly evolving under the influence of globalization and digital transformation. Leading trends include increased investment in artificial intelligence, blockchain technologies, and renewable energy sources. Startups are increasingly aiming for global markets from the very beginning, which forms the concept of "born global" companies. In addition, there is a growing focus on sustainability and social responsibility, which encourages entrepreneurs to integrate ecological and social aspects into their business models.

Developed economies, such as the USA and Israel, foster entrepreneurship through factors such as highly developed research infrastructure, access to capital, and a tolerant culture towards failure. In contrast, less economically developed countries, such as Serbia, face challenges such as insufficient government support, bureaucratic obstacles, and limited resources.

However, the comparative analysis of the entrepreneurial ecosystems of the United States, Israel, and Serbia reveals significant differences, as well as opportunities for improving Serbia's entrepreneurial ecosystem, based on practices from these two countries that can be implemented in Serbia. Data from the "GEM" company in 2022 indicate a high level of confidence in personal abilities and the perception of technological entrepreneurship as a good career choice in Serbia. However, the challenges lie in administrative barriers, inadequate financial and non-financial support, and low risk tolerance.

To strengthen technological entrepreneurship in Serbia, in addition to increasing financial support, it is necessary to focus on institutional strengthening, education, and the promotion of innovative thinking. Efforts should be made to normalize failure in order to encourage entrepreneurs to pursue further ventures.

Through the synergy of the academic community, the private sector, government institutions, and international partners, the startup ecosystem in Serbia has the opportunity to position itself as a driver of economic development and innovation in the region. The proposed strategy for the future also includes strengthening international visibility and connecting the Serbian entrepreneurial ecosystem to facilitate the internationalization of domestic startups and access to foreign markets.

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THE INFLUENCE OF ENOLOGICAL MEANS ON THE CHEMICAL COMPOSITION AND SENSORY CHARACTERISTICS OF VRANAC AND KRATOSIJA WINES

UTICAJ ENOLOŠKIH SREDSTAVA NA HEMIJSKI SASTAV I SENZORNA SVOJSTVA VINA VRANAC I KRATOŠIJA

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***Abstract**: The proper use of oenological agents, along with high-quality and well-processed grapes, is one of the basic conditions for producing good and quality wine. Oak chips are an oenological agent that represents an alternative to oak barrels. The aim of this study was to examine the effect of oak chips on wine quality. This paper presents the results of quality analysis of Vranac and Kratošija wines, both without oak chips and with the addition of oak chips at concentrations of 1g/l and 3g/l. The results obtained showed a very good chemical composition of the tested wines. All sensory parameters were best rated in the samples with the addition of oak chips at a concentration of 1g/l, for both wine varieties. The use of oak chips did not have a statistically significant impact on the chemical composition, but it positively influenced the sensory characteristics of the wines.*

***Key words:** oak chips, chemical composition, sensory characteristics, Vranac, Kratosija*

***Apstrakt:** Pravilna upotreba enoloških sredstava je, uz kvalitetno i dobro prerađeno grožđe, jedan od osnovnih uslova za proizvodnju dobrog i kvalitetnog vina. Hrastov čips je enološko sredstvo, koje predstavlja alternativu hrastovim buradima. Cilj ovog rada je bio proučiti uticaj hrastovog čipsa na kvalitet vina. U ovom radu prikazani su rezultati analiza kvaliteta vina Vranac i Kratošija bez dodatka hrastovog čipsa i sa dodatkom u koncentraciji od 1g/l i 3g/l. Dobijeni rezultati pokazali su vrlo dobar hemijski sastav ispitivanih vina. Svi parametri senzorike su najbolje ocijenjeni kod uzoraka kojima je dodat hrastov čips u koncentraciji od 1g/l, za ispitivana vina obje sorte. Upotreba hrastovog čipsa nije imala statistički značajan uticaj na hemijski sastav, ali je pozitivno uticala na na senzorne karakteristike vina.*

***Ključne reči:** hrastovi čips, hemijski sastav, senzorna svojstva, Vranac, Kratošija*

1. INTRODUCTION

The quality of a wine depends on a large number of factors, such as grape variety, method of production, aging conditions of wine, etc. (Ribéreau-Gayon et al., 2000, Hanlin et al., 2011, Raičević et al., 2015). Also, in addition to the variety and other factors (quality of grapes, ecological conditions), the technological process of wine production itself has a great influence

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on the quality of wine and whether any oenological agent was added during this process. Oenological agents are usually added in the process of alcoholic fermentation and their use is limited and prescribed by law. Due to all the characteristics it gives to wine, oak is often used in winemaking technology. However, as stated by Blesić et al. (2013), the high costs of procurement and maintenance of wooden barrels and the short lifespan of their exploitation have motivated winemakers to find an acceptable alternative to the maturation of wine in barrels. Wine production using alternative means involves adding wood to the wine so that it acquires certain properties that resemble those of wine aged in barrels (Delia et al., 2017). The International Organization of Vine and Wine (OIV) has approved the use of oak alternatives, and this oenological practice is also included in the International Oenological Code and is approved by the European Community, being subject to regulations (Rubio-Bretón et al., 2018).
Oak chips are one of the most well-known oak alternatives. It is made from the same wood as the barrel, and French oak (Quercus petraea and Quercus robur) is most often used for this, but in addition to French, American, Hungarian, Portuguese and others can also be used (Tavares et al., 2017, Kainuma et al., 2024).

Oak chips can have a significant impact on the quality of wine (Raičević et al., 2011, Gambau et al., 2024). The use of oak chips has increased in recent years, as it speeds up the production process and increases its cost-effectiveness (Gambau et al., 2024).
Numerous studies have shown that the determination of chemical-physical, sensory and other parameters in wine is of great importance for determining and maintaining the quality of wine (Raičević et al., 2015, Mor et al., 2022).

The aim of the study was to examine the effect of oak chips on the quality of Vranac and Kratošija wines. During the production of wine samples, basic oenological agents such as SO2 and selected yeast were used for research, in addition to oak chips. In Montenegro, red grape varieties are most often used, and the dominant place in the wine assortment of Montenegro is occupied by the autochthonous varieties Vranac and Kratošija. These two varieties are the most widespread in our country, and due to their varietal characteristics, they are valued beyond the borders of Montenegro. The autochthonous variety Vranac is the leading grape variety in the production of red wines (80%), followed by the Kratošija variety, followed by other international varieties (Raičević et al., 2015; Pajović Šćepanović et al., 2014; Raičević et al., 2017; Pajović Šćepanović et al., 2019; Maraš et al., 2020; Raičević et al., 2020, Popović et al., 2024).

In order to examine the effect of oak chips on the quality of wine, various sample analyses were carried out. The chemical composition (alcohol content, total and washable acids, extract, free and total SO2, reducing sugar, pH value) was determined, as well as their sensory characteristics (clarity, color, fragrance and taste). Also, statistical processing of data was done, as well as a comparison of the obtained values in wines without and with the addition of different amounts of chips.

Control samples of Vranac and Kratošija wines were produced, to which the oenological agent oak chips was not added and samples to which different concentrations of oak chips were added. The study was conducted in order to find out whether and to what extent there are changes in certain characteristics and quality of Vranac wine and Kratošija wine after the application of different amounts of oak chips.

2. MATERIAL AND METHODS

Samples and winemaking process

The research on the impact of oak chips on the quality of Vranac and Kratošija wines, 2022 vintage, was carried out in the wine cellar of the Experimental Estate of the Biotechnical Faculty (Figure 1, Figure 2), which is located in Lješkopolje and belongs to the Podgorica subregion.

Figure 1: Satellite view of the Experimental Estate of the Biotechnical Faculty

Figure 2: Vineyard of the Biotechnical Faculty

The wine is produced in the traditional way, by spontaneous fermentation. The grapes of the examined varieties, in excellent health, were harvested at the beginning of September in optimal technological and phenolic ripeness (Vranac: 25.2 % sugar; pH 3.45; total acidity 6.6 g/l, and Kratošija: 25.1% sugar; total acidity 6.4 g/l).

Table 1. Tested samples of Vranac and Kratošija wines

VK	Vranac - control	KK	Kratošija - control
V I	Vranac + chips 1g/l	K I	Kratošija + chips 1g/l
V II	Vranac + chips 3g/l	K II	Kratošija + chips 3g/l

The grapes are processed using an electric mulcher with the separation of the stalk. The resulting hook was sulphurized with 5 g/hl of grape and inoculated with 25 g/hl of selected yeast *Saccharomyces cerevisiae* (Uvaferm BDX, Lallemand). The yeast is prepared by rehydrating 25-30 g in 250 ml of water (30) and added to the hook after 15-20 min. Two control samples of Vranac and Kratošija wines were produced without the addition of chips, while four samples of wine were produced by adding oak chips to the fermentation hook. One sample of the Vranac variety is enriched with 1g/l of oak chips, while the other sample of the Vranac variety is enriched with 3g/l of oak chips. The same concentration was also added to samples of the Kratošija variety. French oak chips (FO) were used for the study, which is medium burnt (MT+).℃

The hook of the tested samples of both varieties was mixed by hand, three times a day in 50 liter fermentation vessels. Fermentation and maceration lasted seven days for both varieties at a temperature between 25 and 28. After the end of alcoholic fermentation and tapping, all wines are subjected to malolactic fermentation. The wines were stabilized at -4 °C for a period of two months to stabilize the tartrate and bottled. The bottled wines, with a volume of 0.75 l, were stored at 10–15 °C in the cellar and analyzed for six months after production. °C

Chemical composition of must and wine

Analyses of physico-chemical and sensory characteristics of grape and wine samples were performed according to OIV methods (Recueil d OIV, 1990) in the Oenological Laboratory (Biotechnical Faculty, Podgorica).

The following parameters were examined by chemical analysis: specific gravity, total alcohol content, extract, total and volatile acids, free and total SO_2, pH, reducing sugar.
The specific gravity is measured directly on the hydrostatic scale (GIBERTINI Hydrostatic Balance mod. Densimat-CE + Alcomat2).
The alcohol content was measured on the same device (hydrostatic scale – GIBERTINI Hydrostatic Balance mode. Densimat-CE + Alcomat2), after distillation of the wine.

The amount of extract is determined by the evaporation method, whereby at 100°C the wine evaporates.
The determination of the pH value is carried out on the principle of determining the difference in potentials between two electrodes immersed in wine, where the potential of one electrode is a function of the pH of the liquid, while the other is fixed (reference electrode) (Recueil d OIV, 1990; Blesić, 2006).
The content of volatile acids was determined by distillation and titration with the help of NaOH, while the content of total acids was determined volumetrically by potentiometric titration.
The potentiometric titration method has been used to determine the amount of total acids (Recueil d OIV, 1990).

Reducing sugars are determined by the Luff–Schoorl method, which is based on the characteristic of sugars, which have a free glycosidic OH group, to reduce $Cu2+$ ions from alkaline solutions of copper complexes.
Free SO_2 is determined by the Ripper method, which involves iodine titration, leading to oxidation of SO_2 and reduction of iodine. Iodometrically, the concentration of bound SO_2 was also determined in the sample, which is released by the addition of a base (Blesić, 2006).

Sensory evaluation of wine
Sensory evaluation was carried out according to the 100-point method (OIV), by 7 trained, licensed tasters: maximum 15 points for appearance, maximum 30 points for fragrance, maximum 44 points for taste and maximum 11 points for harmony (Resolution OIV/concours 332A/2009).

Statistical analysis
Data was processed by ANOVA (p indicated) and when significant, the means were separated using Tukey's honest significant difference (HSD) test ($p < 0.05$). Statistical analysis was performed using the Stat.Soft.Inc. (2003) Statistica.

3. RESULTS AND DISCUSSION

Chemical composition of the wines tested

Chemical analysis determined the specific gravity, amount of alcohol, total extract, amount of reducing sugars, total and volatile acids, free and total SO_2 and pH value in the tested wines Vranac and Kratošija with the addition of different concentrations of oak chips and without the addition of oak chips. The results of the analysis are shown in Table 2.

Table 2. Results of chemical analysis of the tested wine samples

Sample	Specific gravity (g/ml)	Alcohol (%vol)	Total extract (g/l)	Reducing sugar (g/l)	Total acids (g/l)	Volatile acids (g/l)	Free SO_2 (mg/l)	Total SO_2 (mg/l)	Ph
VK	0.9933	14.0±0.4B	28.9±3.4B	2.1±0.3	5.5±0.3	0.89±0.1	29.71±3.94	80.72±8.47	3.48±0.07
V I	0.9945	14.9±0.3A	35.7±1.8A	2.0±0.3	6.3±0.3	0.75±0.08	07/29±4/08	77.51±4.90	3.43±0.11
V II	0.9944	14.8±0.4A B	33.1±2.1AB	2.10±0.4	6.6±0.2	0.82±0.20	26.51±5.81	72.39±9.93	3.40±0.10
V mean	**0.9941**	**14.5±0.5**	**32.6±3.7**	**2.0±0.3B**	**6.1±0.5**	**0.82±0.11**	**28.43±4.31**	**76.78±7.86**	**3.43±0.08**
KK	0.9929	14.9±0.6	32.0±0.3	2.8±0.5	6.3±0.3	0.82±0.1	27.75±2.9	66.62±5.63B	3.44±0.06
K I	0.9945	14.3±0.5	34.4±3.1	2.4±0.2	5.8±0.4	0.89±0.06	29.71±3.44	82.00±0.41A	3.47±0.07
K II	0.9952	14.1±0.2	35.1±1.1	2.5±0.4	5.8±0.5	0.85±0.15	10:42±3/82	65.34±5.00B	3.45±0.05
K mean	**0.9942**	**14.4±0.6**	**33.8±2.2**	**2.6±0.4A**	**5.9±0.4**	**0.85±0.10**	**26.63±4.40**	**71.32±8.87**	**3.45±0.05**

*different letters indicate statistically significantly different values of the analyzed parameters ($p<0.05$) of the tested wines ($p>0.05$)

The average value of the specific gravity of the tested samples of Vranac and Kratošija wines was 0.9941 g/ml and 0.9942 g/ml, respectively, which is in accordance with the results of the Sošić et al. research. (2023), where the average value of 0.9940 g/ml for Vranac and 0.9945 g/ml for Kratošija is stated. The average values of the specific gravity of the samples of Vranac wine (0.9941 g/ml) and samples of Kratošija wine (0.9942 g/ml) are in accordance with the results of the research Pajović-Šćepanović et al. (2016) and Sošić et al. (2023). The obtained values of the alcohol content of the tested samples of Vranac wine are above the values reached by Raičević et al. (2014), where the alcohol concentration from 12.8 % vol to 13.5 % vol is stated, as well as Pajović-Šćepanović et al. (2016), where values ranged from 12.9 to 13.7%vol. The average value obtained is in line with the results obtained by Sošić et al. (2023), where the value was 14.57 %vol. The average value of alcohol concentration for samples of Kratošija wine was 14.4 % vol, which is within the limits of the values reached by Pajović-Šćepanović et al. (2016), where the high alcohol content of the Kratošija wine samples is stated, which ranged from 12.3 vol% to 15.7 vol%.

The average value of the total extract for the tested samples of Vranac wine was 32.6 g/l. Samples of tested wines to which oak chips were added showed a higher concentration of total extract compared to the values in control wines. Samples of Vranac wine to which oak chips were added showed a higher concentration of total extract compared to the values published by Pajović-Šćepanović et al. (2016), where they state that the content of the total extract ranged from 25.4 g/l to 29.2 g/l. Only the Vranac – control sample was in accordance with the previously mentioned values. The average value of total extracts in Kratošija wines was 33.8 g/l. On the basis of the data obtained by Pajović-Šćepanović et al. (2016), which state that the extract content varied from 25.8 g/l to 36.5 g/l, we can conclude that the concentration of the total extract in the samples of Kratošija wine is in accordance with the given limits.

On the basis of the content of reducing sugars (< 4 g/l), it can be concluded that all the wines tested belong to the category of dry wines.

The average value of total acids in Vranac wines was 6.1 g/l, which is a higher concentration compared to the data obtained by Pajović-Šćepanović et al. (2016), which indicate a total acid content that ranged from 4.7 to 5.8 g/l and Raičević et al. (2014), in whose research the values range from 5.5 to 5.98 g/l. Only the control sample fits within these values. The average value for samples of Kratošija wine was 5.9 g/l, which is in line with the statements of Žunić et al. (2009), where the content of total acids for the Kratošija variety is emphasized, which ranges from 5.0 to 7.0 g/l.
The average pH value for the tested samples of Vranac wine was 3.43, while for the samples of Kratošija wine it was 3.45.

Statistical processing (ANOVA) of the chemical composition of the samples revealed only a statistically significant difference ($p<0.05$) between the alcohol content and total extract in Vranac wines and total SO_2 in Kratošija wines. In addition, statistical processing of the data determined a statistically significant difference ($p<0.05$) between the varieties Vranac and Kratošija in the values of reducing sugars.

Sensory characteristics of the tested wines Vranac and Kratošija

Table 3 shows the results of sensory analysis of the examined samples of Vranac and Kratošija wines.

Table 3: Results of sensory analysis of the tested samples of Vranac and Kratošija wines

Sample	External appearance		Fragrance (bouquet)			Taste				Overall impression	Total
	Clarity	Visual aspects beyond clarity	Authenticity	Intensity	Quality	Authenticity	Intensity	Harmony and persistence	Quality		
VK	4.15	8.3	4.5	6.43	12.5	4.53	6.53	6.73	17.5	9.74	
	12.45±0.2		23.43±1.0B			35.29±0.9B				9.74±0.5AB	80.91±1.0B
V I	4.16	8.33	4.93	6.87	12.86	4.85	6.6	6.83	19	9.85	
	12.49±0.2		24.66±1.0A			37.28±3.9A				9.85±2.1A	84.28±1.2A
V II	4.16	8.33	4.7	6.89	12.1	4.83	6.83	6.7	17.9	9.6	
	12.49±0.5		23.69±0.5B			36.26±1.9AB				9.6±1.1AB	82.04±0.9B
V mean	12.5±0.1		23.9±0.6			36.3±1.1A				9.7±0.8	82.6±1.4A
KK	4.13	8.11	4.7	6.3	12.2	4.33	6.5	6.67	17.3	9.66	
	12.24±1.3		23.2±1.3B			34.8±1.3				9.66±1.4B	79.9±1.6B
K I	4.16	8.13	4.88	6.73	12.7	4.63	6.8	6.67	17.5	9.85	
	12.29±0.3		24.31±1.1A			35.6±1.1				9.85±0.8A	82.05±1.2A
K II	4.16	8.13	4.79	6.68	12.3	4.56	6.5	6.83	17	9.73	80.68
	12.29±1.2			23.77±1.5AB			34.89±1.5			9.73±1.4B	80.68±1.6B
K mean	12.3±1.5			23.8±1.3			35.1±1.1B			9.7±0.6	80.9±1.3B

* different letters indicate statistically significantly different values of the analyzed parameters ($p<0.05$) of the wine;

The analysis of the data from Table 3 concludes that there is variability between all the examined parameters, except the appearance of the wine, in the samples of wines of the same variety, while a statistically significant difference ($p<0.05$) exists between the parameters of taste and the overall score of the wine between the two varieties.

Sensory evaluation of the tested Vranac wines

For samples of Vranac wine, the average score for the external appearance was 12.5, the lowest score was given to the VK sample (12.45), while the samples to which chips were added were rated with a slightly higher score (12.49). The average score for the fragrance (bouquet) for the tested samples of the Vranac variety was 23.9, and the highest score was given to the V I sample (24.66), while the VK sample had the lowest score (23.43). The average score for taste was 36.6. The highest score for taste was given to sample V I (37.28), followed by sample V II (36.26), while sample VK (35.29) had the lowest value. The average score for the overall impression of the tested samples of Vranac wine was 9.7. The highest score was given to the V I sample (9.85), followed by VK (9.74), while the lowest score was given to the V II sample (9.6). The average overall score for the tested samples of the Vranac variety was 82.6. The lowest overall score was given to sample VK (80.91), followed by sample V II (82.04), while sample V I (84.28) had the highest overall score. Statistical processing (ANOVA) determined a statistically significant difference ($p<0.05$) between aroma parameters, taste parameters, overall impression and overall score of Vranac wine, and the best rated sample, according to all these parameters, was sample V I.

Sensory evaluation of the tested Kratošija wines

The average score for the external appearance of the Kratošija wine samples was 12.3, where the lowest score was given to the Kratošija – kontrolaKK sample (12.24), while the samples to which chips were added were rated with a slightly higher score (12.29). The average score for the fragrance (bouquet) was 23.8. The best rated sample was K I (24.31), followed by sample K II (23.77), while the KK sample was slightly less rated (23.2). The average score for taste was 35.1, and the best rated sample was K I (35.6).

The average score was 9.7. The highest score was given to K I (9.85), followed by sample K II (9.73), while sample KK had the lowest score (9.66). The average overall score of the tested Kratošija wines is 80.9. The lowest score was shown by the KK sample (79.9), followed by the K II sample (80.68), while the highest score was shown by the K I sample (82.05).

Statistical processing (ANOVA) determined a statistically significant difference ($p<0.05$) between the parameters of aroma, overall impression and overall score of Kratošija wines. The best rated sample according to all the above parameters was sample K I.

By all sensory parameters, the best marks were given to wines of both varieties with the addition of 1 gr/l of oak chips, which justifies its use in this quantity.

4. CONCLUSION

The use of oak chips has only been popularized in recent years, so the interest in researching the impact of oak chips has been less than it is today. Consequently, domestic researchers have dealt with several other topics in the field of winemaking, which has resulted in only one published scientific paper on this topic.
Based on the results of the chemical analysis, it was established that the chips did not have a significant effect on the components of the chemical composition of the examined wine samples, except for the alcohol content and total extract in Vranac wines and total SO2 in Kratošija wines, while a statistically significant difference ($p<0.05$) was found in the average values of reducing sugars between the two varieties.

The use of oak chips has also had a positive effect on sensory characteristics. All sensory parameters (external appearance, fragrance, taste) were best evaluated in samples to which oak chips were added in a concentration of 1 g/l, for the tested wines of both varieties.

This research, which examined the physico-chemical and sensory characteristics of Vranac and Kratošija wines, obtained by production with the use of chips, with the presented results, can serve as a basis for expanding knowledge about this technology, in order to help winemakers and experts better understand the impact of oak chips on the quality of wine and serve as an inspiration for further research on the basis of which production will potentially improve.

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UNDERSTANDING THE "GREENHOUSE OF THE FUTURE": HARNESSING NEW TECHNOLOGY TO TACKLE FOOD PRODUCTION INDUSTRY CHALLENGES

RAZUMEVANJE „STAKLENIKA BUDUĆNOSTI“: ISKORIŠTAVANJE NOVE TEHNOLOGIJE ZA SUOČAVANJE SA IZAZOVIMA U PROIZVODNJI HRANE

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Abstract: *With growing global challenges in agriculture, including climate change, arable land shortages, and growing demand for food, the development of "greenhouses of the future" represents a key innovation in sustainable food production. These advanced greenhouses combine automation, artificial intelligence, vertical farming, and renewable energy sources to optimize plant growth conditions. By using technologies such as IoT climate monitoring systems, hydroponic and aeroponic methods, and robotics, it is possible to significantly increase yields, reduce water consumption, and eliminate the need for synthetic pesticides. This paper explores the role of new technologies in designing greenhouses of the future and their potential to revolutionize agricultural production.*

Key words: *greenhouse agriculture, food safety, climate change, IoT system.*

Апстракт: *Sa sve većim globalnim izazovima u poljoprivredi, uključujući klimatske promene, nedostatak obradivog zemljišta i rastuću potražnju za hranom, razvoj „staklenika budućnosti“ predstavlja ključnu inovaciju u održivoj proizvodnji hrane. Ovi napredni staklenici kombinuju automatizaciju, veštačku inteligenciju, vertikalnu poljoprivredu i obnovljive izvore energije kako bi optimizovali uslove za rast biljaka. Korišćenjem tehnologija poput IoT sistema za praćenje klime, hidroponskih i aeroponskih metoda, kao i robotike, moguće je značajno povećati prinose, smanjiti potrošnju vode i eliminisati potrebu za sintetičkim pesticidima. Ovaj rad istražuje ulogu novih tehnologija u dizajniranju staklenika budućnosti i njihov potencijal da revolucionišu poljoprivrednu proizvodnju.*

Клучни зборови: *staklenička poljoprivreda, bezbednost hrane, klimatske promene, IoT sistem.*

1. INTRODUCTION

Global food production is facing increasing challenges due to climate change, population growth and land degradation. Conventional farming methods are increasingly losing efficiency, while the need for sustainable solutions is rapidly increasing. Greenhouses have long been an important factor in improving agriculture, but traditional models often require large amounts of energy and water, and their productivity can be limited by changing external conditions.

The development of new technologies, including automated control systems, smart sensors, renewable energy sources and sophisticated plant nutrition systems, has led to the creation of the

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concept of “greenhouses of the future”. These advanced facilities can operate in a variety of climates, enabling the continuous production of fresh food with minimal environmental impact. (Resh, 2013)

This paper explores how new technologies are transforming the concept of greenhouses, making them more efficient and agriculture more sustainable and resilient to climate challenges. It analyzes the advantages, challenges and opportunities that greenhouses of the future offer in solving global food problems.

2. CHALLENGES AND INNOVATIONS IN MODERN GREENHOUSE PRODUCTION

Greenhouse growers are faced with increasing market demands, stringent quality standards, and unpredictable climate changes that can significantly impact production. The ability to adapt quickly and effectively to these challenges is not only an advantage, but often a crucial factor for survival in the industry. Maintaining continuous greenhouse operation requires the integration of advanced technologies and a strategic approach to resource management, as any disruption in the production chain can lead to reduced yields or significant financial losses.

In an effort to ensure food safety, optimize costs, and create a more sustainable growing environment, growers rely on smart climate control systems, automated irrigation systems, and the application of artificial intelligence in plant monitoring. Using IoT devices, sensors, and data analysis algorithms, they can accurately monitor plant moisture, temperature, lighting, and nutrition levels, allowing for rapid response to any changes in growing conditions. This level of monitoring and management not only reduces water and energy consumption, but also contributes to greater production efficiency. (Sethi, Sharma, 2007)

One of the biggest challenges facing growers is the shortage of labor. As modern greenhouse production becomes increasingly dependent on technological solutions, there is a need for workers with skills in managing digital tools, automated systems, and data analysis. The lack of qualified personnel can lead to production downtime and increased operating costs, which encourages growers to explore alternative approaches, such as harvesting robots, mechanized packaging systems, and training existing workers to work in digital agriculture.

Despite these challenges, greenhouse production offers numerous advantages over traditional agriculture. It allows for continuous production throughout the year, regardless of external weather conditions, reduces the need for chemicals thanks to better pest and disease control, and allows for the optimization of resource use. With the continuous development of innovation and the increasing application of sustainable practices, greenhouse growers have the potential to significantly contribute to global food security, while reducing their ecological footprint and improving the economic viability of their production.

In addition to agricultural production itself, smart building technology is becoming an increasingly important factor in optimizing greenhouse energy efficiency and reducing greenhouse gas emissions. In the manufacturing sector, large and small buildings are responsible for a significant percentage of carbon dioxide emissions, and overall, buildings contribute almost 30% of all greenhouse gas emissions. By adopting technologies that can significantly reduce energy consumption, the path to net zero emissions becomes more feasible.

However, to achieve this goal, it is necessary to consider several key factors. First of all, it is necessary to implement renewable energy sources, such as solar panels and geothermal sources, in order to reduce greenhouses' dependence on traditional energy sources. Also, advanced energy storage systems and smart grids can help optimize consumption. In addition, improving thermal insulation and using materials that contribute to energy efficiency significantly reduce overall consumption.

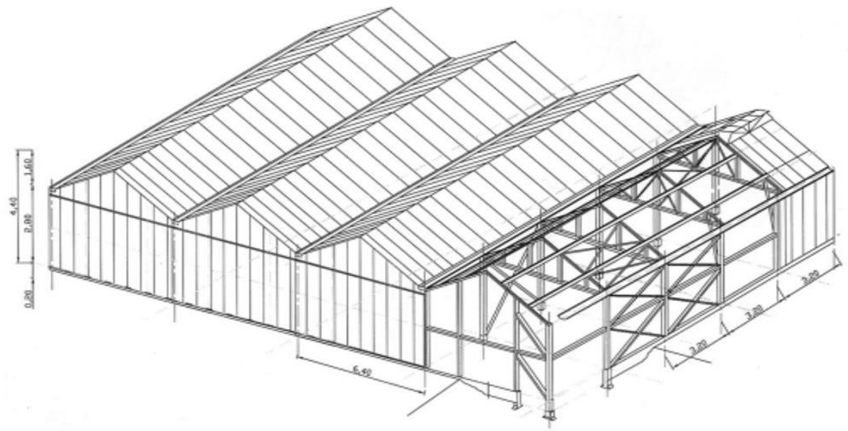

Figure 1. Greenhouse construction (photo documentation)

Ultimately, the key to a successful transition to more sustainable greenhouse production lies in collaboration between growers, research institutions, the private sector and governments. Investment in new technologies, subsidies for energy-efficient systems and the development of educational programs that will prepare the workforce for the future play a crucial role in shaping the future of greenhouse production. (Resh, 2013)

3. GLOBAL LEADERS IN GREENHOUSE PRODUCTION: LEARNING FROM EUROPEAN AND CANADIAN EXPERIENCES

Europe and Canada are investing heavily in greenhouse farming, using innovation to increase productivity and sustainability. European countries are leading the way in technology and exports, while Canada is developing energy-efficient models adapted to harsh climate conditions. Both regions are examples of how the greenhouses of the future can transform agricultural production.

Europe, one of the world leaders in the application of high-tech greenhouses. Countries such as the Netherlands, Spain and Germany are heavily using innovation in greenhouse farming.

- The Netherlands is a global leader in greenhouse production, with a large number of highly automated greenhouses that use LED lighting, hydroponic systems and microclimate control through AI and IoT technologies. Despite its small geographical area, the country is one of the largest exporters of agricultural products in the world. (https://www.keesgreeve.nl/)
- Spain (especially the Almeria region) has vast areas under greenhouses that use sustainable irrigation methods and solar energy. (https://www.dipalme.org › VAnnexes › IEA-B19-C1)
- Germany and Scandinavia are increasingly investing in vertical farming and greenhouses that use renewable energy sources. (https://www.harnois.com/)

The main challenges in Europe are high energy costs, regulatory standards regarding sustainability and limited resources such as water. (https://www.q-s.de)

Canada has a significant development of greenhouse agriculture, especially in the provinces of Ontario and British Columbia.

- Due to the cold climate, greenhouses allow for continuous production throughout the year.

• Hydroponic and aeroponic production are increasingly being implemented, reducing dependence on soil and increasing efficiency in water use.
• Green energy is key – Canada is introducing renewable energy sources into greenhouses to reduce heating costs. (https://www.harnois.com/)

Although Canada has great potential for development, the main challenges include the high cost of greenhouse construction, dependence on energy resources and the logistics of distributing fresh produce

3.1. Monitoring effectiveness

Optimizing greenhouse processes and achieving operational excellence requires informed decision-making. Better data understanding and intelligence-driven technology empower growers to make strategic decisions based on accurate and real-time information.
"The key is data," explains Stan Wachon, National Business Development, Food & Beverage for ABB Canada's Electrification Division. "Solutions that provide actionable insights through advanced data analytics help growers optimize their operations and improve overall equipment effectiveness (OEE)." (https://new.abb.com › segments)

Solutions to improve OEE provide real-time monitoring and analytics. By identifying inefficiencies and implementing corrective actions, growers can enhance their equipment performance and achieve higher productivity. As a result, productivity goes up, and costs go down. Outdated equipment and technology hinder visibility into facility operations and asset management. Limited insight makes it difficult to make informed decisions and respond to issues swiftly and efficiently.

3.2. Mitigating unplanned disruptions

By leveraging advanced data analytics, growers can gain real-time visibility into their operations, enabling savvier decision-making and more efficient asset management. But what of unplanned production interruptions? Severe weather conditions that lead to power outages can wreak havoc on greenhouse growth.
If remote, 24/7 monitoring allows growers to keep tight control of their operations, it also supports preventative maintenance. With careful monitoring, growers can foresee and evaluate the status of their equipment – making unplanned disruptions much easier to manage and mitigate.

Unplanned disruptions caused by aging equipment or power failures present a significant challenge for growers as they can incur costly downtime and impact productivity and profitability. Predictive and preventative maintenance approaches can mitigate these risks by identifying potential issues before they cause significant problems. Such measures allow growers to be proactive rather than reactive in their process, making their production much more manageable and efficient.

3.3. Automation to tackle labour shortages

If technology optimization can help monitor effectiveness and mitigate risks such as unplanned interruption of greenhouse production, can it also help with labour shortage?

Multiple industries in Canada must cope with a thinning labour force — and the greenhouse industry is not spared. As the food demand grows, growers are turning to automation to maintain the production pace at optimal levels.

When it comes to automation, the questions are when and how. Robot pickers, for example, can address labour gaps while enhancing operational efficiency and product quality. Flexible automation solutions can be tailored to various greenhouse needs and help growers not only close the labour gap but also save costs in the process.

3.4. Flexibility is key

In automation and processes alike, flexibility is key — particularly in the greenhouse industry. First, every product comes with its growing particularities and energy requirements. Also, as market demands shift and consumer preferences evolve, growers must be able to adapt quickly. Flexible equipment and technology allow seamless transitions between production lines and product types.

4. PROPOSAL FOR SOLVING PROBLEMS IN GREENHOUSE AGRICULTURE

To overcome the challenges of greenhouse agriculture in Europe and Canada, it is necessary to adopt a multidisciplinary approach that combines technological innovation, sustainability and economic viability. Key solutions include:

1. **Smart greenhouses with automated management** – The introduction of IoT sensors and artificial intelligence enables precise microclimate control, which reduces energy and water consumption and increases productivity.
2. **Renewable energy sources** – The use of solar panels, geothermal energy and wind energy can significantly reduce greenhouse heating costs in cold climates such as Canada.
3. **Advanced cultivation methods** – Hydroponic, aeroponic and aquaponic systems allow for more efficient use of resources, reducing water consumption and eliminating the need for pesticides.
4. **Vertical greenhouses in urban areas** – This concept can reduce transportation costs, enable local production of fresh food and reduce pollution.
5. **Subsidies and incentives for innovation** – Governments and the private sector should support investments in new technologies through grants and soft loans to make greenhouse production more accessible to small and medium-sized agricultural producers.
6. **Strengthening educational and research programs** – Collaboration between universities, research centers, and the private sector can accelerate the development of new solutions and their implementation in practice.

Three key takeaways for greener greenhouses

1. **Control your facility**: Don’t let your facility control you. By leveraging advanced technology and proactive maintenance strategies, growers can take control of their operations and minimize unplanned disruptions.
2. **Make informed decisions**: Informed decision-making is essential for optimizing greenhouse processes and achieving operational excellence. Better data understanding and intelligence-driven technology empower growers to make strategic decisions.
3. **Aim for technology flexibility**: Select and rely on technology that is adaptable to changing consumer and market needs. By embracing flexible equipment and automation solutions, growers can stay competitive and meet evolving demands.

5. CONCLUSION

Greenhouse agriculture is one of the most important models of sustainable food production in the modern world. Faced with climate change, the instability of traditional agriculture and the increasing demand for healthy food, many countries are investing heavily in the development of greenhouse systems to ensure continuous and high-quality production.

Europe and Canada are two regions that have successfully integrated new technologies into greenhouse agriculture. While in Europe, especially in the Netherlands and Spain, advanced systems for automated microclimate management are being implemented, in Canada great attention is paid to the use of renewable energy sources and efficient solutions for production in extreme climatic conditions. Both regions show that with an adequate strategy it is possible to significantly increase yields, optimize resource consumption and reduce the negative impact of agriculture on the environment.

However, greenhouse production still faces a number of challenges. The high costs of building and maintaining greenhouses, energy dependence, the need for a highly educated workforce, and complex logistical processes are obstacles that limit their widespread use. In addition, it is necessary to ensure that this form of agriculture remains economically viable for smaller producers, and not only for large agri-corporations.

The solution lies in further investment in innovation and research that will reduce production costs, increase efficiency, and enable the expansion of greenhouse agriculture on a global scale. The application of smart technologies, such as automated IoT systems, artificial intelligence, and hydroponic methods, can significantly improve productivity and reduce dependence on natural conditions.

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CIRCULAR ECONOMY: A NEW BUSINESS MODEL OF SUSTAINABILITY IN RURAL TOURISM

CIRKULARNA EKONOMIJA: NOVI POSLOVNI MODEL ODRŽIVOSTI U RURALNOM TURIZMU

Milan Novović, PhD, ecc,[51]
Paun Lučanović, Mr, ecc,[52]

Abstract: *Circular economy is a completely new approach to integrating the economy and waste management systems, which is of particular importance for rural tourism. The currently dominant business model is the linear production model, which involves the use of existing natural resources to produce as many products as possible, most of which end up as waste. This business model concept is environmentally unacceptable, economically unprofitable, and does not contribute to sustainability goals in rural tourism. The main objective of this paper is to demonstrate that the circular economy contributes to the sustainable use of resources and waste elimination. The results indicate that adopting a new business philosophy influences economic actors and decision-makers, whose decisions have a direct impact on defining the strategic and institutional framework for the implementation of the circular economy in rural tourism.*

Key words: *circular economy, business model, sustainable tourism, sustainability*

Abstract: *Cirkularna ekonomija je potpuno novi pristup integracije ekonomije i sistema upravljanja otpadom, što je od posebnog značaja za ruralni turizam. Trenutno dominantan poslovni model je linearni model proizvodnje koji podrazumeva korišćenje postojećih prirodnih resursa za proizvodnju što većeg proizvoda, od kojih najveći deo završi kao otpad. Ovakav koncept poslovnog modela je ekološki neprihvatljiv, ekonomski neisplativ i ne vodi ciljevima održivosti u ruralnom turizmu. Osnovni cilj rada je da pokaže da cirkularna ekonomija doprinosi održivom korišćenju resursa i eliminisanju otpada. Rezultati ukazuju da prihvatanje nove poslovne filozofije utiče na privredne aktere i donosioce odluka čije odluke imaju direktan uticaj na definisanje strateškog i institucijalnog okvira primene cirkularne ekonomije u ruralnom turizmu.*

Key words: *cirkularna ekonomija, poslovni model, održivi turizam, održivost*

1. INTRODUCTION

The linear economy, or linear model, is based on the concept of "take – make – use – dispose." After the production of a product, consumption follows, and after a certain period, the product reaches the end of its lifespan and becomes waste. This business model has led to the generation of large amounts of waste, which negatively impacts environmental quality and human health. The circular economy model is in complete contrast to the dominant linear model. By its nature, the circular economy is regenerative and strives to maintain the maximum usability, functionality,

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and monetary value of products at all times. Due to these advantages, its implementation in rural tourism would enable long-term sustainability.

Because of its essence, the circular economy can be a significant part of the solution to the growing challenges of the modern world and serves as one of the responses to the sustainability demands in rural tourism. It reconciles the need for economic growth and social well-being on one hand with the limitations of natural resources on the other. The transition to a circular economy represents a systemic shift that contributes to building long-term resilience of society and local communities to climate change and economic disruptions.

2. FUNDAMENTALS OF THE CIRCULAR ECONOMY

The circular economy represents a regenerative economic system in which production resources, waste, waste emissions, and energy outflows are significantly reduced by slowing down, closing, and extending energy and material cycles (life cycles) in production. This is primarily achieved by designing and creating products in a way that maximizes their lifespan, as well as through maintenance, servicing, and recycling (Novović, et al., 2024, p. 319). There are numerous definitions of the circular economy, but they are most commonly summarized into the following three key points (Kuzmanov, 2020):

1) Sustainable management of limited resources,
2) Maximization of resource utilization, and
3) Minimization of waste and transformation of waste into resources.

The main goal of the circular economy is to strive for the sustainable use of resources and waste elimination. It offers a new model of "product – waste – product." In essence, the circular economy urges us to rethink our relationship with natural resources, which are increasingly being used in tourism.

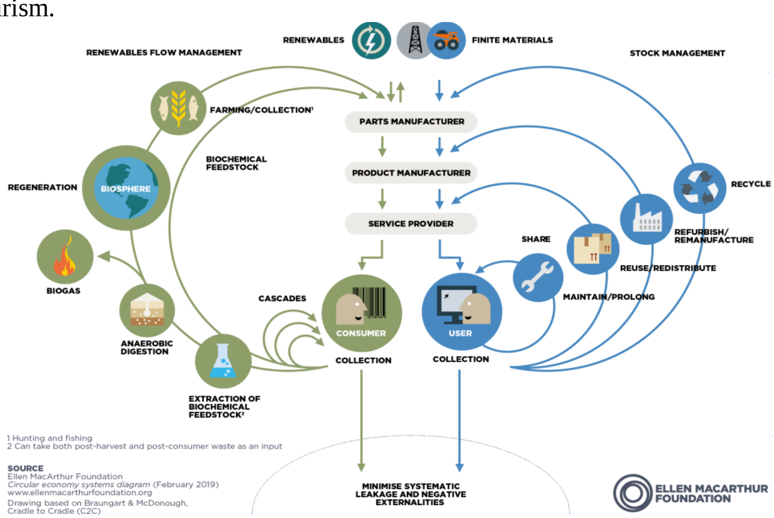

Figure 1. Overview of the Circular Economy Framework
Source: Ellen MacArthur Foundation (2021). What is a Circular Economy?

There is no single, universally accepted definition of the circular economy in the literature. According to the document "Roadmap for Circular Economy in Serbia," the circular economy is defined as a regenerative industrial economy that transforms the concept of production and consumption in terms of design, resource use, and waste management (Ministry of Environmental

Protection of the Republic of Serbia, 2020, p. 5). Despite the lack of a unified definition, there seems to be a shared understanding regarding the three levels of circular economy implementation: micro, meso, and macro levels.

- The micro level refers to the application of circular economy principles in enterprises and the creation of new, circular business models.
- The meso level pertains to interactions among different economic entities, which can lead to industrial symbiosis.
- The macro level involves the application of circular principles on a broader societal scale, including local communities, cities, regions, nations, and the international community (Gluščević, Kaluđerović, 2019, p. 13).

The circular economy is characterized by its restorative nature, reliance on renewable energy, minimization or complete elimination of toxic chemicals, and reduction or eradication of waste through careful material, product, production system, and business model design (Mitrović & Pešelj, 2021). The pursuit of zero waste is the primary characteristic of the circular economy. If the components of a final product can serve as inputs for the creation of the same or similar products, waste ceases to exist. Since the production process requires the use of new technologies with lower energy consumption, the energy system in the circular economy should be based on renewable energy sources.

A key feature of the circular economy is the creation of so-called industrial symbiosis—networks of companies that exchange by-products with one another (Đorđević, Jandrić, 2020, p. 157). One such example is the business network known as Kalundborg Symbiosis.

The European Green Deal, which came into force at the end of 2019, focuses on transforming the existing economic model by creating new economic opportunities, including the application of circular economy principles and improving citizens' quality of life. EU member states recognize the need to transform their economies and societies to meet established climate goals (Balčin, 2021, p. 28).

3. PARADIGM AND PRINCIPLES OF THE CIRCULAR ECONOMY

In a general sense, the circular economy can be considered an economic system aimed at eliminating waste and ensuring the continuous use of resources. The circular economic model, which is based on the principle of extending the lifecycle of materials and products as long as possible, stands in contrast to the linear model, which relies on resource exploitation, transforming them into products that are permanently discarded after use. Analyzing various definitions leads to the conclusion that there are three common theoretical paradigms of the circular economy (Suárez-Eiroa et al., 2019):

1. Minimizing the input of raw materials and the output of waste materials from the economic system,
2. Retaining the value of resources within the economic system for as long as possible,
3. Reintegrating products into the economic system at the end of their lifecycle.

When discussing the principles of the circular economy, five key principles form its foundation (Mitrović, Pešelj, 2021, p. 45):

1. Creating products that do not become waste,
2. Differentiating between consumable and durable product components,
3. Relying on energy from renewable sources,
4. Considering waste as an input (raw material),
5. The principle of "cascading" successive use.

According to the Ellen MacArthur Foundation, the leading international foundation for research and policy development in the field of the circular economy, the principles of the circular economy are (Ellen MacArthur Foundation, 2021):

1. Eliminating waste and pollution through improved product design,
2. Keeping products and materials in use for as long as possible,
3. Regenerating natural systems.

Eliminating waste and pollution through improved product design involves identifying and removing undesirable effects by examining the planning, design, and production processes. The essence of this principle is to create products and processes that inherently have the least possible negative impact on the environment and minimal consumption of non-renewable natural resources. Keeping products and materials in use for as long as possible entails optimizing resource yields, i.e., achieving the maximum level of utility for materials, components, and products by keeping them in the usage cycle for as long as possible. Regenerating natural systems refers to the preservation and enhancement of natural capital. This is achieved by controlling the use of limited natural resources and transitioning to renewable materials and energy sources. The transition to a circular economy represents a systemic shift that contributes to building long-term resilience in society and local communities against climate change and economic shocks, creates business opportunities and jobs, and has lasting positive effects on rural tourism and society as a whole.

Circular value chains are one of the key elements of the economic system and represent the physical and temporal trajectory along which additional value is generated and retained for materials, goods, or services. This applies to both linear and circular economies, with a fundamental difference in the trajectory along which value is created. In a linear economy, the path is a straight line that begins with the exploitation or extraction of natural resources and ends with the permanent disposal of the product at the end of its lifecycle. In a circular economy, however, the value chain—or rather, value chains—are circular, where products or their components cycle through and remain in use much longer before being permanently disposed of. Each movement along the chain creates additional value (Gluščević, Kaluđerović, 2019, p. 15-16).

Finally, it is important to note that circular value chains should not be limited solely to products that can be recycled at the end of their lifecycle. In reality, waste is generated throughout the entire production chain, and the circular approach dictates that such waste should be reintegrated into the production cycle whenever possible. Therefore, in practice, two types of circularity can be distinguished: **horizontal** and **vertical**.

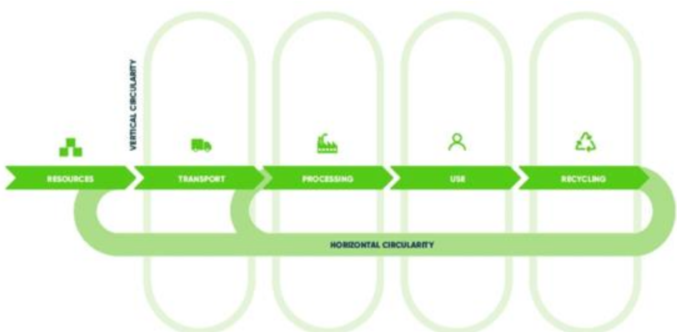

Figure 2. Circular value chains: horizontal and vertical
Source: Quist, Z. (2025). Circular Economy: Beginner's Guide

Horizontal circularity refers to a product that is reused after the end of its lifecycle. It does not necessarily have to be converted into raw material, and it can also mean that its parts are reassembled into a new product. Vertical circularity refers to a circular process within the value chain, for example, waste from the production process being reused.
Circular business models have their own characteristics and can be used either individually or in combination, depending on the productivity of the business sector. These models are (Quist, 2025):

1. The sharing economy and providing services instead of purchasing the product itself,
2. The economic model of reusing used resources,
3. Extending the product's lifespan, and
4. Product as a service.

4. ADVANTAGES OF THE CIRCULAR ECONOMY

According to World Bank data, since 1990, nearly 1.1 billion people have been lifted out of extreme poverty. Data from this global institution from 2013 show that 767 million people were earning less than $1.90 a day, a reduction from 1.85 billion in 1990, particularly in countries in East and South Asia, such as China, Indonesia, and India (Stevanović, 2020, p.18).
Globally, there is increasing interest in and implementation of circular economy tools, especially during the Covid-19 crisis. In this post-crisis period, it is particularly important to include developing countries. At the end of 2017, several African countries (Rwanda, Nigeria, and South Africa) launched the African Circular Economy Alliance. The goal of this alliance is to help achieve a continental coalition of African countries and transition the entire continent to a circular economy, with the help of the World Economic Forum and the Global Environment Facility. The mission of this movement is to create new jobs, economic growth, and achieve positive ecological results for Africa [Circular Economy, online source].

Key elements of strategic commitments for nearly all modern countries include building the innovative potential of the economy and implementing sustainable development principles. With the process of globalization and world integration, the need for sustainable development is increasingly emphasized, with particular attention given to ecological sustainability (Marković et al., 2020, p.2). In addition to implementing circular economy practices, such as the reuse of materials and eradication of poverty, sustainable development promotes efficient management and use of natural resources, reducing food waste per capita, minimizing waste flows, and reducing fossil fuel consumption, with a focus on renewable energy sources in the energy sector.

Circular economy and sustainable rural development are in symbiosis, and more serious steps should be taken regarding the implementation and innovation of tools, processes, and technologies of these concepts, as well as international cooperation to achieve more goals, share information, and preserve flora and fauna, natural goods, natural resources, and the human environment as key sources of tourist value. In 2015, the European Commission adopted a legal framework that encourages the transition of the economy to a circular economy, aiming to strengthen and modernize Europe’s economy, increase its competitiveness, and ensure long-term sustainable growth. This approach achieves efficient use of natural resources, generates financial benefits, and reduces environmental pollution. Circular economy ensures that production, trade, and consumption are designed in such a way that, by using renewable energy sources, the exploitation of key resources such as various raw materials, fuel, water, land, and the environment is minimized. The European Commission’s goals are to achieve 70% recycling of municipal waste and 80% recycling of packaging waste by 2030, with estimated savings of around 600 billion euros at the EU level (Stevanović, 2020, p.19).

Circular economy, in which materials and substances circulate and where the goal is zero waste, has numerous advantages over the linear model (Kalkan, 2022):

1. **Improvement of resource and environmental protection** – It is clear that reduced exploitation of natural resources directly impacts environmental preservation.
2. **Energy savings** – Companies can use repaired and refurbished parts from old products and integrate them into new ones, saving significant amounts of energy.
3. **Reduction of unemployment** – In a circular economy, companies engaged in maintenance, repairs, recycling, eco-product design, and services can offer interesting and attractive employment opportunities in the near future.
4. **Promotion of innovation and increased competitiveness** – Circular economy requires creativity and the ability to introduce different types of innovations into business operations.
5. **Reduction of the impact on climate change.**

5. THE IMPORTANCE OF CIRCULAR ECONOMY FOR RURAL TOURISM DEVELOPMENT

In recent years, there has been an increasing emphasis on the importance of involving all participants in tourism in the process of transitioning to a circular economy, as circular business practices can reduce the negative impact of tourism on the environment. There is a significant gap in the literature on circular economy in tourism, in terms of the lack of studies identifying the transition of the tourism sector to circular business practices, similar to what exists in other sectors like industry (Rodriguez et al., 2020). Despite the lack of literature on circular economy in tourism, many authors highlight the importance of circular business practices in economic activities.

The circular economy in rural tourism involves a model in which all tourism stakeholders (tourists, destination management organizations, hotels, restaurants, local communities) adopt an environmentally friendly approach (Rodriguez et al., 2020). Previous research on circular business practices in tourism has mainly focused on tourism suppliers who can adopt and implement the principles of circular economy, rather than tourists, who play an active and integrative role in the tourism industry (Sorensen et al., 2018).

Considering the main principles of circular economy outlined by the Ellen MacArthur Foundation (2021), all participants in rural tourism, together, can achieve these principles step by step and contribute to establishing a circular economy and transitioning business operations from the current linear model, which cannot be sustainable in the future. However, the shift from linear to circular business practices is a slow process that starts with the implementation of sustainable practices, which year by year turn into circular practices, thereby extending the lifespan of tourism resources (Florido et al., 2019). The development of circular economy in rural tourism can help achieve more sustainable use of natural resources, increase the efficiency of the tourism industry, and enable tourism to contribute more effectively to environmental protection.

However, there are numerous challenges in attempting to implement a circular economy in rural tourism, such as: misunderstanding the concept of circular economy, particularly in tourism, excessive tourist pressure on specific areas within the tourist space, low recycling rates of resources, and limited knowledge among employees about circular economy (Jones & Wynn, 2019). Therefore, greater government involvement in the circular economy is necessary, encouraging tourism companies to gradually develop “green” sourcing of materials, better waste management, promoting energy-saving initiatives, and designing excursion routes with environmentally friendly vehicles.

The transition to a circular economy in rural tourism requires overcoming many challenges in its implementation and developing strategies that can be applied on a global level. To enable this, a holistic approach is important to facilitate this transition (Florido et al., 2019, 7). For example, circular strategies would include improving the development of tourism infrastructure and the quality of services provided at the tourist destination, reducing the seasonality of tourism services, diversifying the travel industry (cultural tourism, religious tourism, ecotourism, business tourism, health tourism…), etc.

6. CONCLUSION

Circular economy is a new business model aimed at replacing linear business practices, whose principles are not in line with sustainable business practices. It is a complex process that requires the involvement of all stakeholders in its implementation. The transition from a linear to a circular economy is a complex process. However, despite this, businesses in the tourism industry have a great potential for implementing circular economy practices, and they are more likely to adopt circular business activities than businesses in other sectors. Gradually implementing individual circular economy activities can bring us one step closer to a full transition to circular business practices.

Tourism has a negative impact on the environment due to waste from production and consumption, as it involves travel between locations, relies on cheap and easily accessible resources, produces solid waste, and pollutes water sources. In this regard, more efficient waste management in rural tourism is necessary. Instead of sending discarded items to landfills, they could be reused through recycling. As we know, waste management is a very important aspect of the circular economy, where production processes should be designed so that waste from one process becomes raw material for another.

By introducing circular economy into rural tourism, multiple positive effects can be achieved. First, there is a shift from traditional manufacturing and processing industries to an innovative industry with much higher value-added final products. Also, transitioning from a manufacturing to a service-based economy allows for a higher market value. The introduction of sustainability through a new business model, via circular economy, includes: waste management, renewable energy sources, reverse logistics, knowledge economy, service activities, large-scale state infrastructure projects, industrial symbiosis projects, establishment of eco-industrial parks, organized repair, refurbishment and remanufacturing systems, waste and pollution treatment, increasing employment rates, new technologies, "green" innovations, "green" entrepreneurship, etc.

The increased demand for products and services in rural tourism, based on circular economy principles, could stimulate the development of other activities based on the same principle, such as agriculture, crafts, trade, transportation, etc. Circular economy would help reduce negative environmental impacts, preserve natural resources (including minerals, metals, other materials, water, and air), and biodiversity, which is especially important for rural tourism. The circular economy model offers an opportunity for coordinated economic development, ecological safety, "green" jobs, improved water and air quality, healthy food, and generally a higher quality of life.

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MOVEMENTS AND TRENDS IN THE PRODUCTION OF ORIENTAL TOBACCO IN MACEDONIA

ДВИЖЕЊА И ТРЕНДОВИ НА ПРОИЗВОДСТВОТО НА ОРИЕНТАЛЕН ТУТУН ВО МАКЕДОНИЈА

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Abstract: *Macedonia is a country where good oriental tobaccos are traditionally grown, in addition to the famous regions in Turkey, Izmir and the Sea of Marmara area, where there are ecological conditions for the production of quality oriental tobaccos. After the rapid structural change in cigarette consumption with the acceptance of the American blend, 90% of tobacco production in Macedonia is oriented towards the foreign market. The basic formula of the American cigarette blend is based on the formula of the R. J. Reynolds cigar company, first introduced in 1913, with the percentage of blends: 50% "Light Virginia", 25% "Berley", 20% Oriental tobaccos and 5% other types of tobacco. Today, this formula is the gravity point around which tobacco blends are made to produce the American blend of cigarettes, depending on the smoking tastes of consumers from different countries around the world. In that regard, according to the statements of the producers - processors and cigarette companies, the tobaccos in the Republic of Macedonia are not second-rate, but on the contrary, independent and unique in terms of quality and aroma. Today the leading variety is "P-66", which stabilizes the production and significantly improves the quality. The characteristic of relative stability of tobacco production indicates that the possibilities for replacing tobacco with other, alternative crops are marginal and unpromising. The poor and dry soils are the most suitable for the tobacco culture from several aspects: social, economic and profitable compared to any other culture. Occasional oscillations in tobacco production depend on weather conditions that affect their quality and quantity. Starting from the requirements of the world market, the scientific and technological achievements in the world and the available natural, production and human potentials, it can be concluded that, today, and even more so in the future, the need to raise the quality of tobacco production will be expressed in many higher level, taking into account the demands of the buyers and the need for efficient and effective production.*

Key words: *oriental tobacco, tobacco industry, variety structure, buying companies, protective prices of tobacco*

Апстракт: *Македонија е земја каде традиционално се одгледуваат квалитетни ориентални тутуни, покрај познатите региони во Турција, Измир и областа на Мраморното Море, каде што постојат еколошки услови за производство на квалитетни ориентални тутуни. По брзата структурна промена во потрошувачката на цигари со прифаќањето на американскиот бленд, 90% од производството на тутун во Македонија е ориентирано кон странскиот пазар. Основната формула на американскиот цигарен бленд се базира на формулата на компанијата R. J. Reynolds, која првпат беше воведена во 1913 година, со следниов процентуален состав: 50% „Лесна Вирџинија“, 25% „Берлеј“, 20% ориентални тутуни и 5% други видови тутун. Денес, оваа формула претставува гравитациска точка околу која се создаваат тутунските блендови за производство*

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на американскиот тип на цигари, во зависност од вкусовите на потрошувачите во различни земји низ светот. Во тој контекст, според изјавите на производителите - преработувачи и компаниите за производство на цигари, тутунот во Република Македонија не е второкласен, туку напротив, независен и уникатен во поглед на квалитетот и аромата. Денес водечка сорта е „П-66", која што го стабилизира производството и значително го подобрува квалитетот. Карактеристиката на релативна стабилност на производството на тутун укажува на тоа дека можностите за замена на тутунот со други, алтернативни култури се маргинални и неперспективни. Сиромашните и суви почви се најпогодни за одгледување на тутун од повеќе аспекти: социјални, економски и профитабилни во споредба со било која друга култура. Повремените осцилации во производството на тутун зависат од временските услови кои влијаат врз неговиот квалитет и количина. Тргнувајќи од барањата на светскиот пазар, научно-технолошките достигнувања во светот и достапните природни, производствени и човечки потенцијали, може да се заклучи дека денес, а уште повеќе во иднина, потребата за подобрување на квалитетот на производството на тутун ќе биде изразена на многу повисоко ниво, имајќи ги предвид барањата на купувачите и потребата за ефикасно и ефективно производство.

Клучни зборови: *ориентален тутун, тутунска индустрија, сортна структура, откупни компании, заштитни цени на тутунот*

1. INTRODUCTION

The production of raw tobacco in the Republic of Macedonia in the pre-transition period, starting from 1971-1975, was around 30,000 tons of raw tobacco, which indicates a long-term period of stable tobacco production. It is characteristic to note that during this period there was absolutely no stimulation from the state, but there were protective prices that were imposed by state authorities through administrative means, on which the production prices of raw tobacco were built. The lack of stimulation of raw tobacco can primarily be justified by the developed domestic market of the tobacco industry, as well as the long-standing existence of a high level of inflation that ranged from 25-30%, given that Macedonia is an exporter on a convertible market and generates additional financial resources from exchange rate differences due to the existing inflation. The production of raw tobacco in Macedonia in the transition period reaches an average of 29,500 tons, which is equal to the pre-transition period. Specifically, in 1994, during this part of the transition period, the tobacco industry operated under changed socio-political conditions and it is characteristic that there were still no state incentives for tobacco. After 1994, a period of radicalism occurred in the production of raw tobacco for various reasons, primarily a great lack of discipline in the varietal representation of tobacco, so that from 2001 to 2008 there was a decline in average production compared to 1994 and amounted to 21,000 tons. However, with the elimination of semi-oriental tobacco varieties and the introduction of incentives, in the period from 2009 to 2015 production stabilized again at an average of 24,700 tons of oriental tobacco. The trend of stabilization of tobacco production is shown in the data in Table 1. attached:

Table 1. Production of oriental tobacco in the Republic of North Macedonia (2016 – 2024)

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024
Tobacco productio n in tons	25.443	22.885	25.547	26.234	26.112	24.329	20.880	14.412	24.163

Source: State Statistical Office of the Republic of Macedonia (https://www.stat.gov.mk/)

The data in the table clearly show the stable trend of tobacco production, with the exception of the last year 2023 when we have a decrease in the produced quantities to 14,412 tons. In order to maintain stability in production, it is necessary to continue the policy of subsidization and stimulation by the state. Macedonian tobacco production, supported by the Government's subsidy policy, should increase in the future because production in Greece, Bulgaria and Turkey will continue to decrease, i.e. the trend in the production of this type of tobacco in the Balkan countries shows a further linear decline. Albania and Serbia have very small and almost insignificant quantities of oriental tobacco.

2. RESULTS AND DISCUSSION

After 2001, in the varietal structure of oriental tobacco production, Prilep-type tobacco varieties with different quality and quantity were represented. These varieties were placed under the same tobacco purchase price regime and all were aligned with the well-known oriental tobacco variety P-12-2/1. This meant that production was more oriented towards quantity than quality, which of course reflected on the possible realization of tobacco on the foreign market. A large number of the produced and fermented tobacco, due to the inability to be exported (due to the small domestic realization), was taken over by the Bureau for Commodity Reserves of the Republic of Macedonia. These conditions also had their reflection on the size of tobacco production until 2008, which can be seen from the following table:

Table 2. Trends in raw tobacco production (2001 – 2008)

Year	**Raw tobacco production**	**Subcontra ctors**	**Planted areas in ha**	**Producti on kg/ha**	**Production by cooperator**
2001	20.094	33.906	20.074	1.000	592
2002	22.500	26.971	20.615	1.091	832
2003	23.000	27.343	15.017	1.531	841
2004	19.839	38.498	15.204	1.304	515
2005	23.196	29.028	15.808	1.467	799
2006	23.083	29.230	15.072	1.531	789
2007	19.680	29.771	16.870	1.166	661
2008	16.280	30.519	17.185	1.775	533
Average	20.959	30.658	19.090	1.097	684

Source: Ministry of Agriculture, Forestry and Water Management of the Republic of North Macedonia

During the transition period, which is considered quite liberal, especially in terms of freedom of choice of tobacco variety, an average of 20,959 tons of raw tobacco were produced with an average number of cooperators of 30,658, with raw tobacco per hectare of 1,097 kg and tobacco per cooperator - 684 kilograms. From the situations known in this period in tobacco production, which are that many cooperators had concluded an agreement with more than one company for the purchase of tobacco, from which the assumption arises that the production of raw tobacco per hectare and per cooperator is higher. In the period after 2008, the production of raw tobacco enters a more stable period. The varietal production of tobacco is stabilizing, the semi-oriental varieties of tobacco are decreasing, primarily due to the prevalence of the American blend in cigarette production, which eliminates semi-oriental tobaccos not only in our country but also in the surrounding countries (Greece, Turkey and Bulgaria). For more than two decades, the P-66 variety has been stabilizing in tobacco production in Macedonia, which with its characteristics is closest to the classic oriental tobaccos, i.e. it has a wide area of its adaptation that is little reflected in its quality. The dominance of this tobacco variety, which is represented by almost 98% compared to the other tobacco varieties Jaka and Basmak, is also significantly contributed by the stimulation of the primary production of tobacco of 60 den. per kg, which has been applied since 2006. In the production of raw tobacco after 2008, a certain stabilization is already present, despite the visible oscillations in production, which are primarily a result of the weather conditions in this period. The production of raw tobacco after 2008 by sown areas, cooperatives, achieved production, as well as production per unit area and cooperative is as follows:

Table 3. Trends in raw tobacco production (2009 – 2015)

Year	**Raw tobacco production**	**Subcontractors**	**Planted areas in ha**	**Production kg/ha**	**Production by cooperator**
2009	23.196	38.710	16.212	1.430	599
2010	26.393	40.743	18.846	1.400	647
2011	21.024	33.234	15.677	1.340	632
2012	27.993	29.090	14.609	1.916	962
2013	30.997	42.367	19.806	1.565	732
2014	24.857	34.445	14.030	1.770	722
2015	19.000	28.454	13.600	1.397	667
Average	24.780	35.292	16.112	1.538	702

Source: Ministry of Agriculture, Forestry and Water Management of the Republic of North Macedonia

The results obtained for the period 2001-2008 and the period 2009-2015 show that tobacco production per unit area increased by 40% (1,538/1,097), while production per cooperative has a minimal increase of 3% (702/684). However, this shows that there are more registered cooperatives in relation to the increased quantity obtained per hectare.
The structure of oriental tobacco by varieties for 2015 is as follows:

Table 4. Varietal structure of purchased tobacco in 2015 in tons

Type of tobacco	**Purchased tobacco**	**Percentages**
Prilep - 66	16.684	88,3
Jaka	2.150	11,3
Basmak	77	k0,4
Total	18.911	100

Source: Ministry of Agriculture, Forestry and Water Management of the Republic of North Macedonia

Of the raw tobacco production in Macedonia in 2015, 88.3% was of the P-66 variety, 11.3% of Jaka and 0.4% of Basmak, which, although it has the highest purchase price, is on the margins. In the following years, this percentage has changed, i.e. P-66 tobacco is represented by 98% and Jaka by 2%.

Table 5. Number of concluded contracts, planted area under tobacco, production in tons, obtained yield kg/ha (2016-2024)

Year	Number of concluded contracts	Areas planted with tobacco	Production in tons (t)	Yield (kg/ha)
2016	27.380	16.379	25.443	1.553
2017	29.132	15.961	22.885	1.434
2018	34.104	16.582	25.547	1.541
2019	24.854	16.719	26.234	1.569
2020	29.531	16.592	26.112	1.574
2021	27.712	15.457	24.329	1.574
2022	29.653	13.237	20.880	1.577
2023	30.610	13.321	14.412	1.082
2024	29.957	12.959	24.163	1.865

Source: State Statistical Office of the Republic of North Macedonia (https://www.stat.gov.mk/)

The data in the table clearly indicate the fact that the number of individual tobacco producers (contracts concluded), as well as the planted areas, have been decreasing over the years, but the produced quantities are relatively stable as a result of the use of healthy seed material, modern mechanization, a proper managerial approach in organizing and implementing the production process and applying Good Agricultural Practices (GAP). This contributes to the constant increase in the realized yield of kg/ha, which certainly represents a special incentive for tobacco producers. In fact, with a proper policy of subsidization and stimulation, as well as by maintaining relatively acceptable purchase prices, tobacco production will continue to be maintained at a stable level, with good opportunities in the future to increase. This is especially important because the analyses so far show that there is no alternative crop that would absorb so much labor and would have such an economic impact as tobacco, both from the perspective of tobacco producers and from the perspective of the country as a whole.

3. CONCLUSION

Based on the aforementioned analyzes and research, which support the fact that the Republic of North Macedonia is the most favorable country for the production of oriental tobacco, the following conclusions can be made:

1. Seen in perspective, tobacco production with certain oscillations had a stable movement trend, with slight upward trends in world production, and our country must follow these trends and adapt to them. The future of tobacco production will mostly depend on a good agricultural and export policy, but also on a good subsidy policy from the state, all with the aim of encouraging and directing the young able-bodied population to tobacco production, in which they will see not only an opportunity for livelihood but also space for development, expansion and, of course, making a profit. In that direction, motivation and leadership are a necessary link in a series of other related activities for realizing the entrepreneurial spirit among young people who are the future of our country. If all the measures continuously offered by the European commissions for the protection and promotion of agriculture, including the IPARD funds, are used, the development course of tobacco production in our country will be greatly advanced.

2. In Macedonia, the planted areas per hectare have decreased over the years, but the production and the yield of kilograms per hectare have almost doubled as a result of the use of modern mechanization in the production process, but also due to the increasing education and upgrading of knowledge of the tobacco producers in this domain, who are increasingly organized into larger family businesses that make more profit, but, of course, also because of the support and subsidies they receive from the state. In this context, it can be said that the production of tobacco in Macedonia follows world trends, where there is also an increase in yield, so that our country is gradually approaching the world average of 1,800 kg/ha.

3. The long-term future of tobacco production can only be made possible with a quality production policy, proper investment, encouraging employment, motivation, capital increase, correct price policy, stimulating subsidy policy, education and advice from experts and correct market policy.

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REDUCING BUSINESS RISKS WITH THE HELP OF ARTIFICIAL INTELLIGENCE IN AGRIBUSINESS

SMANJIVANJE RIZIKA POSLOVANJA UZ POMOĆ VEŠTAČKE INTELIGENCIJE U AGROBIZNISU

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Abstract: *Artificial intelligence (AI) is increasingly present in business, including modern agribusiness, where it plays a crucial role in risk management. By applying AI, producers can significantly reduce risks associated with production, distribution, market fluctuations, and unforeseen consequences. The contribution of this study lies in highlighting the importance of AI in identifying, pricing, and managing risks in agribusiness. The findings of this study indicate that AI not only plays a role in risk reduction but also contributes to increasing the efficiency of producers.*

Key words: *Artificial Intelligence (AI), agribusiness, risks*

Apstrakt: *Veštačka inteligencija (AI) je sve više prisutna u poslovanju pa tako i u savremenom agrobiznisu, koja se ogleda u upravljanju rizicima. Proizvođači primenom AI mogu značajno smanjiti rizike koji su povezani sa proizvodnjom, distribucijom, tržišnim kretanjima i neželjenim posledicama. Doprinos ovog rada ogleda se u značaju AI kroz identifikaciju, cenu i upravljanje rizicima u agrobiznisu. Ishod ovog rada ukazuje da AI nema samo ulogu u smanjivanju rizika već ima ulogu i u povećanju efikasnosti proizvođača.*

Ključne reči: *Veštačka inteligencija (AI), agrobiznis, rizici*

1. INTRODUCTION

Modern agribusiness increasingly relies on advanced technologies and data processing. In a world where climate change, trade conditions, and needs are constantly fluctuating, it is essential to improve risk management when establishing sustainable and competitive agricultural systems. Information plays a central role in all aspects of agribusiness—from planning and production to marketing and distribution. The accuracy and speed of information processing can have a decisive effect on the decision-making of economic entities.

Recently, the integration of artificial intelligence into agribusiness has opened new opportunities for optimizing production processes and reducing risks. The advantage of artificial intelligence lies in its ability to analyse large amounts of data, predict trends, and provide concrete advice,

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which helps farmers in decision-making. Artificial intelligence manages information that serves as the foundation for successful operations in agriculture and provides a method for effectively managing and adapting to unforeseen situations.

2. MATERIALS AND METHODS

This article explores the theoretical frameworks and key works in the field of artificial intelligence that have applications in agribusiness, particularly focusing on methods and tools that assist in reducing production risks. A method of analysing available data and scientific papers was utilized, alongside their classification based on risk management approaches. A comparative theoretical review of contemporary theories on the application of artificial intelligence in agribusiness has been provided. Finally, the results are presented using synthesis methods according to their theoretical significance.

3. RESULTS AND DISCUSSION

In the paper titled "What is Artificial Intelligence" (Tortorella 2021), artificial intelligence refers to the simulation of human intelligence through heuristics encoded in software. Based on the analysis of available literature, several key roles of AI in the process of assessment and risk reduction in agribusiness are highlighted. These include: improving efficiency, predictive analytics (forecasting consumer behavior), and crisis management.

The first of the described AI methods, namely the improvement of agricultural production efficiency, is primarily reflected in the analytics of soil quality enhancement and the establishment of conditions for increased yields (Javaid et al., 2022). In addition, agribusiness employs artificial intelligence and machine learning technology to enhance production security, particularly concerning the emergence of plant diseases (Sahoo et al., 2023). This reduces overall business costs and enables comprehensive insights into the production process, from the input of goods to customer supply, as well as timely responses in critical situations (Sahoo et al., 2023). One of the essential functions of improving agricultural production efficiency provided by artificial intelligence is finding the shortest supply routes from the seller to the buyer. The effects achieved by shortening the route include: efficiency in fuel consumption, which impacts harmful emissions and transportation costs. The benefits of such operations increase customer trust by enhancing visibility and transparency, contributing to flexible adaptability to market changes.
Furthermore, in terms of production efficiency, AI can manage the production, distribution, and promotion of agricultural products. This advantage of digitalization contributes to overcoming the complexities of the agribusiness market caused by climate change, as well as the everyday dynamic movements that present various risks. Technological solutions implemented with artificial intelligence allow for greater and more precise data analysis, while the application of new technologies enables farmers to predict yields more accurately, optimize resource use, and find the most efficient routes for product distribution.

A significant contribution to agribusiness is also made by the so-called "predictive analytics" that can be obtained as a result of the work of AI. Predictive analytics, or the ability of AI to forecast consumer behavior, is a technology aimed at understanding and predicting consumer actions. By utilizing historical data and advanced analytical techniques, this method provides insights that allow businesses to optimize production, enhance customer experience, and reduce costs. The method of artificial intelligence, either independently or in combination with statistical methods, significantly improves the accuracy of demand forecasting methods (Amosu et al., 2024). Artificial intelligence classifies the data used for predicting demand and draws conclusions based on that. AI-driven models process large amounts of data, identify patterns, and adapt to changes in market conditions, ensuring more accurate and reliable forecasts. The implementation of demand forecasting models has several key advantages. First, it reduces the risk of stock overload, thereby minimizing maintenance costs. Second, it increases customer satisfaction by ensuring product availability, which is crucial for maintaining customer loyalty and competitive advantage. Third, it supports more rational decision-making in procurement, planning, production, and distribution (Amosu et al., 2024). The AI-driven forecasting of consumer behavior and needs is described in a scientific paper (Ebele et al., 2024).

By analyzing historical data on consumer interactions, predictive models can identify customer characteristics and predict how different market segments will respond to marketing strategies (Azuka et al., 2024). Predictive analytics, empowered by artificial intelligence, significantly transforms the forecasting of market trends and the analysis of consumer behavior. For example, integrating data from remote sensing, image processing, and deep learning can enhance the accuracy of yield predictions for crops in large regions (Senthil et al., 2025). Predictive analytics requires transparency and accuracy of data obtained from customers. The application of such a model consists of several steps to achieve precise results. The first and fundamental step is the formulation of the desired goal, which involves defining the purpose of the model and the expected outcomes. The second step is collecting information obtained from customers. The third step is based on the selection, extraction, and modification of data. Selecting relevant information is conducted through analysis, and then, in accordance with priorities, the selection and standardization of the obtained data is performed. The success of this model will depend on the accuracy and filtering of the data. After testing the model, its validity is confirmed in relation to the set goals, such as quality, speed, and customer satisfaction.

When it comes to critical situations, AI in some cases leads the recovery of businesses after disruptions and plans for future production interruptions (Ghobakhloo et al., 2023). Specifically, AI plays a key role in predicting yields and growth by using deep learning models to analyse complex datasets that affect the analysis of weather conditions, leading to more accurate yield predictions. In this case, AI performs the analysis of large quantities of complex, multidimensional data to assess the overall plant biomass and its morphological characteristics. The quality of conclusions drawn by artificial intelligence depends on the quality and accuracy of the information it possesses. On the other hand, the quality of information in agribusiness depends on the sensors used to recognize an object and the degree of vulnerability. Therefore, the accuracy of the information depends on the validity of the data entered in the form of text and numbers that AI 186nalyses to draw conclusions.

All of the above refers to precision agriculture, which increases the quantity and quality of products, something that can be termed ‘smart business’ in agribusiness. The application of smart business through the use of artificial intelligence improves both the position of the employer and the trust of consumers.

3. CONCLUSION

Available technology enables modern agribusiness to analyze large volumes of data using machine learning models and AI, thus identifying risk factors. This new predictive approach provides an advantage in production planning, which, among other benefits, leads to more competitive prices for agricultural products in the market.

The tools used by artificial intelligence not only serve to launch new businesses but also have significant benefits in resource management and the production of healthier products (with fewer pesticides). This can be achieved through the use of drones and sensors, applying machine learning models. The benefits of artificial intelligence do not end with its application in agricultural production; there is also greater transparency in production and distribution, which helps eliminate barriers between producers and consumers. This way, a high level of trust is established, which is a prerequisite for a healthy market development.

The use of artificial intelligence in agribusiness poses challenges such as financial constraints, specialized training, and the need for advanced technological solutions. These challenges can represent barriers, especially for smaller agricultural producers. Generally, small farms are unable to invest in new technologies due to the inability to finance expensive projects aimed at increasing efficiency, large analytics, or crisis management. The inaccessibility of this technology for small farmers could lead to a lack of competitiveness in the market. Therefore, a strategic approach from the government is necessary when subsidizing such complex projects, as well as implementing education.

It is clear that the unstoppable technological changes will also affect agribusiness, further enhancing this form of business. The development of generative networks and deep learning will enable nearly perfect precision in risk management. This can be observed in three significant areas: achieving greater efficiency, predictive analytics, and crisis management.
It is very important that decisions made based on artificial intelligence results must be grounded in practical knowledge and experience, which implies possessing a significant amount of relevant and accurate information, or databases that will contribute to creating a correct model of reasoning. In order for AI to be used correctly, it is necessary to establish standards for accurate and quality information.

In conclusion, it is striking that artificial intelligence represents a promising technology in agribusiness, and it is evident that it has the potential to significantly enhance risk management, whether in optimizing production processes, analytics, improving customer satisfaction, or managing unforeseen situations. In light of the global changes and challenges faced by agribusiness, including climate change and food production security, it is unequivocal that there is a great need for adaptation to changes and the integration of new technologies in agribusiness.

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"ORGANIC PRODUCTION AS A SUSTAINABLE APPROACH TO AGRICULTURE: PRODUCING 'FOOD FOR THE SOUL' WITH MINERAL FORTE PLUS"

"ORGANSKA PROIZVODNJA KAO ODRŽIV PRISTUP POLJOPRIVREDI: PROIZVODNJA 'HRANE ZA DUŠU' SA MINERAL FORTE PLUS"

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Abstract: *Organic fertilizers are an essential component of a sustainable agricultural system, significantly contributing to the improvement of the soil's physical and chemical properties, increasing its fertility and resilience to climate change. Through the gradual release of nutrients such as nitrogen, phosphorus, and potassium, these fertilizers provide long-term plant nutrition, enhancing the soil's water, air, and thermal regimes, as well as its microbiological characteristics. Although organic fertilizers offer numerous environmental benefits, their application also carries certain risks, such as the presence of heavy metals in higher concentrations, which can have toxic effects on plants, microorganisms, and ecosystems, and potentially impact human health through contamination of the food chain. Additionally, elements in organic fertilizers may be prone to leaching, creating a risk of groundwater pollution. This paper analyzes the benefits and potential risks of using organic fertilizers, as well as the need for responsible management of their application to maintain ecological balance and safeguard human and animal health.*

Key words: *Organic fertilizers, sustainable agriculture, environment*

Apstrakt: *Organska đubriva predstavljaju nezaobilaznu komponentu održivog poljoprivrednog sistema, koja značajno doprinosi poboljšanju fizičko-hemijskih karakteristika zemljišta, povećavajući njegovu plodnost i otpornost na klimatske promene. Kroz postepeno oslobađanje hranljivih elemenata poput azota, fosfora i kalijuma, ova đubriva obezbeđuju dugoročnu ishranu biljaka, poboljšavajući vodni, vazdušni i toplotni režim zemljišta, kao i mikrobiološke osobine. Iako organska đubriva donose brojne ekološke koristi, njihova primena nosi i određene rizike, kao što su prisustvo teških metala u većim koncentracijama, koji mogu imati toksične efekte na biljke, mikroorganizme i ekosisteme, a potencijalno i na ljudsko zdravlje kroz kontaminaciju lanca ishrane. Takođe, elementi u sastavu organskih đubriva mogu biti podložni ispiranju, što stvara rizik od zagađenja podzemnih voda. Ovaj rad se bavi analizom koristi i potencijalnih rizika od upotrebe organskih đubriva, kao i potrebom za odgovornim upravljanjem njihovom primenom kako bi se očuvala ekološka ravnoteža i zdravlje ljudi i životinja.*

Ključne reči: *Organska đubriva, održiva poljoprivreda, životna sredina*

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1. UVOD

Organic production is a system that takes into account the ecological, economic, and social aspects of agriculture at local, national, and global levels. Its beginnings are associated with efforts to address soil degradation, declining quality, and reduced productivity, which resulted from the long-term application of conventional farming methods.

Conventional agricultural production often leads to environmental pollution, soil depletion, and the disruption of natural balance, primarily due to the excessive use of synthetic substances that force production in an unnatural way. Additionally, through the use of various chemicals and genetic manipulation, products are obtained that often lose their natural taste and nutritional value. In the race for higher yields and profit, techniques and substances are frequently applied that directly threaten human health and the entire ecosystem.

On the other hand, organic farming avoids the use of synthetic fertilizers, pesticides, and genetically modified organisms. Its principles are based on preserving natural ecosystems, protecting biodiversity, and improving soil biological activity. The application of natural substances and a circular production model enables the establishment of a stable ecological balance, directly contributing to environmental protection and sustainable development.

It is important to note that even production that does not use synthetic substances cannot automatically be classified as organic if it disrupts the natural balance and degrades the environment. In organic production, only natural materials are permitted, while artificial substances are strictly prohibited. However, in exceptional situations, when there is no adequate natural alternative, certain synthetic substances may be allowed, but only under strict conditions and in controlled quantities. At the same time, even natural substances that contain toxins, such as tobacco, are not permitted in organic production.

Organic production implies a holistic approach, where the environment is viewed as a unified whole, and arable land is considered an integral part of it. In this system, humans have a moral responsibility to produce in a way that does not harm nature but rather protects and improves it. This approach offers a sustainable solution that balances the need for sufficient high-quality food with the preservation of the environment.

In addition to its ecological benefits, organic production has significant socio-economic aspects. Since it requires lower initial investments in terms of substances, materials, and equipment, it allows a large number of small producers to participate in the production process. Due to their high quality and natural production methods, organic products achieve higher prices in the market, ensuring fair income for producers and compensating for lower yields and increased labor. In this way, organic production not only improves the living conditions of farmers but also contributes to regional development and strengthens the national economy.

The growing demand for organic products further confirms the value of this method of production. An increasing number of consumers recognize the importance of healthy eating and are willing to pay more for products that are produced without pesticides, artificial fertilizers, and genetic modifications. By purchasing organic products, consumers not only protect their health but also actively contribute to environmental protection and the sustainable development of local communities.

The advantages of organic production are reflected in several key aspects:
• It enables a healthy way of eating and living,
• It contributes to environmental conservation,

• It strengthens the local economy,
• It provides better taste and nutritional value of products. (Lazić, et al., 2008)

Thanks to these advantages, organic production today represents the fastest-growing sector of the food industry. Many developing countries have recognized its export potential and are increasingly investing in the development of this sector.

Organic production is of particular importance to small farmers in rural, underdeveloped areas, who often lack access to modern technologies and face high production and transportation costs. However, many of them already apply traditional land cultivation methods that are close to organic farming, using little or no synthetic substances. Since production costs are lower in such conditions, organic production can provide them with economic security and a chance for a better life. (Lazić, Malešević, 2004)
On the other hand, small farmers in developing countries struggle to compete with large production systems in developed nations, both in terms of productivity and market prices. Globalization and market competition favor large producers, while small farmers often remain at a disadvantage. This is precisely why organic production represents their opportunity to enter the market, as it allows product placement at higher prices and ensures economic viability, even in conditions of lower productivity.

In conclusion, organic production is not just a method of growing food – it is a philosophy of production based on sustainability, nature conservation, and human health. Its application provides numerous benefits, from environmental protection and improved food quality to the economic empowerment of small producers. With growing consumer awareness and increasing demand for healthy products, organic agriculture continues to develop and is becoming a key part of the future of sustainable food production. (Lazić, et al., 2008)

2. ORGANIC AGRICULTURE – PRIMARY GOALS

The last few decades of the 20th century brought numerous problems in agriculture, primarily due to the uncontrolled application of conventional production methods. Excessive use of synthetic pesticides, herbicides, and artificial fertilizers, as well as the introduction of genetically modified organisms, led to soil degradation, reduced biodiversity, and disruption of ecological balance. These problems created the need for legislative restrictions and regulations to steer agricultural production toward more sustainable practices.

Organic agriculture represents an alternative system of growing plants and animals, based on the principles of ecological balance, conservation of natural resources, and human health protection. According to materials from IFOAM (International Federation of Organic Agriculture Movements), agriculture should be developed as a single organism, that is, as a living ecosystem that functions in accordance with natural laws, rather than as an industrial system based on chemical inputs and forced production. (Babović, et al., 2005)
When organic agriculture is implemented correctly, it does not create additional environmental pollution compared to natural processes. On the contrary, this approach contributes to soil regeneration, increased fertility, and the establishment of a stable ecological balance. In the long run, this method of food production improves conditions in agriculture and livestock farming, enabling healthier and more sustainable production.

3. STANDARDS AND CERTIFICATION OF ORGANIC AGRICULTURE

IFOAM has defined basic standards that provide a framework for the development and implementation of organic practices worldwide. However, due to the specific local climatic, ecological, and economic conditions, it is necessary to develop national and regional standards adapted to the particular environment. These standards are developed by national and regional organizations for organic production, which are responsible for the inspection and certification of farms. (IFOAM, 2005)

Every farm that wants to market its products as organic must operate in accordance with these standards and undergo a certification process. Certification bodies conduct regular inspections, monitor production methods, and ensure compliance with organic farming regulations. These mechanisms help prevent false product labeling and ensure transparency and consumer trust in organic food.

IFOAM standards also include guidelines for certification programs and on-farm inspections. Individual producers who are not members of certified organizations cannot claim to comply with IFOAM standards. This ensures consistency and adherence to the principles of organic agriculture on a global scale. (IFOAM, 2005)

4. ORGANIC AGRICULTURE – BASIC GUIDELINES (EXTENDED VERSION)

IFOAM standards set clear guidelines that organic agriculture must meet to be sustainable, environmentally friendly, and beneficial to human health. These standards encompass a set of goals that ensure quality and long-term production stability.

4.1. Objectives of Organic Agriculture

- Producing highly nutritious food in sufficient quantities. Organic agriculture is not just an alternative farming method but a system that ensures access to food rich in vitamins, minerals, and essential nutrients, free from pesticide residues and other harmful substances. Maintaining high food quality and its nutritional value is a key aspect of organic production.
- Maintaining production in harmony with biological principles, natural cycles, and ecosystems. Organic production relies on natural laws and processes, mimicking the functional relationships found in ecosystems. The goal is to minimize human impact on nature while allowing soil, plants, and animals to thrive in a harmonious environment.
- Encouraging biological activity in the soil, including microorganisms, fauna, flora, plants, and animals. Soil is a fundamental resource in agriculture, and its fertility depends on the presence of beneficial microorganisms, fungi, and other organisms that contribute to soil health. Organic practices support these natural processes through composting, crop rotation, and the use of natural fertilizers.
- Preserving and enhancing soil fertility in the long term. Unlike conventional agriculture, which often depletes soil through excessive chemical treatments, organic farming focuses on long-term renewal and fertility preservation. Natural methods such as cover cropping, crop rotation, and organic mulching ensure the soil remains rich and productive.
- Maximizing the use of organic matter and nutrients in closed ecosystems. The goal of organic agriculture is to reduce waste and conserve natural resources. Closed ecosystems allow for the recycling of materials such as plant residues and manure, improving soil fertility and reducing dependence on external inputs.
- Ensuring livestock live in natural conditions that allow them to express innate behaviors. Animals in organic farming must not be subjected to industrial rearing methods that restrict their movement and natural instincts. Instead, they are provided with free and healthy living conditions, natural diets, and humane treatment.
- Preserving genetic diversity in agricultural systems and the environment. Organic farming promotes the cultivation of indigenous plant varieties and breeds of domestic animals adapted to

local ecological conditions. This contributes to biodiversity conservation and reduces reliance on monocultures characteristic of industrial agriculture.

🔶 Providing farmers with sustainable income and satisfactory living conditions. Beyond its environmental benefits, organic farming also has a social aspect – it enables farmers to achieve a stable income through the production of healthy food. Healthier working conditions and reduced exposure to chemicals improve the quality of life for agricultural producers and their communities.

🔶 Using renewable energy sources in locally organized agricultural systems. The use of renewable energy sources, such as solar panels, biofuels, and wind turbines, is essential for reducing the carbon footprint in organic farming. Additionally, it decreases dependence on fossil fuels and contributes to environmental protection.

🔶 Considering the social and environmental impact of agricultural practices. Organic agriculture is not just a food production method but a philosophy of sustainable development. Every practice is evaluated in terms of its impact on society and the environment, ensuring responsibility toward future generations. (IFOAM, 2005)

4.2. Organic farming techniques

To achieve the stated goals, organic farming employs specific techniques that ensure ecological balance and the natural development of plant and animal species.

🚫 The following are completely avoided:

✅ Artificial fertilizers and pesticides – Instead of synthetic chemicals, natural compost, humus, manure, and plant-based preparations are used to enhance soil fertility without disrupting the ecosystem.

✅ Growth hormones and antibiotics in livestock farming – Animals in organic farming grow at a natural pace and are primarily treated with natural methods, such as homeopathy and phytotherapy. The use of antibiotics is only allowed in exceptional cases and under strict control.

✅ Methods that force the growth of plants and animals – Industrial farming often employs techniques that accelerate plant and animal growth to increase yield. Organic farming respects natural growth cycles without artificial stimulation.

✅ Industrial livestock techniques that disrupt natural processes – Mass production of meat, milk, and eggs often involves inhumane animal husbandry conditions. Organic farming emphasizes natural conditions, open pastures, and free-range feeding.

4.3. Exceptions and regulations

In cases where compromise is unavoidable due to economic or ecological factors, restrictions are clearly defined through legal acts and standards. For example, if there is a serious pest problem threatening yields, certain biological pest control methods permitted within organic farming can be used.

Additionally, in some regions with extreme climatic conditions, specific adjustments in cultivation methods may be necessary, but always in accordance with the fundamental principles of organic production. National organic farming standards ensure that all regulations are strictly followed and implemented in a transparent manner. (Lazić, et al., 2008)

Organic farming represents a sustainable way of food production that aligns with natural ecosystems and human health. Preserving soil fertility, biodiversity, and farmers' quality of life are key factors in this approach. Investing in organic farming methods not only contributes to a healthier environment but also ensures future generations have access to high-quality and safe food.

5. WHAT IS ORGANIC FOOD?

Organic food includes plant- and animal-based products that are grown and produced without synthetic pesticides, herbicides, mineral fertilizers, growth hormones, antibiotics, and genetically modified organisms (GMOs). This food is produced according to strict ecological and health standards, and its authenticity and quality are guaranteed through certification and regular inspections.

Organic products must meet specific requirements regarding cultivation, processing, packaging, and distribution to maintain their natural composition and nutritional value. They are grown on land that has been free from harmful chemicals for at least three years before the start of organic production. Animals are fed natural diets and have access to open spaces, allowing for healthy development.

5.1. Benefits of organic food

Organic food offers numerous advantages for human health, the environment, and society as a whole: (Oljača, 2012)

✅ Higher Nutritional Value – Organic food contains higher amounts of vitamins, minerals, and antioxidants compared to conventional products. Due to natural growth and the absence of chemical stimulants, plants develop a richer composition of nutrients.

✅ Safety for Human Health – Organic products do not contain pesticides, GMOs, synthetic additives, artificial preservatives, or flavor enhancers that may have negative health effects. Regular consumption of organic food reduces the risk of ingesting toxic substances and supports overall well-being.

✅ Better Taste – Natural cultivation methods, without the use of artificial substances to accelerate growth or enhance appearance, contribute to a richer and more authentic taste of organic food. Many consumers have noticed a difference in freshness and flavor intensity compared to conventional products.

✅ Environmental Sustainability – Organic farming does not disrupt ecosystems but rather adapts to natural cycles. By using renewable energy sources, preserving soil fertility, and minimizing waste, this method of production contributes to environmental protection and the fight against climate change.

✅ Support for Local Farmers – Organic production often comes from smaller, family-owned farms, supporting the sustainable development of rural communities and providing economic opportunities for small-scale producers.

5.2. Differences Between Organic and Conventional Food

Organic and conventional food differ in production methods, nutritional composition, impact on health, and environmental effects. The key differences include: (Oljača, 2012)

💠 Farming Methods – Organic farming uses natural methods such as composting, crop rotation, and biological pest control, while conventional farming relies on synthetic pesticides, herbicides, and chemical fertilizers.

💠 Presence of GMOs – The use of genetically modified organisms (GMOs) is not allowed in organic production, whereas they are commonly found in conventional farming.

💠 Additives and Preservatives – Organic products do not contain artificial colors, preservatives, emulsifiers, or flavor enhancers, which are often present in industrially processed food.

◈ Soil Fertility – Soil used for organic farming must be rich in minerals and treated with natural methods to maintain its long-term fertility. Conventional farming, on the other hand, often depletes soil through excessive chemical use.
◈ Irrigation – In organic farming, water used for irrigation must be clean and controlled, whereas conventional agriculture often uses water sources that may contain chemicals and pollutants.
◈ Distance from Pollution Sources – Organic production takes place in areas far from pollution sources such as industrial zones, highways, and conventional farms that use chemical substances. This ensures that organic products do not come into contact with harmful materials.
Organic Farming – A Sustainable Solution for the Future
Organic farming provides a sustainable response to the ecological, economic, and health challenges of modern society. This method of food production has the potential to become a global standard because:
🌱 It Protects the Environment – Maintains biodiversity, improves soil quality, and reduces carbon dioxide emissions.
🌍 It Reduces Pollution – By eliminating synthetic pesticides and chemicals, it helps preserve air, water, and soil quality.
👩‍🌾 It Supports Local Communities – Provides farmers with stable incomes and stimulates local economic development.
🥗 It Ensures a Healthier Diet – Reduces exposure to harmful substances and contributes to better overall consumer health.
📈 It Meets Growing Market Demand – Consumers worldwide increasingly recognize the importance of organic food and seek products that are both healthy and environmentally friendly.
The rising awareness of healthy eating and environmental protection is driving the demand for organic products. Organic food is not just a temporary trend—it represents a key direction for the future of agriculture and the global food industry.

6. USE OF ORGANIC FERTILIZERS – THE FOUNDATION OF FERTILE SOIL THROUGH THE AGES

Organic fertilizers represent the oldest form of plant nutrition, used since the earliest days of agriculture and continuing to the present. Their use has always been crucial for maintaining soil fertility, allowing plants to obtain essential nutrients in a natural way.
Since ancient times, humans have relied on natural sources of fertilizers, using various organic materials to improve soil quality and increase yields. Among the oldest and most important types of organic fertilizers are manure, compost, and green manure, which have played a key role in agriculture for centuries. (Lazić, et al., 2008)

6.1. Historical Records of the Use of Organic Fertilizers

The first written records of the use of organic fertilizers date back to the time of the ancient Greeks and Romans, who recognized the importance of natural methods for enriching the soil. They documented various fertilization methods and developed a systematic approach to agriculture, using manure and other organic materials to maintain the fertility of their fields.

- The ancient Greeks applied natural methods to restore soil, using manure and other organic materials, and their records left traces of the importance of proper fertilization.
- The Romans improved the techniques of using manure and compost, realizing that proper fertilization could achieve long-term soil fertility. Their agricultural records contain detailed recommendations on the types and methods of applying organic fertilizers.

Types of Organic Fertilizers and Their Application:

1. **Manure** – Considered the most significant and oldest natural fertilizer, obtained from the waste of domestic animals. It provides plants with a wide range of nutrients and improves soil structure, increasing its moisture retention capacity.
2. **Compost** – Made from organic waste such as leaves, grass, kitchen scraps, and manure through a natural decomposition process. It contains a rich spectrum of microorganisms that positively impact soil health.
3. **Green Manure** – Refers to growing plants (usually legumes) that are later plowed into the soil, increasing nitrogen content and improving soil structure. This method was particularly popular among ancient peoples, who used it to enrich poor soils.

6.2. The Importance of Organic Fertilizers in Modern Agriculture

Although chemical fertilizers are widely used today, organic fertilizers still play a key role in sustainable agriculture. Their application not only contributes to plant health but also improves soil quality, reduces erosion, and preserves biodiversity. The use of manure, compost, and green manure allows for an environmentally friendly way of growing plants that does not threaten the natural balance.

Throughout the centuries, organic fertilizers have remained an irreplaceable part of agriculture, proving that natural fertilization methods represent the healthiest and most sustainable approach to maintaining soil fertility. Their use is still recommended as the best way to obtain healthy and nutritious plants while simultaneously protecting the environment.

6.2.1. Organic Fertilizers – The Key to Sustainable and Fertile Agriculture

Organic fertilizers represent a heterogeneous group of materials of animal and/or plant origin that contain nutrients in the form of complex organic molecules. These nutrients cannot be immediately utilized by plants but are gradually released through the process of mineralization, transitioning into inorganic forms that plants can access (Lampkin, 2000). This natural process ensures a long-term supply of nutrients to plants, providing stable and sustainable yields.

6.2.2. The Importance of Organic Fertilizers in Plant Nutrition

One of the main advantages of organic fertilizers is their rich composition, which contains all the essential nutrients needed for plant growth and development. However, unlike mineral fertilizers, the nutrients from organic sources are not immediately available to plants but are gradually released, which allows for a long-lasting and stable effect on plant nutrition. This characteristic helps reduce sudden changes in plant nutrition and prevents unexpected fluctuations in soil fertility.

The goal of using organic fertilizers is not only to directly supply plants with nutrients but also to improve soil fertility, stimulate its biological activity, and ensure a long-term supply of nutrients. Organic matter plays a key role in maintaining soil health and the productivity of agricultural crops, contributing to the sustainability of agricultural production.

6.2.3. The Impact of Organic Matter on Soil Quality

Organic matter has numerous positive effects on the physical, chemical, and biological properties of the soil:

✓ It improves soil structure, allowing for better aeration and easier penetration of plant root systems.

✓ It regulates the mechanical composition and porosity, contributing to the optimal retention of air and water in the soil.

✓ It increases water retention capacity, reducing the need for irrigation and helping plants survive dry periods.
✓ It increases the cation exchange capacity, allowing for better availability of nutrients and reducing their leaching from the soil.

These positive effects of organic fertilizers help preserve soil fertility over a long period, making the soil more resistant to degradation and erosion.

6.2.4. Role in Global Ecological Processes

Organic matter plays an important role in the global carbon (C) cycle, which has a direct impact on climate change and ecological balance. Soil has the ability to release or retain carbon, which can mitigate the effects of greenhouse gases. By using organic fertilizers, the organic matter content in the soil is increased, which contributes to its ability to sequester carbon and reduce carbon dioxide (CO_2) emissions into the atmosphere. This creates a positive ecological effect that helps reduce global warming.

6.2.5. Organic Matter – A Key Factor in Soil Fertility

From the perspective of agricultural production, organic matter is considered one of the most important indicators of soil fertility. Its role in supplying the soil with biogenic elements is invaluable, as it is the primary source of nutrients for plants and microorganisms in the soil. Additionally, it contributes to ecosystem stability, biosphere sustainability, and the renewal of natural resources.

By using organic fertilizers, not only is soil quality improved and crop yields increased, but the environment is also protected, and the negative impact of chemical fertilizers is reduced. Therefore, organic fertilizers are increasingly being used in modern agriculture, both in conventional and organic farming, forming the foundation for healthy and productive farming in the future.

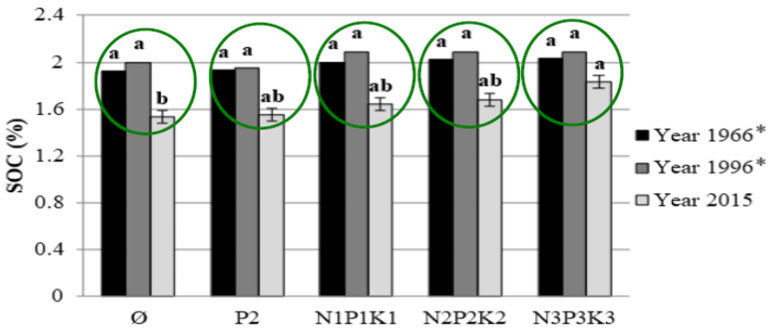
In modern agriculture, the decline in organic matter content in the soil is one of the main challenges to sustainable production. This problem is primarily the result of the intensification of agricultural production, which involves increased use of mineral fertilizers, frequent soil tillage, and a reduction in the use of traditional organic fertilizers.

Causes of Decreased Organic Matter in the Soil:
✓ Intensive Soil Tillage – Deep tillage and frequent plowing lead to increased mineralization of organic matter, causing the rapid loss of nutrients.
✓ Excessive Use of Mineral Fertilizers – Although they promote rapid plant growth, they do not contribute to increasing the organic matter content in the soil.
✓ Reduction in Livestock Numbers – Traditional sources of organic matter, such as manure, are becoming rarer due to the decrease in livestock production.
✓ Insufficient Application of Organic Matter – Due to the reduced availability of manure, compost, and other organic materials, the soil loses stable sources of nutrients.

The Search for Alternative Organic Materials:
To compensate for the lack of traditional organic fertilizers, various alternative sources of organic matter that can improve soil fertility and maintain its productivity are gaining increasing importance:
✓ Compost – Organic waste from households and agriculture can be composted and used as high-quality organic fertilizer.
✓ Green Manuring – Planting crops that are incorporated into the soil, such as legumes and

pulses, improves soil structure and increases organic matter content.
✓ Harvest Residues and Plant Remains – The use of crop residues (straw, corn stalks, stems) increases organic matter content and enhances microbial activity in the soil.
✓ Industrial Organic Materials – By-products from the food industry, such as sugar beet residues, brewer's yeast, or sludge from wastewater treatment plants, can serve as organic fertilizers.

The reduction of organic matter in the soil has long-term negative consequences, including decreased fertility, worsening soil structure, and reduced capacity to retain water and nutrients. To avoid these problems, it is necessary to find suitable alternatives to replace organic matter and improve soil quality. By using various organic materials and sustainable agricultural practices, long-term soil productivity and ecological balance can be ensured.



Fifure 1. Effect of P fertilization on SOC (%) in the soil (1966, 1996, 2015), (Bogdanovic, et. al. 1999)

7. THE IMPORTANCE OF ORGANIC FERTILIZERS IN MODERN AGRICULTURE

In the era of intensive agriculture and increased environmental awareness, organic fertilizers are gaining growing importance. Their role goes beyond classical plant nutrition and encompasses a range of ecological and agronomic benefits that contribute to the sustainability of production and the protection of natural resources.

1. **Popularization of Ecological and Sustainable Agriculture**
   An increasing number of agricultural producers are turning to production systems in which the use of mineral fertilizers is limited or completely excluded. Organic farming, biodynamic production, and regenerative agriculture encourage the application of natural plant nutrition methods, thereby reducing the negative impact of chemical substances on the environment.
2. **Environmental Protection and Natural Resource Conservation**
   Awareness of the need to preserve nature and reduce pollution has become a key factor in modern agriculture. Organic fertilizers enable:
   ✓ Recycling of Organic Waste – The use of compost, manure, and plant residues reduces the amount of biodegradable waste and increases the efficiency of resource utilization.
   ✓ Reduction in Fossil Fuel Energy Use – The production of synthetic fertilizers requires large amounts of energy, whereas organic fertilizers come from renewable sources.
   ✓ Reduction in Greenhouse Gas Emissions – Organic matter in the soil binds carbon, mitigating climate change.
3. **Improvement of Soil Quality and Increased Fertility**

Organic fertilizers play a crucial role in increasing the organic matter content in the soil, contributing to:

✓ Better Soil Structure – The soil becomes looser, more aerated, and improves its water retention capacity.

✓ Increased Biological Activity – Organic matter stimulates the development of beneficial microorganisms that improve fertility.

✓ Long-term Fertility Improvement – The nutrients from organic fertilizers are released gradually, providing plants with a stable source of nourishment.

Today, organic fertilizers represent not only a means of plant nutrition but also an important tool for improving soil quality and protecting the environment. Their use contributes to the conservation of natural resources, reduction of pollution, and the assurance of sustainable agricultural production, thereby creating a stable ecosystem for future generations.
Organic fertilizers contain almost all the necessary nutrients for cultivated plants and have a longer-lasting effect on the chemical properties of the soil, and thus on the yield of cultivated crops, even several years after application.

Table 1. Advantages and disadvantages of use in the conservation of natural resources

Advantages	**Disadvantages**
- Organic matter content - Soil structure - Field water capacity - Microbiological activity - Soil sorptive capacity - Cation adsorption capacity	- Significantly lower concentration of nutrients - Nutrients from organic fertilizers are not immediately accessible to cultivated plants - It is difficult to predict the dynamics of nutrient release from organic fertilizers and align it with crop needs - Higher transportation costs per unit of active substance, so application is often limited to the area of their production - The content of nutrients can be very different even within the same type of fertilizer - They can contain harmful substances such as antibiotics, hormones, pesticide residues, heavy metals and various pathogenic microorganisms - They can contain weed seeds, which leads to the spread of weeds in fertilized plots.

7.1. Organic Materials for Improving and Maintaining Soil Fertility

Organic materials play a key role in preserving and improving soil fertility by providing essential nutrients to plants and enhancing the physical and chemical properties of the soil. The use of natural nutrient sources, such as manure and compost, is becoming increasingly important in sustainable agriculture, as it contributes to reducing the use of mineral fertilizers and protecting the environment.

Organic Materials for Improving/Maintaining Soil Fertility

• A mixture of solid and liquid livestock excrements and bedding
• Besides their nutritional value, they are also important as soil conditioners
• Nutrients are present in organic form
• The quality and content of manure depend on the type, age, and diet of the animals, the bedding material, the method of collection, and especially the storage of manure

Table 2. Organic Materials for Improving/Maintaining Soil Fertility

Element	Content in %	Element	Content mg/kg
N	0,2-0,6	Mn	30-50
P	0,04-0,3	Zn	10-20
K	0,1-0,8	B	3-5
Ca	0,07-1,0	Cu	1-3
Mg	0,06-0,3	Mo	0,1-0,2

1. Nutrients in Organic Materials
Organic materials contain all the essential nutrients necessary for plant growth. These nutrients are present in organic complexes, which gradually decompose over time and become available to plants. Their content varies depending on the type of material, processing method, and storage conditions.

Table 3. Macroelements (expressed in %) Microelements (expressed in mg/kg):

Element	Content (%)	Element	Content (%)
Nitrogen (N)	0,2 - 0,6	Manganese (Mn)	30 - 50
Phosphorus (P)	0,04 - 0,3	Zinc (Zn)	10 - 20
Potassium (K)	0,1 - 0,8	Boron (B)	3 - 5
Calcium (Ca)	0,07 - 1,0	Copper (Cu)	1 - 3
Magnesium (Mg)	0,06 - 0,3	Molybdenum (Mo)	0,1 - 0,2

2. Importance of Organic Materials for Soil
✓ Improve soil structure – Organic matter increases soil looseness and porosity, allowing better aeration and water retention.
✓ Contribute to soil biological activity – They increase the number and activity of beneficial microorganisms that participate in the decomposition of organic matter and the release of nutrients.
✓ Reduce the need for mineral fertilizers – Organic fertilizers gradually release nutrients, providing long-lasting effects on plant growth and development.
✓ Increase cation exchange capacity (CEC) – Organic matter binds nutrients, reducing their leaching and increasing the efficiency of plant nutrition.
✓ Contribute to environmental protection – Using organic materials reduces the negative impact of chemical fertilizers on the ecosystem and improves the sustainability of agricultural production.

Organic materials, such as manure, compost, and green manure, are valuable resources for maintaining soil fertility. Their proper use helps preserve nutrients, improve the physical and chemical properties of the soil, and contribute to a healthier and more productive ecosystem.

8. "MINERAL FORTE PLUS: A NATURAL APPROACH TO SUSTAINABLE AGRICULTURE AND PRODUCT QUALITY IMPROVEMENT"

After reviewing the broader framework within which modern agriculture operates and its relationship with nature, society, and ecological principles, it is clear that sustainability is key to ensuring healthy and nutritious products. This holistic approach involves not only providing adequate conditions for plant growth but also maintaining balance in ecosystems, protecting the environment, and developing a responsible society. In this context, the importance of natural preparations that can contribute to creating such conditions, as well as their application in agriculture based on sustainability and natural processes, is recognized.

One of the key products based on this philosophical approach, which fits perfectly into the strategy for sustainable food production, is Mineral Forte Plus. Developed by AZARTREDE, this preparation is a natural product that uses mineral components such as calcium, magnesium, and boron to improve soil and plant quality, all in accordance with the principles of ecological production.

Mineral Forte Plus is not just an ordinary plant nutrition product. It is the result of years of research and development, and its use in agriculture offers a range of benefits for plants, soil, and producers. Its action is based on bioregulatory properties that increase soil fertility, improve plant resistance to stress factors, and enable better utilization of nutrients from the soil. Additionally, this preparation is used in organic farming, which means it not only contributes to plant health but is also completely safe for humans, animals, and the general environment.

What makes Mineral Forte Plus unique is its ability to directly impact photosynthesis in plants through foliar application. When dissolved in water and applied to plants, the preparation works by increasing the concentration of carbon dioxide in the leaves, thereby improving the photosynthesis process. This process is crucial for the synthesis of organic materials that plants use for growth and development, as well as for the production of nutrients like glucose, which is the main energy source for plants. By using Mineral Forte Plus, plants not only grow faster but also become more resistant to unfavorable conditions, such as drought, temperature changes, and pathogen attacks.

Mineral Forte Plus also contributes to improved fruit quality, as plants fed with this preparation develop more quickly and produce fruits richer in nutrients, which is particularly important for producers aiming to meet all standards of ecological production and offer consumers food with high nutritional value. Furthermore, the preparation reduces the need for chemical pesticides and other protective agents, thereby decreasing the negative impact on the environment and human health.

In the following, we will explore in more detail the specific benefits that Mineral Forte Plus brings in the context of modern agriculture, as well as the ways in which this preparation contributes to sustainability, plant quality, and increased yields, while minimizing negative environmental impacts. This product is an example of how technology and nature can work together to create better conditions for agricultural production, in accordance with the principles of fairness and respect for natural resources.

8.1. Produce "FOOD FOR THE SOUL" with organic preparations

The " AZARTREDE " company and its employees are not only a "practical system of knowledge about food production in accordance with nature" but, above all, they are a value system that tries to create connections and relationships between producers and consumers, between producers and ecosystems and ecosystems and consumers, between institutions and civil society. It's all part of a puzzle where, if one piece is missing, the system is out of balance, doesn't work as it should, and threatens to slowly collapse. The main task is to try to look at the food production system from a holistic perspective. And the human spirit is also part of the puzzle, a spice that completes and makes the dish better. In addition to the environmental and climate crisis, we live in a time of spiritual crisis. Traditional values that held society and families are slowly being lost, new values are leading to individualism, in which the sense of community and collective good is slowly dissolving. And nature is a collective good that should serve all beings. All our products are made respecting all of the above in constant coordination with farmers, a direct and irreplaceable factor in our mission.

23.12.2022.

ЛИСТА РЕГИСТРОВАНИХ СРЕДСТАВА ЗА ИСХРАНУ БИЉА И ОПЛЕМЕЊИВАЧА ЗЕМЉИШТА КОЈИ СЕ МОГУ КОРИСТИТИ У

ОРГАНСКОЈ ПРОИЗВОДЊИ

А) ЛИСТА СРЕДСТАВА ЗА ИСХРАНУ БИЉА И ОПЛЕМЕЊИВАЧА ЗЕМЉИШТА

Бр.	Ред. бр. уписа / Рок важења решења	Назив и тип оплемењивача земљишта		Скраћено пословно име				Хранљиви елементи/хранљива материја назив и садржај
				дистрибутера и увозника		произвођача		
1	2	3	4	5	6	7	8	9
1	1537/2032	Physiomax 975	Кречни оплемењивач	Timac Agro Balkans	Нови Сад	Timac Agro	Аустрија	42% CaO, 2,5 MgO
2	1962/2023	Agrosol	Кречни оплемењивач-калцијум карбонат	Agromineral	Влајковац	Agrosolution	Аустрија	53,6% CaO
3	2063/2024	Mineral Forte Plus	Кречни оплемењивач-калцијум карбонат	Azertrade	Нови Сад	Azertrade	Нови Сад	50% CaO, 12% MgO, 1%B
4	1999/2024	Protect Forte	Калцијум магнезијум мешани	Pirsteel	Пирот	Pirsteel	Пирот	35% CaO, 5% MgO
5	2156/2025	Zeo-Min	Кречни оплемењивач-Калцијум магнезијум карбонат	TMB Diamond	Панчево	TMB Diamond	Панчево	41% CaO, 17% MgO

УПРАВА ЗА ЗАШТИТУ БИЉА

Figure 2. List of approved substances
Source: Ministry of Agriculture, Forestry and Water Management, http://www.minpolj.gov.rs › download › Lista-sre...

9. MINERAL forte PLUS

Human presence is necessary regardless of all the artificial intelligence that is offered, we must have young and educated people who will share the acquired experience in agricultural production with direct producers and control their work in the field. Our cooperation with such organized people is the right approach that leads to the goal, the production of healthy and controlled plant and animal food.

The Mineral forte Plus product is of natural origin. It is produced in the form of a powder and dissolves in water in a few seconds. It is soluble because it is composed of properly selected minerals, calcium Ca, magnesium Mg and boron B are declared. Fine grinding is achieved through a high-tech processing process. It is a means for supplementing plants and improving the soil – it regulates the acidity of the soil.

Mineral forte Plus applied foliarly or through the root system nourishes the plant and enables a wide range of positive effects. Intended for conventional and organic production, it meets the certification requirements for the production of organically healthy food.

Mineral forte Plus can be mixed with all protective agents. It is non-toxic to humans, animals and insects. The preparation changes the energy composition of the plant, accelerates the creation of organic matter, increases the natural resistance of plants.

Table 4. Name and content of the nutrient.

Nutrient matter	Content
Calcium oxide (CaO)	**50 %** / - 3%
Magnesium oxide (MgO)	**12 %** / - 3%
Bor	1%

Source: Mineral forte Plus, plant food and soil improver, composition (https://www.azermineral.rs/mineral-forte-plus/)

Physical properties: powder, white-gray color, odorless
Granulometric composition: Particles of 1 mm min 98%, Particles of 0.25 mm min 80%
Recommended quantities: 3-4 kg/ha depending on the type of soil and culture, dissolved 0.2-0.5%
Storage method: Store in original packaging in dry storage rooms

In order to fully understand the role of this agent in agriculture and its effect on plants, we must refer to plant physiology. Green plants have the ability to, with the help of chlorophyll, synthesize organic matter from carbon dioxide, water, light and solar energy by assimilation. The word photosynthesis means combining by means of light. Life on Earth would be endangered without this process.

The most important process that occurs in the photosynthetic reaction (this is the second part of the process) does not require the presence of light and takes place in chloroplasts. We need to understand this cycle to understand the importance of adding calcium from our product. Here, one oxygen atom is removed from the carbon dioxide (CO_2) molecule, and then the carbon (C), hydrogen (H) and oxygen (O) atoms combine to form the organic molecule CH_2O. Carbohydrate molecules, monosaccharides, disaccharides or polysaccharides, are formed by linking several of these molecules together. The first carbohydrate formed is glyceraldehyde-3 phosphate, which contains 3 carbon atoms. This means that for the synthesis of one molecule of carbohydrates, the cycle must turn three times and fix three molecules of CO_2.

Glucose is therefore very rich in energy. Plants use it as fuel for their growth, but also for the production of starch (it is an energy store) and cellulose. Throughout the process, the importance of carbon dioxide is constantly emphasized. The reason for this is that increasing the concentration of carbon dioxide (up to the optimal limit) accelerates photosynthesis, and thus increases organic matter.

Carbon dioxide appears in the air in a concentration of (about) 0.03% (it usually varies because it is heavier than air), which is insufficient for normal photosynthesis and metabolism. We make up for it by foliar application of our preparation.
By applying the dissolved Mineral forte Plus powder to the leaves of the plant, we manage to increase the amount of CO_2 and thereby have a positive effect on all the described processes (https://www.azermineral.rs/mineral-forte-plus/)

The preparation dissolved in water creates a very fine film with extremely small particles on the surface of the leaf and begins to penetrate through the stomata into the interior of the leaf. Once inside the leaf, calcium carbonate is dislocated due to the large contact surface of the micronized calcite. This creates two decomposition products: carbon dioxide and calcium oxide. Because calcite dissociation is easy, carbon dioxide is constantly available to plants through the leaves.

This process is important during high heat, which saves water through reduced transpiration. In these processes, free calcium is a good barrier for plant stress, whether it is pathogen attack or environmental conditions. The plant closes its openings because it has a sufficient amount of carbon dioxide necessary for photosynthesis.

The element BOR is part of the composition of organic compounds, it plays an important role in the process of pollen germination, biosynthesis of phosphorus compounds, sugar translocation from leaf to fruit.

Magnesium affects numerous processes, the intensity of photosynthesis and dry matter. Any deficit is solved by applying Mineral forte Plus.

Summarizing the effect of Mineral forte Plus, it can be concluded that it is applied to all plant species through the leaves in a concentration of 0.3-0.5%. It increases the organic matter and thus the yield, strengthens the immunity of plants, if necessary accelerates the vegetation of plants, reduces the need for water in the dry period, is completely non-toxic and suitable for the production of healthy food and ecologically preserves the environment..

The preparation represents a combination of high technology and nature, enabling plants to:
https://www.azermineral.rs/mineral-forte-plus/
1. Bioregulation
2. They feed the plant
3. They increase immunity
4. They improve the quality of cultivated plants

Benefits for users, producers of organic food are presented by:
(https://www.azermineral.rs/mineral-forte-plus/)
1. Increase in yield
2. Improvement of land
3. The possibility of reducing expensive means for feeding and protection, proper nutrition is half the protection!!!

Accordingly, the preparation will help plants to produce fruits of high nutritional and biological value without chemical treatments. Mineral forte Plus is the base product for several products in a series produced by the company AZERTRADE and present on our market. It is used outdoors and in closed systems.

The preparation is a natural biostimulator and is used under regular circumstances in all phenophases of plants.
It is especially recommended for SOS use - after mechanical damage to plants in the phase before flowering because it quickly restores the herbaceous stem and leaf mass.
Many years of experience show the exceptional resistance of the treated plants to temperature stress, the durability of the leaf mass in conventional chemical treatments.
The presence of micronized particles improves physiological effects: (Ministry of Agriculture and Environmental Protection of the Republic of Serbia 321-01-00453/2022-11, Register of funds for plant nutrition and land improvers, List of funds for organic production in 2022.)
- Improved photosynthetic activity of the plant even in unfavorable circumstances.
- Accelerated metabolic activity reflected in increased protein synthesis.
- Increased amount of polyphenols

Effects and benefits after using Mineral Forte Plus:
- More intensive growth and development of plants.
- Resistance of plants to stress caused by lack of water.
- Increased fruit resistance during ripening,
- Increased yield of crops per unit area.
- The amount of FIRST class fruits increases considerably - /12-15%/
- The need to use protective equipment is reduced.
- The harmful effect of the used chemical preparations is neutralized, the withdrawal period in the fruit of the plants is shortened.
- Micronized calcium from the preparation also acts protectively on the fruit.
- Reduces soil acidity and creates an environment in which:
*microorganisms cannot be active.
*plants easily absorb microelements from the soil.

Special benefits are manifested in plants where an increased presence of BOR and MAGNESIUM is required - better flowering, greater presence of sugar in the tubers of sugar beet and potatoes because the use of useful energy by the plant during photosynthesis is reduced
- The presence of this preparation enables preservation of moisture near the root system.
- The presence enables better utilization of nitrogen, N which is already in the immediate vicinity of the root system and reduces the need for additional N (nitrogen).

The principle of fairness in the context of organic agriculture refers to the creation of honest and fair relations towards the wider social environment, nature and life as a whole. Mineral forte Plus is a preparation that tries to bring the context of fairness back into the framework of a healthy life.

Analyzes performed in authorized laboratories gave a recommendation for permission to be included in the list of funds of the Ministry of Agriculture as a preparation/means allowed for organic production.

10. CONCLUSION

"Whoever is the father of a disease, improper diet is its mother"

Believe it or not, this was said in the 16th century. We put our health at the service of corporate profits, the chemical industry in the broadest sense, the one that "supports" small and large food producers, processes their plant and animal products, adding a sea of additives, emulsifiers, artificial colors and now also the production of meat from plant proteins. we are already building a factory that will do it, but unfortunately it doesn't end there either, completely chemically produced meat, "printed meat" for 98% of the planet's inhabitants. Of course, we are all here, you who work in a chain of state institutions or you are a scientist and expert who will be very happy to participate in the quasi-success of high technology. How is it possible ?

Let's all ask ourselves if this is normal, ethical, healthy, deeply human, then who are we?
Let's start from thinking, are we interested in their profits or the crumbs of something that will fall from that table? Is it worth being in that company? Will you feed it to your children and grandchildren? We are only people who have our own life on this planet, we inherited it from our ancestors and we should leave it to our descendants. At this moment, let everyone think of someone they love who is five, ten years old...
What do we feel? Shame, anger, helplessness or are we resigned to reality?

We as a company and all our associates perceive the situation as the last alarm to start changing things. It's not impossible, just that each of us should think about what to do or not to do in the context of this story and we started an avalanche.
Let's remember our childhood, how much we had and what we ate, how we rejoiced when there was the smell of homemade bread at grandma's house, when vegetables were being picked and lunch was being prepared, we reached out and picked a fruit and ate it without washing it. She was not ideal, a little lumpy, but healthy. That happiness was real. Are we happier now when they sell us ideal fruits and vegetables, beautiful on the outside, but without taste or smell?

Let us, the consumers, be the ones who set the standards and requirements, impose our needs and desires on the producers. Let's not let them keep offering us their technological products. Let's get back to ourselves. Let's take action and produce the little food we need to live a healthy life, without supplements and medicines, in harmony with the nature that surrounds us. Let's let the people who struggle to come up with this idea and produce that food, make money, and let us eat what supports our bodies to function according to the same nature that we selfishly kill.
Let's raise those who produce our food to a higher level.
The goal of growing plants and animals is precisely a rounded cycle that we need to manage in accordance with reason.

Organized agriculture uses appropriate biological and chemical materials to produce unpolluted food in an ecologically justifiable and economically beneficial way - sustainable agriculture in which ecology and economy are reconciled.

Let's be free people and not slaves to our positions and high salaries, freedom is taken for granted but still chosen. Every normal person, who as a good host takes care of his house, family, household, offspring, future, will accept healthy food as taking care of his health and our planet. The awareness that man is a part of Nature, something that is above everything and all of us, has existed since ancient times.

Man's attitude is inconsistent with awareness of this. As he "conquered" nature more and more, he behaved less and less in accordance with the respect for its sublimity. Reciprocally to that behavior, a retrograde attitude towards people's health is established. The increasing use of chemistry as a justification for "preventing" hunger on the planet has not solved that problem. We are witnessing dying of hunger in African countries as well as in megalopolises. An even more tragic consequence of such behavior is the increasing contamination of the soil with chemicals, which again creates the need for new chemicals that will "defeat" the bad condition. That cycle must be broken to reconnect with nature. A great resistance to this is provided by those who created this situation.

It is up to us who are aware of the situation to work on it and take from the realm of nature what is offered as the possibility of healing the land, water, air and food we produce for ourselves and the animal species we have. cruelly torn from nature.
One of the sure ways is to use minerals that come from the Earth's crust to stimulate and protect the plants and clean the soil from the presence of added chemicals.

Agriculture is essentially one big business with the goal of finding a person anywhere on the planet at a table with a plate of food. From the basic necessity of life, a situation has arisen, on one side are food producers, and on the other are consumers. We have conflicting interests, the producer's goal is profit, and the goal of all our users (we are the majority) is health through a balanced diet.

"AZARTRADE" is a company that follows new technology, but in a way that we use knowledge and expertise to process what nature has in different forms, NATURAL MINERALS. By grinding the three types of minerals to a micronized form, we make a product that supports the nature of the plants, we do not change the plants, we just follow their needs. They reward us with healthy fruits, which again with knowledge we can bring into various forms, and all of them have the expected smell and taste. We don't need chemical additives for flavor, color. For us, plants are not a labyrinth
- we know where and how Mineral forte Plus should work.

Food production in harmony with nature is our mission!!!

"WE DO NOT CHANGE NATURAL LAWS BUT SUPPORT THE PROPER NUTRITION AND PHYSIOLOGY OF PLANTS"

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SYNERGY OF SUSTAINABLE AGRICULTURE AND RURAL TOURISM

SINERGIJA ODRŽIVE POLJOPRIVREDE I RURALNOG TURIZMA

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Abstract: *Since the middle of the last century, the production of food has taken the form of an industrial process in which food has the status of a commodity like any other marketable commodity. This method of production involves a higher intake of necessary chemical inputs (fertilizers and protective agents), a higher production of toxicants and greenhouse gases in the external environment and a higher consumption of energy, where soil and water represent only the environment for high production of plant and animal mass. This form of production has led to the emergence of "ecological diseases" and is a danger to the survival of humanity. That is why, at the beginning of the 21st century, food production experienced its great technological transformation and the introduction of green directives aimed at protecting the environment. The European Green Directive has a series of requirements in food production aimed at reducing the emission of gases that affect the increase in climate change, as well as standards that define a product with a high biological value. Slogans such as Zero Residues, Zero Waste and Zero Kilometers represent a manifesto of a new food concept. This motivated the scientific and professional public to find new directions in food production by introducing ecologically acceptable inputs in the system of sustainable agriculture. In sustainable systems of primary agricultural production where chemical inputs are replaced by biological ones, products with increased nutritional properties are obtained without toxic substances. Need or trend, healthy food has taken a significant place in the kitchen of consumers in the west. The goal of the work was to determine the nutritional properties of certain vegetable gardens produced in sustainable agriculture systems (integral and organax). By applying microbiological preparations with different groups of microorganisms in the sustainable production of beans, soybeans and breadcrumbs, an increase in the protein content of grains was determined, which is very significant because these plant species are very common in the human diet. By using a microbiological preparation with different groups of microorganisms, an increase in protein content in the grain of two varieties of beans (white and yellow) was determined from 5.92 to 9.54%. An increase in protein content from 1.91 to 4.02% was also found in the grain of two varieties of bread wheat compared to the conventional system. Research on the foliar application of a microbiological preparation in an integral system of soybean production revealed an increase in grain protein by 1.37%, which is also very significant considering that soybean proteins are a good substitute for meat proteins. In the closed system of the organic method of tomato production, an increase in the total antioxidant activity from 29.80 to 16.30% was determined in cherry fruits compared to the integral production system.*
With the development of awareness about the importance of health-safe food, a healthy and clean environment, and the desire for characteristic smells and tastes, the number of requests for holidays in rural

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areas is increasing. Food produced in sustainable systems can easily find its way into tourism, to be the carrier of rural tourism development. The synergy between agriculture and tourism can improve rural areas on the one hand and have a preventive effect on people's health on the other.

***Key words:** sustainable agriculture, nutritional properties, rural tourism*

***Apstrakt:** Od sredine prošlog veka proizvodnja hrane ima oblik industrijskog procesa u kome hrana ima status robe kao svaka druga tržišna roba. Ovaj način proizvodnje je sa većim unosom neophodnih hemijskih inputa (đubriva i zaštitnih sredstava), većom produkcijom toksikanata i gasova staklene baste u spoljnu sredinu i većom potrošnjom energije gde zemljište i voda predstavljaju samo sredinu za visoku produkciju biljne i animalne mase. Ovaj oblik proizvodnje je doveo do pojave "ekoloških bolesti" i predstavlja opasnost za opstanak čovečanstva. Zato je proizvodnja hrane početkom 21. veka doživela svoju veliku tehnološku transformaciju i uvođenje zelenih direktiva u cilju zaštite životne sredine. Evropska zelena direktiva ima niz zahteva u proizvodnji hrane čiji je cilj smanjenje emisije gasova koji utiču na povećanje klimatskih promena kao i standardi koji definišu proizvod sa visokom biološkom vrednošću. Slogani kao što su Zero Rezidues, Zero Waste i Zero Kilometers predstavljaju manifest novog koncepta ishrane. To je motivisalo naučnu i stručnu javnost na iznalaženje novih pravaca u proizvodnji hrane uvođenjem ekološki prihvatljivih inputa u sistemu održive poljoprivrede. U održivim sistemima primarne poljoprivredne proizvodnje gde su hemijski inputi zamenjeni biološkim dobijaju se proizvodi sa povećanim nutritivnim osobinama bez toksičnih materija. Potreba ili trend, zdravstveno bezbedna hrana je zauzela značajno mesto u kuhinji potrošača na zapadu. Za cilj rada postavljeno je da se utvrde nutritivne osobine pojedinih biljnih vrtsa proizvedenih u sistemima održive poljoprivrede (integralna i organakse). Primenom mikrobioloških preparata sa različitim grupama mikroorganizmima u održivoj proizvodnji pasulja, soje i hlebne pršenice utvrđeno je povećanje sadržaja proteina u zrnu, što je veoma značajno jer su to biljne vrste veoma zastupljene u ishrani ljudi. Korišćenjem mikrobiološkog preparata sa različitim grupama mikroorganizama utvrđeno je povećanje sadržaja proteina u zrnu dve sorte pasulja (belog i žutog) od 5,92 do 9,54 %. U zrnu dve sorte hlebne pšenice takođe je utvrđeno povećanje sadržaja proteina od 1,91 do 4,02% u odnosu na konvencionalni sistem. U istraživanjima folijarne primene mikrobiološkog preparata u integralnom sistemu proizvodnje soje utvrđeno je povećanje proteina u zrnu za 1,37%, što je takođe veoma značajno obzirom da su proteini soje dobra zamena proteina iz mesa. U zatvorenom sistemu organskog načina proizvodnje paradajza utvrđeno je povećanje ukupne antioksidativne aktivnost od 18,64 do 20,92% u plodovima tipa čeri u odnosu na integralni sistem proizvodnje.*

Razvojem svesti o značaju zdravstveno bezbedne hrane, zdravoj i čistoj sredini, željom za karakterističnim mirisima i ukusima sve je veći broj zahteva za odmorom u ruralnim sredinama. Hrana proizvedena u održivim sistemima može lako da nađe svoj put u turizmu, da bude nosilac razvoja ruralnog turizma. Sinergija između poljoprivrede i turizma može da unapredi ruralna područja s jedne i preventivno deluje na zdravlje ljudi sa druge strane.

***Ključne reči:** održiva poljoprivreda, nutritivne osobine, ruralni turizam*

1. INTRODUCTION

It is generally accepted in the world that the environment cannot be preserved and improved by separate policies and partial measures, but it is only possible to do so by realizing and implementing the concept of sustainable development. One of the basic principles of sustainable development is the principle of ecological sustainability. The physical endurance of the environment sets limits to many human activities and indicates that the consumption of natural resources must be protected and reduced. The United Nations has made great efforts over the last few years to draft a series of documents that would direct the development policies of states to combat poverty, improve well-being for all, protect the environment and successfully respond to the challenges of climate change.

Agricultural production is the area experiencing the greatest changes. It can be said that industrialized agriculture balances between, on the one hand, the requirement to meet the needs of the growing population for food and the desire to realize profit in production, and on the other hand, the need to preserve the quantity and quality of natural resources. According to the report of the international association of environmental activists Greenpeace, it is stated that, if the trend of agricultural production remains as it is now, in the coming decades it will produce 52% of global emissions of harmful gases, of which 70% comes from animal production. In addition, the quality of agricultural and natural land is threatened, and the health safety of food is also threatened. According to a United Nations study from 1991, intensive land management methods have led to the degradation of 38% of arable land, as it is estimated that 1% of the topsoil is eroded by water and wind every year worldwide (United Nations. Global Outlook 2000). One of the most serious problems in solving the problem of feeding a growing population is the decrease in soil fertility, which makes food production difficult. Also, the excessive use of fertilizers and pesticides represents a risk to the environment because it leads to disruption of the agrochemical properties of the soil, which primarily lowers the quality of plant products. Thus, as early as 1987 (Brundtland Report), the idea of developing sustainable agriculture emerged, together with the comprehensive concept of sustainable development (Tait et al., 2000). However, like the concept of sustainable development itself, the concept of sustainable agriculture has given rise to a large number of different definitions, views or paradigms of sustainable agriculture. (Pierce et al., 1993; Rezaei-Moghaddam et al., 2008). A greater number of definitions of sustainable agriculture were created as a result of different paths towards the achievement of the set goals (Lazić and Šeremešić, 2010). The most acceptable definition of sustainable agriculture is that it is an integrated system of plant and animal production processes that is applied in the long term to: meet food and fiber needs; improve the quality of the environment; efficiently uses non-renewable energy sources and farm resources and integrates appropriate natural biological cycles; maintains the economic viability of the farm/holding; and to improve the quality of life of farmers and society as a whole. In the system of sustainable agriculture, there are two subsystems, integral and organic production, which have a common goal, to support and encourage the natural cycles of circulation of matter and energy flow and increase biodiversity by applying modified agrotechnical measures (Kovačević and Momirović 2008). The basic principles of both systems of sustainable agricultural production are that nutrient cycles must be balanced and losses minimized. Integral production is based on principles that include inputs that are introduced in a controlled "low-input" manner, while the organic system of growing plants mainly uses inputs that are of biological origin. The central place in these production systems was taken by microbiological preparations with different groups of microorganisms in the preventive protection of plants from diseases and pests, as a replacement or supplement for mineral fertilizers and as plant growth stimulators. These preparations include mainly live bacteria, mycorrhizal fungi that have been isolated from soil, compost and from different parts of plants. Direct promotion of plant growth by microbes is based on increased availability of nutrients and hormonal stimulation. The advantage of biostimulators of this type is that they have no negative side effects, they are completely safe for the environment. They can be applied during the vegetation period in different phenological stages of plant development or in the soil before sowing.

Today, the use of multiple inoculants with a mixture of different types of so-called of effective microorganisms, in which there are molasses from sugar cane, humic acid, phosphoric acid, a large number of microelements, algae, extracts of medicinal plants and water. Formulations with effective microorganisms can be applied in all branches of agricultural production (farming, vegetable growing, fruit growing, viticulture, animal husbandry, manure and compost preparation) (Cvijanović et al., 2019; 2021.). Effective microorganisms play a significant role in the decomposition of organic matter and residues, fixation of atmospheric nitrogen, increasing the availability of nutrients for plants, suppression of soil phytopathogens, decomposition of various toxic compounds and pesticides. In addition, they synthesize antibiotics and other bioactive substances (hormones, vitamins, and others), simple organic compounds, polysaccharides, create complex compounds with heavy metals, which make them unavailable to plants, dissolve less soluble compounds (Javaid, 2010). The use of preparations with a large group of effective microorganisms of different formulations has a positive effect on the physical, chemical and biological properties of the soil..

In addition to the fact that these systems do not pollute the environment, numerous studies indicate that products from sustainable production have better nutritional properties (higher concentration of antioxidants and other phytochemicals). (Hepperly et al., 2018; Çakmakçı and Çakmakçı, 2023). Montgomery and Biklé (2021) state that vegetables had 20-120% higher antioxidant activity, as well as flavonoid content, with quercetin levels up to ten times higher. Sustainable farming methods and fertilization practices have been found to increase total phenolics in strawberries, pears, peaches, maize, and the like (Asami et al., 2003; Reeve et al., 2016). Cuevas et al. (2015) determined that in the integral system of cultivation of Japanese plum there was a significant increase in the concentration of polyphenols, anthocyanins and total antioxidant capacity than in the conventional system of production. Lombardo et al. (2012) stated that in the sustainable production of potatoes of certain varieties, a higher content of phenols, less nitrates and a better taste of the tubers were found. Cvijanović et al. (2021a) state that a higher content of macroelements was determined in the fruits of different varieties of tomatoes grown on ecologically acceptable principles. Çakmakçı and Çakmakçı (2023) point to many studies where the content of vitamin C, iron, magnesium and phosphorus is higher, and the content of nitrates is lower compared to products of conventional origin.

Considering the specifics of this form of production and the extensive way of land use, sustainable agriculture systems can be successfully applied in rural areas, because the largest part of the rural population is engaged in agriculture. In addition, the largest number of agricultural farms in the EU and in Serbia, according to their physical characteristics, can be classified as small farms, which is an advantage in organic production. In recent times, apart from agriculture as their main source of income, the rural population is increasingly diversifying its economic activity and turning to activities that are a continuation of primary agricultural production, such as the processing of primary agricultural products or activities that rely on agriculture such as some form of tourism through which they can market their products. In addition, rural areas are becoming more and more interesting for vacations. The reason for this is society's need for a peaceful environment, healthy air, healthy and safe food, healthy social relations, a return to nature, tradition and true values. Agricultural tourism (vacation on farms), nature tourism, green tourism, special interests (gastronomy and wine, observation of flora and fauna, etc.), and active vacation (horse riding, cycling, walking, etc.), historical and cultural forms of tourism are often highlighted as forms of rural tourism. All these forms of rural tourism rely on sustainable agricultural production. According to Cvijanović et al. (2017) sustainable agricultural and rural development is based on: an increase in agricultural production that brings food security, financial increase, as well as the possibility of employing more people, and at the same time affects the preservation of natural resources and environmental protection.

The goal of the paper is to show that in the system of sustainable production, good quality of fruits of plant species that are represented in human diet (beans, wheat, tomatoes) and can be produced in rural areas can be achieved.

2. MATERIAL AND METHODS

The results of research conducted at different locations with different plant species grown in an integral and organic production system will be presented in a row. In both production systems, in addition to mandatory agrotechnical measures, a microbiological preparation with a large group of effective microorganisms was applied in order to stimulate plant growth, replace mineral fertilizer and prevent plant protection. Preratau EM Aktiv (trade name) is a liquid preparation certified for organic production in Serbia and the EU. On the website of the Ministry of

Agriculture, Water Management and Forestry of the RS, the preparation EM Aktiv is on the list of permitted and registered means for plant nutrition and soil improvers that can be used in organic agriculture (http://www.minpolj.gov.rs/organska/). Effective microorganisms (EM) represent a mixture of cultures of more than 80 different families of beneficial microorganisms that have been isolated from natural habitats, and the preparation belongs to the group of mutypic inoculants. These include: photosynthetic bacteria (*Rhodopseudomonas palustris* and *Rhodobacter sphaeroides*), actic acid bacteria (*Lactobacillus plantarum, Lactobacillus casei, Streptococcus lactis*), yeasts (*Saccharomyces cerevisiae, Candida utilis*), actinomycetes (*Streptomyces albus, Streptomyces griseu*) and fungi (*Aspergillus oryzae* and *Mucor hiemalis*).

The preparation was applied to the soil immediately before sowing in the amount of 30 l/ha and during the growing season it was applied twice in the amount of 4%.

3. RESULTS AND DISCUSSION

Total protein content in beans

Beans are a plant species that belongs to the legume family and is a staple food in the diet of the entire world population (Cuadra et al., 2000). In terms of its nutrition, it is one of the richest sources of plant proteins, the most biologically valuable in human nutrition (Bennink, 2004; Tepić et al., 2007). It is considered one of the vegetables with the richest nutrients, primarily due to its high protein content. Its characteristic is that it gives good yields, and the dried grain is easy to store and does not lose any of its nutrients, and it is also easy to transport. Due to its neutral taste and its availability throughout the year, it is very common in people's diet as a main dish and as a spice. Beans have a high nutritional value of pods and seeds (Cardador-Martínez et al 2002). According to its chemical composition, beans contain the necessary biological substances: proteins (26%), carbohydrates (52%), fats (2.1%), then all essential amino acids, lecithin, potassium, etc. Bean pods are rich in pectins and, thanks to a good combination of fiber and folic acid, they have a number of benefits in maintaining human health. The production of beans according to ecological principles (organic production) tends to increase the area. In relation to other certified vegetables, that percentage increased from 2% to 9.17% compared to other vegetables in the last 10 years.

By applying organic production methods (use of organic fertilizer and effective microorganisms) when growing beans, it is possible to increase the protein content in the grain. The preparation EM Aktiv was applied in the physiological phase of the first trefoil and before cutting. Based on research conducted in the period from 2016-2018 in the region of Vojvodina with two varieties of beans (Maksa beli and Zlatko žuti), an increase in protein content in the grain of both varieties of beans in different agrometeorological conditions was determined by 5.92-9.54% compared to the conventional system (Table 1).

Table 1. Total protein content (%) in the grain of different bean genotypes

Hybrids	Method of production	2016	2017	2018	Average	Deviation (%)
Maksa	Convencional	21,97	18,37	19,97	20,10	100
	Organic	23,26	19,45	21,15	21,29	5,92
Zlatko	Convencional	20,37	17,03	18,52	18,64	100
	Organic	22,32	18,67	20,29	20,42	9,54

Total protein content in wheat grain

Wheat production is very important because it is the basis of the bakery industry and nutrition of over 80% of the population. The importance of wheat is mainly attributed to its ability to be ground into flour and semolina, which are the basic ingredients of bread, other bakery products and pasta. Wheat and wheat products are the most important source of protein in the human diet, as well as sources of amino acids, fats, minerals and vitamins (Braun et al., 2010). In recent decades, wheat products have accounted for more than 40% of protein supply (Zhong et al., 2019) and on average provide about 21% of daily protein needs in the diet (Shiferaw et al., 2013). Wheat seeds contain 60-75% carbohydrates, 12% water, 12-18% protein, 2.0% crude fiber, 1.5-2.0% fat and about 1.80% mineral elements. (Šramkováa et al., 2009). Grain protein content generally varies from 10-15% in wheat cultivars grown under field conditions (Shewry and Hey 2015). The biological, chemical and physical properties of the soil, temperature, soil humidity and the content of mineral elements, especially nitrogen, have a significant influence on the protein content of seeds. Cultivation technology plays a significant role in achieving high seed yields and protein content, and especially the provision of accessible nitrogen to the plant through various sources of nitrogen. (Knezevic et al., 2007). There are twenty amino acids in the structure of proteins, which are divided into essential amino acids, which the human body cannot synthesize, and non-essential amino acids, which the human body can synthesize (Shewry and Hey, 2015). Non-essential amino acids are associated with gluten proteins and play an important role in determining the quality of final wheat flour products (Saddiqi et al., 2020). According to research on the impact of the application of integral ecological production methods in different varieties of bread grain, it was determined that the content of total proteins in the grain can be increased from 1.56-3.98%, depending on the variety and the way of feeding. For wheat nutrition, NPK fertilizer was used in the conventional system 129 : 60 : 60 $kg \cdot ha^{-1}$, and in integral production 109 : 60 : 60 $kg \cdot ha^{-1}$ and EM Aktiv was applied twice (in the phenological phase of leafing and flowering). The results show that the application of a microbiological preparation can replace 20 $kg \cdot ha^{-1}$ of mineral fertilizer while increasing the content of total proteins in the grain (Table 2).

Table 2. Total protein content (%) in the grain of different wheat genotypes

Bread wheat	Method of production	2017	2018	2019	Average	Deviation (%)
Ratarica	Convencional	13,02	13,79	13,40	13,40	100
	Organic	13,17	13,88	13,79	13,61	1,56
Pobeda	Convencional	13,19	13,40	13,29	13,29	100
	Organic	13,78	13,86	13,82	13,82	3,98

Total antioxidant activity in tomato fruits

Due to its energetic, nutritious and medicinal properties, tomato is the most represented vegetable species in the human diet. Tomato fruits and its products have significant antioxidant, anti-inflammatory and anti-cancer effects. Epidemiological studies have proven the importance of tomatoes and its products in reducing cancer and cardiovascular diseases, because they contain large amounts of antioxidants such as carotenoids, polyphenols, ascorbic acid and many others (Perveen et al., 2015). The tomato fruit is used green and ripe in consumer food and in the processing industry. During the last decade, consumers have become more aware of food as a source of health benefits and its role in the prevention of several chronic diseases and dysfunctions (Pem and Jeewon 2015). Tomatoes contain many health-promoting compounds and are easily integrated as a nutritious part of a balanced diet (Martí et al., 2016). Also, research is cited in the literature that explains that if the body has a low level of antioxidants, the work of those enzymes slows down, which implies stress and damage to the body's cells. In addition to fresh consumption, consumers use tomatoes in processed products such as soups, juices and sauces (Krauss et al., 2006; Li et al., 2018). For human consumption, tomatoes are especially important in their fresh state

In the period 2020-2021, research was conducted on the integral and organic system of growing two tomato hybrids in a protected area. The plants were grown on banks and the basic nutrition of the plants was with NPKMgO 135:105:90:35 kg ha^{-1} (Humus Vita, biozolfo, castor plates and natur soil) in the organic system, and in the integral system 125:105:120:40 kg ha^{-1} (Humus Vita, biozolfo, potassium fertilizer). The content of total antioxidant activity was examined in the fruits of two tomato hybrids (Tomagino and Sakura) belonging to the cherry tomato type.
Total antioxidant activity was expressed in trolox equivalent units per gram mM TE kg^{-1} of fresh tomato sample. Antioxidant activity is related to the content of various biomolecules such as vitamins, terpenoids, carotenoids, polyphenols including phenolic acids and flavonoids. In research, it was determined that there was a difference in antioxidant activity depending on the type of production and hybrid. The tomato hybrid Tomagino had a higher antioxidant activity by 6.27%, and in the organic system, on average, both hybrids had a higher antioxidant activity by 19.80%. Individual tomato hybrids in the organic production system increased antioxidant activity from 18.64% (Sakura) to 20.92% (Timogino) (Table 3).

Table 3. Total antioxidant activity (mM TE kg^{-1}) in tomato fruits

The system of production	Timogino	Sakura	Average
Integral	133,8	129,8	131,8
Organic	161,8	154,0	157,9
Average	150,8	141,9	

4. CONCLUSION

The production of health-safe food as a form of organic agriculture can be a part of sustainable tourism and a significant factor in the determination of tourists to come to that household. Considering that this form of food production has its own specificities, it is very suitable for smaller areas located in rural areas. The development of awareness among consumers about the importance and values of organically produced food, a healthy environment, significantly influences the determination of tourists for destinations such as vacations in rural households. Considering that tradition and culture are preserved through this type of food production, destinations should be highlighted in promotions where health-safe food is produced with increased nutritional properties that are significant in the function of preserving the health of tourists.

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METHOD OF PREPARING A PLANT COMPONENT FOR A PROTEIN FUNCTIONAL FEED ADDITIVE

СПОСОБ ПРИГОТОВЛЕНИЯ РАСТИТЕЛЬНОГО КОМПОНЕНТА ДЛЯ БЕЛКОВОЙ ФУНКЦИОНАЛЬНОЙ КОРМОВОЙ ДОБАВКИ

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Abstract; *The development relates to the field of agriculture and concerns feed production, in particular methods for preparing a functional feed additive from sprouted pea grain for the purpose of introducing it into the diet of farm animals and birds. A method is proposed for preparing a plant component for a protein functional feed additive, which includes treating plant seeds by soaking them in an aqueous solution of an organic growth substance containing, by weight: sodium salt of naphthenic acid - 35-45, rapeseed oil - 0.005-0.015, fresh water - the rest, wherein the seeds of wintering peas (Pisum sativum L.) of the Legion variety are used as plant seeds, washed in a weak 0.1% solution of potassium permanganate (KMnO4), the aqueous solution of the organic growth substance is taken at a concentration of 0.1 ml / l of water, and the soaking of the seeds is carried out at a ratio of seeds to an aqueous solution of the organic growth substance of 1: 2, after which the soaked seeds are left in conditions of darkened natural light at a temperature of 18-20 ° C for three days until a finished plant component in the form of pea seed sprouts is obtained. The invention provides for obtaining a high-quality plant component for a protein functional feed additive in the shortest possible time, without additional energy and labor costs, without loss of raw material quality, due to increased germination and enrichment of the reserve of biologically active substances in the plant component of the feed additive.*

Key words: *Animal feed, nutritional supplement, peas*

Abstract: *Разработка относится к области сельского хозяйства и касается кормопроизводства, в частности способов приготовления функциональной кормовой добавки из пророщенного зерна гороха с целью ввода в рацион сельскохозяйственных животных и птиц. Предложен способ приготовления растительного компонента для белковой функциональной кормовой добавки, включающий обработку семян растений путем их замачивания в водном растворе органического ростового вещества содержащего, мас.%: натриевую соль нафтеновой кислоты - 35-45, рапсовое масло - 0,005-0,015, пресную воду - остальное, при этом в качестве семян растений используют семена зимующего гороха (Pisum sativum L.) сорта Легион, промытые в слабом 0,1% растворе перманганата калия (KMnO4), водный раствор органического ростового вещества берут в концентрации 0,1 мл/л воды, а замачивание семян проводят при соотношении семян к водному раствору органического ростового вещества - 1:2, после чего оставляют замоченные семена в условиях затемненного естественного освещения при температуре 18-20°C на трое суток до получения готового растительного компонента в виде проростков семян гороха. Изобретение*

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обеспечивает получение качественного растительного компонента для белковой функциональной кормовой добавки за максимально короткое время, без дополнительных энерго- и трудозатрат, без потери качества сырья, за счет повышения прорастания и обогащения запаса биологически активных веществ в растительном компоненте кормовой добавки.

Ключевые слова: *Корма, пищевая добавка, горох.*

1. INTRODUCTION

It is known that the condition of arable lands is deteriorating every year, which is due to the fact that more nutrients are removed from the soil with the harvest than are applied with fertilizers. More and more soils are becoming degraded and subject to erosion every year. (Riger, et al., 2016); (Soppelsa, 2018) For example, in Russia, less than half of the crop area is fertilized and less than 50 kg per 1 ha is applied, which is 4-5 times less than in Western Europe. The stabilization of the humus reserve in the soil is determined by the supply of organic matter. In the conditions of agricultural land use, a large role is given to organic fertilizers. (Xu, et al., 2012); (Zhao, Naeth, 2022)

One of the most urgent tasks in modern animal feed production is the development and application of high-quality functional additives that can significantly improve the nutritional status of farm animals and poultry. Special focus is placed on obtaining protein-vitamin supplements of natural origin, which not only improve feed utilization, but also contribute to animal health, increase their productivity and reduce the need for synthetic additives in the diet. (Ma, et al., 2021); (Dospekhov, 2014); (Romanenko A.A. Bespalova, 2019)
In this context, sprouted pea grains are a valuable source of natural nutrients, because the germination process activates enzymes that improve protein digestibility, as well as increases the content of vitamins, antioxidants and other biologically active components. Therefore, the development of optimal seed germination technology is essential for animal feed production, in order to obtain a high-quality product with the recommended biochemical and microbiological characteristics in the shortest possible time (Skamarokhova, et. al. 2024).

One of the key challenges in this process is to simplify the technological process of germination, reduce its duration and optimize the conditions for sprout growth, which allows for faster and more economical production without compromising on quality. To achieve these goals, various stimulating treatments are applied, such as soaking seeds in a solution of organic growth substances, including sodium salts of naphthenic acid and rapeseed oil, which stimulate germination and the development of plant components with an improved nutritional profile.

This method allows for a significant increase in the protein and vitamin content of the resulting additive, while maintaining the optimal ratio of essential amino acids and biologically active compounds. In addition, the use of mild antiseptic solutions, such as 0.1% potassium permanganate ($KMnO_4$) solution, contributes to the elimination of potentially harmful microorganisms, thereby ensuring the microbiological safety of the final product.

Another advantage of this approach is the minimization of energy and labor costs, as the germination process can be carried out under standardized conditions, without the need for complex technological procedures. This is especially important in the context of sustainable agricultural production, where the goal is to reduce dependence on expensive synthetic additives and focus on natural solutions that are both efficient and economically viable.

In this way, high-quality native protein-vitamin feed for farm animals and poultry is obtained, which not only improves their nutrition and productivity, but also contributes to sustainable development in the livestock sector. Such innovative solutions represent a step forward in the production of functional feed additives, allowing agricultural producers to improve their animal nutrition systems with minimal investment and maximum quality of the resulting product.

2. RESEARCH RESULTS AND METHOD

The technical result of the new method is to obtain a high-quality plant component for a functional feed additive in the shortest possible time without additional energy and labor costs, without loss of raw material quality, due to an increase in the energy of pea grain germination and enrichment of the supply of biologically active substances in the plant component of the feed additive.

The result is achieved by the fact that in the method for preparing a plant component for a protein functional feed additive, which includes treating plant seeds by soaking them in an aqueous solution of an organic growth substance containing, wt.%:

sodium salt of naphthenic acid	35-45
rapeseed oil	0.005-0.015
fresh water	the rest

The seeds of the plants are winter peas (Pisum sativum L.) of the Legion variety, washed in a weak (0.1%) solution of potassium permanganate ($KMnO_4$), an aqueous solution of organic growth substance is taken at a concentration of 0.1 ml / l of water, and the soaking of the grains is carried out at a ratio of grain to an aqueous solution of organic growth substance of 1: 2, after which the soaked grain is left in conditions of darkened natural light at a temperature of 18-20 ° C for three days until a ready plant component is obtained in the form of a sprouted pea grain.

The method for preparing the functional feed additive is as follows. For the functional feed additive from sprouted pea seeds (Pisum sativum L.), winter pea (dvuruchka) of the Legion variety was used. This variety was bred at the P.P. Lukyanenko Scientific Center for Plant Protection (Krasnodar region). In terms of quality, these seeds meet all the requirements for seed material (grain) of field peas. The experiment was conducted in accordance with the requirements of GOST 12038-84 (Seeds of agricultural crops. Methods for determining germination). Peas were taken in the amount of 5 kg, thoroughly washed in a weak (0.1%) solution of potassium permanganate ($KMnO_4$) and cleaned of foreign inclusions. After placing the washed pea grain in a clean plastic container, the grain was poured with an aqueous solution of organic growth substance prepared according to Russian patent No. 2 713 902 dated 10.02.2020 (0.1 ml / l of water) until the top seeds were wetted, and covered with clean linen cloth. Then, this container was placed in a dark place with an air temperature of 18 ° C for three days. On the third day, a small sprout appeared on the peas, which makes such seeds extremely useful when used as a feed additive. Next, the sprouted seeds were washed with running water, laid out in a thin layer on a clean cotton cloth and, when they got rid of moisture, they were sent to a drying cabinet. The sprouted seeds were dried to a state where they could be crushed (12-14%) in a grain crusher and used as a plant component for the preparation of a protein functional feed additive.

As a result of the complete zootechnical analysis (PZA) of pea grain treated with a growth agent according to the stated method, conducted in the laboratory (IC "Argus"), the germination energy increased (see Table 1).

On average, the difference in the germination energy of pea grains between the control and experimental variants (according to the proposed method) was 4.67%. The following vitamin content was determined in the sprout mass: B1 - 1.7 mg/100 g, B2 - 0.6 mg/100 g, B3-4.1 mg/100 g, B6 - 3 mg/100 g, E - 20.5 mg/100 g.

Table 1 - germination energy, % (on the 3rd day)

Name of solutions	Germination energy of seed peas (per 100 pcs.)		
	1 repetition	2 repetition	3 repetition
control (water)	56.00±1.47	63.75±3.77	59.75±0.75
test (the aqueous solution of the organic growth substance Grivlag 0.1 ml/l)	62.00±0.91***	64.75±0.95***	64.50±0.65***

Note: *** - differences with control at $p<0.05$

As a result of the complete zootechnical analysis (CZA) of pea grains treated with a growth substance according to the declared method, conducted in the laboratory, the content of nutrients (protein, starch, fat, etc.) increased (see Table 2).

Table 2 - Nutrient Content of Sprouted Pea Seeds

Variant	Dry matter (DM), %	Starch, %	Protein, %
control (water)	90.65	34.15	23.82
test (by the proposed method)	92.20	35.51	24.33

Thus, the claimed method for preparing the plant component for the protein functional feed additive will improve the quality of the feed.

The presented biochemical data allow us to conclude that the plant component obtained by the claimed method is suitable for inclusion in the protein functional feed additive in the diet of farm animals and birds.

The optimal ratio of grain to growth agent solution is declared to be 1:2, respectively. If the ratio of grain to growth agent solution is higher, this will contribute to the development of unfavorable microflora, which will hinder its germination; if it is lower, the saturation of the grain endosperm with moisture will be insufficient, which will also adversely affect the quality of germination.

Therefore, the optimal ratio of grain to aqueous solution of growth agent is, accordingly, 1:2. According to GOST 12038-84, the germination energy of peas is determined on the third day after soaking. It is at this time that the peak accumulation of all nutrients in the grain and sprouts is observed. If the grain germination time is less than 3 days, this contributes to insufficient accumulation of the necessary for a quality feed additive Sugars and enzymes. If more than 3 days - the grain overgrows, due to which its quality deteriorates, therefore the optimal germination time is 3 days.

3. CONCLUSION

As can be seen from the experimental data, the application of the proposed method of processing pea grains significantly improves the efficiency of the germination process, allowing to achieve an increased seed germination rate already on the third day. This effect is achieved due to the presence of naphthenic acids in the growth substances, which not only stimulate the activation of enzymatic processes in the seed, but also provide additional nutrition to the endosperm, thereby increasing the content of key nutritional components – primarily starch and protein.

The proposed method for the preparation of a functional feed additive brings significant advantages in terms of cost-effectiveness and sustainability of production. The reduction of energy and labor costs makes this process particularly suitable for application in small and medium-sized agricultural holdings, where resources are often a limiting factor. In addition, the fact that the method does not require specialized germination equipment makes it easily accessible and applicable in various production conditions, allowing flexibility in the scale of production – from experimental batches to larger commercial quantities.

This achieves the desired technical result: the nutritional value of livestock feed is increased in a natural and efficient way, without the use of synthetic additives, while at the same time optimizing the production process, thereby contributing to the improvement of livestock nutrition with minimal costs and maximum utilization of raw materials.

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MODELS FOR EVALUATING THE SUSTAINABILITY OF TOURISM: CREATING A SUSTAINABLE REGIONAL FUTURE

MODELI ZA EVALUACIJU ODRŽIVOSTI TURIZMA: KREIRANJE ODRŽIVE REGIONALNE BUDUĆNOSTI

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Abstract: *The goal of the paper is to refer to the possibility of measuring the impact of tourism on environmental factors and highlight the potential contribution of sustainable tourism to regional development. In order to encourage tourism activity in the new context of respect for environmental factors and regional development, several courses of action are formulated in the conclusion. In order to encourage sustainable tourist activity and increase the economic competence of the region, it would be desirable for the directions of action to be followed by regions with a developed economy as well as less developed ones.*

Key words: *Sustainable tourism, Environment, Sustainable development, Regional development*

Apstrakt: *Cilj rada je da se ukaže na mogućnost merenja uticaja turizma na ekološke faktore i naglasi potencijalni doprinos održivog turizma regionalnom razvoju. Kako bi se podstakla turistička aktivnost u novom kontekstu poštovanja ekoloških faktora i regionalnog razvoja, u zaključku su formulisani nekoliko pravaca delovanja. Kako bi se podstakla održiva turistička aktivnost i povećala ekonomska konkurentnost regiona, bilo bi poželjno da pravci delovanja budu praćeni i od strane razvijenih kao i manje razvijenih regiona.*

Ključne reči: *Održivi turizam, Okolina, Održivi razvoj, Regionalni razvoj*

1. INTRODUCTION

The development of tourism is conditioned by the quality of the environment, so the degree of its preservation and attractiveness has a direct impact on the development opportunities in a certain area. In addition to being responsible for the economic, social and cultural environment, tourism also bears a significant responsibility for the natural environment. In general, two groups of factors influence the quality of the environment. The first group consists of objective factors that arise from the manifestation of unfavorable natural phenomena. There are also subjective factors caused by human activities.

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Research of the relationship between tourism and sustainable development has become a prominent topic among researchers since the publication of the Brundtland Report in 1987. In recent decades, the principles put forward by this report, starting from the central idea of "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (Sonuç, 2023), have provided a framework for the development of tourism.

Bearing in mind the above, further development of tourism faces the task of achieving a balance in which meeting the current needs of tourists will not compromise meeting the needs of future generations. It follows that the relationship between tourism and the environment is of particular importance and its protection and preservation is the primary condition for establishing a sustainable and responsible development. Accordingly, the Swiss professor J. Krippendorf (Krippendorf, 1982) emphasized: "If we can lose, and then rebuild our capital in other fields of economy, the same is not true in tourism, where the basic substance is the landscape, and the land – once lost, is irretrievably lost".

Starting from the fact that space is transformed under the influence of tourist activity, the development of sustainable tourism gains more and more importance as a convincing concept for reconciling the economic benefits of tourism with the imperative to preserve the environment. With the increasing importance of the sustainability of the tourist industry for economy, a large number of scientists has researched the link between the sustainable development of tourism and the economy. Their results indicate that there is a strong connection (Ainou et al., 2022, Danish, Wang 2018, Pulido-Fernández and Cárdenas-García, 2020).

According to the interpretation of the World Tourism Organization and the UN Environment Program, "sustainable tourism" implies the development of activities that respect and satisfy the needs of tourists as demand bearers, without impairing the possibility of achieving economic, social and environmental goals at the same or higher level in the future" (Pavlovic, 2018). It is a long-term integrated process with broader economic, social and environmental policy considerations with the overall framework of sustainable development that maximizes economic, environmental, social and cultural benefits to the environment (Kahle-Piasecki, 2013).

In order for the concept of sustainable tourism to take root in practice, it is necessary to establish such a development model that will maximize positive relationships between the mentioned categories of goals (economic, environmental and social), and minimize the negative ones. The goals which are pursued are also prerequisites for their realization. Unlike the current practice, it is necessary that the new approach to the development of tourism emphasizes the importance of environmental protection in the foreground, while the economic dimension loses importance in a relative sense. One-sided profit-oriented tourism can make good economic results in a short period and satisfy many tourist needs, but, on the other hand, produce negative consequences for the environment and the life of local population (Jakovljević et al., 2020).

The importance of tourism and its contribution to overall regional development was recognized by Hunziker and Krapf in 1942. In their research, the two researchers proved that depending on the inbound and outbound tourist flows, tourism can have positive, as well as negative, effects on the scope and degree of regional sustainable economic development.

2. MATERIALS AND METHODS

As a concept, sustainable development is based on an integral and complex approach that puts equal emphasis on the five components (Stefanovic, Azemovic, 2012):

1. preservation of the environment;
2. affirmation of social integrity;

3. nurturing cultural peculiarities of the local population;
4. optimal satisfaction of tourist needs and
5. realization of economic profit.

Bearing in mind the forward foregoing, in the process of writing the article used general and special scientific research methods:

- *analysis and synthesis* – when choosing materials for research;
- *generalization* – for formulation the essence of the concept of "sustainable tourism";
- *retrospective analysis* – to study the concept of sustainable development and to build a conceptual framework for sustainable development of tourism;
- *framework analysis* – to identify the main directions of rural tourism development in Serbia in the context of sustainable development;
- *induction and deduction* – to summarize the results of the study and formulate conclusions.

3. RESULTS AND DISCUSSION

In many countries, tourism is recognized as an important factor of economic development. It is clear that economic factor is a positive effect of tourism. However, due to its mass and extremely fast global development in recent decades, tourism has brought a large negative impact on the environment, in addition to its positive contribution to the economic progress of society. Precisely because of these reasons of increasing pressure on natural resources, there is a need to plan and control tourism. The concept of sustainable development of tourism within a tourist destination should represent the basis of long-term development (Khoja et al., 2021).

Starting from the previously presented aspects, the relationship between tourism and sustainable regional development can be seen through the following considerations (Cernat, Gourdon, 2012):

1. Tourism activity has a great impact on the economy. On the one hand it has positive effects on the environment and the community (increased employment, greater contribution to GDP, better quality services, higher salaries, higher production, capital generation, larger local budget through tax collection, attracting investors to the area, etc.). On the other hand, the negative impacts of tourism on the environment are the impacts on natural resources, generation of pollution and waste and damage to the ecosystem;

2. Most studies that assess the economic impact of tourism activities usually take into account data on the number of arrivals, revenue per tourist, average length of stay and other economic indicators. Unlike many studies that treat only the physical and human environment, (Miller, 2010) presents a series of indicators that cover many aspects related to sustainability: environmental issues, employment, financial leakages from the system, aspects related to the client (satisfaction level), consumer behavior, the degree of social responsibility of tourism companies, etc.).

At the same time, the degree of development of a territory, through its economic, social and cultural characteristics, but also through the natural resources it possesses, is a factor that affects the predisposition of the population of the territory to travel, and implicitly, affects their behavior later on to the destination, and the effects on it (Table 1).

Table 1. Relations between tourism and sustainable development

Geographical elements of the tourist system	**Area of origin** **Dimension**	**Transit area***	**Area of destination** **Effects**
Interactions between tourism and sustainable development	*ECONOMIC DIMENSION The level of economic development influences the income of potential tourists;*	- investments for the development of transport infrastructure for the accommodation of tourists;	- economic growth; - profit from local resources that do not require major investments; creating jobs; -the development of transport infrastructure and public utilities; **- price increase (land, goods, services,** **- poorly paid jobs and affected by** **seasonality;** **- addiction to tourism.**
	SOCIAL AND CULTURAL DIMENSION Access to education (the educational level of the population); cultural values;	- over time, it can become a destination, becoming specific to its impact and relationships;	- improving the quality of life; - diversifying the job offer; - the revitalization of the region; - the revival and protection of local cultural values; **- acculturation;** **- overcrowding;** **- potential conflicts;**
	ENVIRONMENTAL DIMENSION	**- pollution and degradation of landscapes;**	- encouraging environmental protection; - conservation of historical buildings/monuments; **- pollution;** **- degradation of landscapes, historical sites, monuments;** **- changes in wild habitats;** **- constructions inconsistent with the environment**

Bold -negative efect

* The transit area is specific to the transport infrastructures intended to ensure tourists from the area of origin to the destination. Depending on the distance covered, various other elements of the tourist system may be present: infrastructure, leisure, tourist attractions.

Source: Manea, Cozea, 2022.

Given the significant potential of tourism industry to create jobs and income for local community and investors, the economic externalities of tourism are often substantiated and supported by empirical studies (Garcia et al., 2015).

The approaches concerning the impact of tourism on the environment are based on complementary perspectives aimed at monitoring natural resources in order to evaluate the transformations that tourism activities cause on the environment. The negative effects of tourism on the environment are of interest in academic circles.

The evaluation methods used vary from surveys aimed at analyzing the perception of residents, local actors or even tourists about these effects, to complex quantitative analyses. These analyses include data related to energy consumption or emission of various chemical compounds associated with the tourism industry or other indicators (Table 2), (Gossling, Peeters, 2019).

Table 2. Indicators regarding the Regional sustainability of tourism

Indicators within the Environmental Sustainability pillar
1.The strictness of environmental regulations
2. Application of environmental protection regulations
3. Sustainability of the development of the tourism sector
4. Carbon dioxide emissions
5. Concentration of harmful particles
6. Endangered species
7. Ratification of environmental protection treaties

Source: Manea, Cozea, 2022.

Over the years, the creation of models has aimed at steady economic growth and thus shaped several types of models. Most of the tourism development strategies formulated in the last two decades include an approach from a sustainability perspective and include environmental, socio-cultural and economic components (Kisi, 2019). In this way, on a theoretical level, they offer potential benefits at all levels, while at the same time proposing a holistic approach to tourism activity (Dezvoltare, 2022).

The expansion of research in economic and social sciences, as well as their connection with the tourism economy, has led to the definition of the following capacities for the further development of tourism (Rodriguez, 2021; WTTC, 2020):

- **Ecological capacity** refers to the establishment of the development of tourist structures and activities without negative impact on the environment and degradation of its components. In this case, natural components (air, water, soil, vegetation) are considered. In addition, it includes the process of production and recovery of economy, which does not require investment costs that would be caused by the degradation of certain tourist destinations.
- **Physical capacity** has a decisive role in determining the degree of saturation that tourism activities can reach in terms of environmental problems. In recent years, the rapid growth of tourism has influenced the increase in the volume of many forms of pollution (coastal, mountainous, etc.). One way to protect the physical capacity of a territory can be achieved by investing in high-performance technology. On the other hand, the provision of high quality services can give contribution.
- **Social-receptive capacity** aims to maintain good relations between hosts (local population) and visitors (tourists). In a situation where the local population realizes that tourist activities lead to the degradation of the natural and cultural environment, on their

part there may be a reduction in the threshold of tolerance with the final result of rejecting tourists. In order to avoid such unpleasant situations, it is necessary to respect the traditional way of life of the inhabitants and their habits when developing a tourist area or locality in a certain territory. Starting from the fact that a friendly interaction between visitors and local residents creates significant effects on visitors' satisfaction with the destination, maintaining positive attitudes of local residents towards the development of tourism is extremely important.

- **Economic capacity** emphasizes the valorization of all existing resources through tourism activities. This capacity implies the maintenance of the tourist function of the given territory, where the efficiency of exploitation is measured by the ratio between costs and benefits. The size of benefit can be increased by using high-performance technologies, while the level of costs is expressed by the qualitative and quantitative value of resources (natural, cultural, workforce, general infrastructure, etc.).
- **Psychological capacity** is related to the negative perception of tourists towards a tourist destination. This occurs as a result of degradation of the environment or inadequate attitude of the local population. More precisely, psychological capacity is related to the motivation of tourists to visit a certain destination as well as the maintenance of their personal satisfaction. Its application is conditioned by the quality of managerial activity. Ultimately, the quality of managerial activity can affect the loyalty of requests.

All the capacities mentioned above are closely related to tourism activity. They determine the material or immaterial, measurable or non-measurably boundary of the space it has or to which a tourism function can be attributed. Although these capacity indicators do not offer a standard formula, some components of the natural or cultural framework are difficult to quantify through statistical-mathematical data series.

Taking into account the above, the support concepts motivate and encourage the sustainable development of tourism and indicate to which the impact of tourism on the environment can reach. Accordingly, they also provide the possibility of identifying ways to reduce degradation caused by transport and tourist activities.

Due to the fact that the intensification of the process of globalization of the world economy during the past few decades has also affected tourism, it is necessary to take into account the socio-economic ties between nations around the world. Accordingly, international tourism stands out as an important area of economic development and a significant factor in the international economic exchange of services between people located on different continents. However, the global character of international tourism in today's conditions makes this activity very sensitive.

4. CONCLUSION

Sustainable tourism must focus on creating a synergy between the realization of tourism objectives and the protection of nature, landscape and cultural heritage. For this, an integrated government approach is necessary, which encourages and supports the increase in the level of competitiveness and the sustainable development of tourism. Essentially, this represents an effort to research and discover the best practices of social responsibility for sustainable development.

More precisely, it implies the implementation of an ambitious politics aimed at favorable positioning of tourist destination. All this includes awareness of the beneficial effects of tourism on economic growth (income generation, jobs, adequately trained human resources, economies of scale, etc.).

In order to achieve more sustainable forms of tourism, it is necessary to focus on less economically developed areas, but with ecological potential. In finding weaknesses and turning them into probable strengths that attract tourists, this can be achieved by intensively involving multiple actors.

That is why the priority directions of the development of the state policy in the field of tourism should be a sustainable approach that will be supported by the economic development policy, the creation of sustainable development plans with the provision of quality services, but at the same time with the reduction of excessive and inadequate use of natural and cultural heritage. The permanent nature of environmental education from the earliest period (childhood) is also extremely important.

Competitiveness, environmental and social issues of sustainable tourism development can be solved together by applying innovations and fostering the principles of sustainable consumption. In addition, the provision of new tourism services with respect to the needs of local communities and the priorities of the sustainable development of tourist destination make an additional contribution.

In the end, it should be emphasized that legislation and regulations play a key role in the development of forms of tourism based on sustainable principles.

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COMPARISON OF ORGANIC AND CONVENTIONALLY PRODUCED FOOD

СПОРЕДБА НА ОРГАНСКА И КОНВЕНЦИОНАЛНО ПРОИЗВЕДЕНА ХРАНА

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Abstract:*Organic production is focused on sustainable development, conservation of natural resources, and the use of traditional methods, resulting in healthy and biologically valuable products. Organic foods do not use synthetic pesticides or genetically modified organisms (GMOs), making them more desirable for both health and the environment. Although there are differences in the nutritional and sensory characteristics between organic and conventionally produced foods, factors such as the variety and climatic conditions have a greater impact than the production methods themselves. From a scientific perspective, there is still insufficient evidence regarding the bioavailability and health benefits of organic food. This literature review presents a comparison between organic and conventionally produced food in terms of safety, quality, bioavailability, and health effects.*

Key words: *Organic, sensory, pesticides, nutrients, health status*

Апстракт: *Органското производство се фокусира на одржлив развој, зачувување на природните ресурси и употреба на традиционални методи, што резултира со здрави и биолошки вредни производи. Органските производи не користат синтетички пестициди и ГМО, што ги прави посакувани за здравјето и животната средина. Иако постојат разлики во нутритивните и сензорните карактеристики помеѓу органската и конвенционално произведената храна, факторите како сортата и климатските услови имаат поголемо влијание од производните методи. Од научна гледна точка, сеуште нема доволно докази за биорасположливоста и здравствените придобивки на органската храна. Овој преглед на литература претставува споредба помеѓу органска и конвенционално произведена храна во однос на безбедноста, квалитетот, биорасположливоста и здраствените ефекти.*

Клучни зборови: *органска, сензорна, пестициди, хранливи материи, здраствена состојба*

1. INTRODUCTION

Organic production includes practices that emphasize agriculture based on ecosystem management, integrated livestock systems, a variety of products based on natural pest and disease control, without the use of chemical/synthetic products (Bernacchia et al., 2016). The

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consumption of organic food is continuously growing, and organic products are becoming increasingly demanded by consumers (Jensen et al., 2014). The increased demand is a result of consumer perception, who often view organic food as safer, higher quality, and healthier compared to conventionally produced food (Galgano et al., 2016). In response to this demand, the global market for organic food and beverages increased by more than 500% from 1999 to 2018 (Willer et al., 2020). According to Kashif et al. (2020), the market value of organic food, which amounted to 124.76 billion US dollars in 2017, is expected to grow by around 323.09 billion US dollars by the end of 2024, indicating an increase of 14.56%.

2. SAFETY

The increased demand for organic food raises the issue of its safety compared to conventional food (Malmauret et al., 2002). Organic food production differs from conventional production in terms of the procedures that are essential for identifying, labeling, and certifying organic products (Kouba, 2003). Organic farming uses cover crops, organic waste, compost, crop rotation, and bio-fertilizers to maintain and improve soil structure and fertility. Biological pest control, using resistant seeds, hand weeding, and biopesticides, is also a practice in organic farming (Liebman & Davis, 2000; Seufert & Ramankutty, 2017). In contrast to conventional agriculture, which includes inorganic fertilizers to increase yields, as well as pesticides, insecticides, herbicides, and fungicides for pest control (Crinnion, 2010), organic livestock are fed with "natural" feed, without pesticides. Moreover, animals are provided with unrestricted access to the outdoors and a higher degree of freedom of movement (Sundrum, 2010; Chander et al., 2011). Additionally, organic production practices zero tolerance for genetically modified organisms, radiation, prophylactic antibiotics, and engineered nanoparticles (Paull, 2020).

In the last decade, interest in organic agricultural and livestock production has been increasing both globally and locally. According to EU Regulation No. 834/2007, organic production is defined as a comprehensive system of farm management and food production that combines the best ecological practices, a high level of biodiversity, conservation of natural resources, application of high animal welfare standards, production standards, and methods, in accordance with the desires of certain consumers for products made using natural substances and processes. Organic production involves a process of sustainable development in rural areas, in line with available resources and tradition, and represents a well-rounded farming system of plant and animal production that includes the conservation and renewal of natural resources and the return to traditional values and knowledge.

Consumers most often choose to consume organic food because they consider it safer due to the ban on synthetic pesticide use (Bourn & Prescott, 2002), which can cause various toxicities such as neurotoxicity, mutagenicity, carcinogenicity, teratogenicity, and endocrine disruptions (Ahmad et al., 2024), as well as a range of diseases, especially if residues in food exceed the maximum residue limit (MRL) (Rekha Naik & Prasad). The organic sector aims to minimize the contamination of organic products with such substances (EU, 2018/848). The dominant pesticides used in organic production are biopesticides, which are compounds created by microorganisms and natural materials of plant and animal origin, offering a natural, safe, and ecological alternative to chemical pesticides (Golijan-Pantović & Sečanski, 2022). These pesticides are characterized by a non-toxic mode of action and present minimal risk to human health and the environment (Benbrook et al., 2021).

Although the use of synthetic pesticides in organic production is limited (EC 834/2007; EC 889/2008), their presence is still confirmed. In the European Union, 500 maximum residue levels (MRLs) have been harmonized, covering 370 food products or food groups. The standard MRL of 0.01 mg/kg applies to pesticides that are not explicitly mentioned in the MRL legislation

(EFSA, 2018). Regulation (EC 396/2005) obliges EU member states to carry out controls to ensure that food placed on the market complies with legal limits. For organic products produced in accordance with Regulation (EC 834/2007), no specific MRLs have been set. That is, plant protection products should only be used if they are compatible with the objectives and principles of organic production. Thus, Regulation (EC) No. 396/2005 regarding MRLs applies equally to both organic and conventional food.

Consumers of organic food are justifiably concerned because, despite the restrictions on the use of synthetic pesticides in organic production, traces of pesticides continue to be found in organic products (Schleiffer & Speiser, 2022). A total of 373 samples of twelve different fruits grown and imported to the UK were tested for the presence of 398 different pesticides. About 85% of the tested conventional fruits and vegetables contained pesticides, while 86% of organic fruits and vegetables did not contain pesticides. Organic samples that contained pesticides included 3 (out of 4) spinach samples, 1 (out of 4) tomato sample, and 1 (out of 9) cucumber sample (John, 2023). Analyzing pesticide residues in conventional samples from Switzerland and Europe, it was confirmed that 60% of conventional food samples in Switzerland and 44% in Europe contained pesticides, while 9% of organic samples in Switzerland and 6% in Europe contained pesticide residues. In Switzerland, among organic samples, substances allowed in organic farming accounted for 30% of the cases of residues, while organochlorine pesticides (leftovers from past use) and bromide (mostly of natural origin) accounted for 5% and 10% of cases, respectively. The remaining 55% of residues in organic food were due to pesticides used in conventional agriculture (Schleiffer et al., 2021).

According to the European Food Safety Authority (EFSA, 2018) report on pesticide residue monitoring in food or animal feed from Iceland and Norway from 2013 to 2015, the following findings were reported: a total of 28,912 conventional and 1,940 organic food samples were analyzed. Of the conventional samples, 44% contained one or more quantifiable pesticide residues, while for organic food, the frequency of detectable pesticide residues was 6.5%. The percentage of samples exceeding the maximum residue levels (MRL) for conventional and organic food was 1.2% and 0.2%, respectively.

Although organic production does not support the use of synthetic pesticides, artificial fertilizers, or any herbicides, their widespread use in conventional agriculture causes contamination throughout the food supply chain (Schleiffer & Speiser, 2022). According to the European Organic Certifiers Council (EOCC, 2019), 7,500 organic products were analyzed to identify the cause of pesticide residue contamination. In 43% of cases, contamination was due to environmental factors, 18% from air contamination, 8% from pesticide transfer to organic crops from contaminated soil or water, and 17% from post-harvest contamination during transport and handling, mostly from equipment. To protect the integrity of organic production, organic certifiers are required to investigate the causes of pesticide residues in organic food. Such residues may have different origins, such as unintended contamination, but the possibility of fraud by producers cannot be ruled out (Schleiffer & Speiser, 2022). Fraud or false labeling of organic food, as well as its higher price compared to conventional food, are significant barriers to the broader implementation of organic food (Rock et al., 2017).

In addition to pesticides, the presence of mycotoxins, patulin, and increased levels of Campylobacter in certain organic food products have been observed, compromising the safety of organic food. Campylobacter spp. was isolated from 100% of organic broiler flocks, 36.7% of conventional broilers, and 49.2% of intensive broiler flocks in closed housing, of which 6 out of 62 Campylobacter isolates were resistant to one or more of the tested antimicrobial agents (Heuer et al., 2001). A similar study was conducted on organic broiler meat in Denmark. Thermostable Campylobacter spp. was isolated from 54.2% of organic carcasses and 19.7% of conventional carcasses. The results were presented as annual average prevalence. The most commonly isolated species was *Campylobacter jejuni*, and the difference in prevalence was evident in all quarters of the year (Rosenquist et al., 2013).

In a meta-analysis of data on the incidence and concentrations of mycotoxins produced by *Fusarium*, *Claviceps*, *Penicillium*, and *Aspergillus* species in grains from organic and conventionally produced cereal crops, Wang et al. (2024) presented the following results. The standard weighted meta-analysis of the concentration data revealed a significant effect of the production system (organic vs. conventional) only for Fusarium mycotoxins deoxynivalenol, with concentrations approximately 50% higher in conventional than in organic cereal crops ($p < 0.0001$). Patulin is a mycotoxin mainly found in rotting apples and apple-based products. When analyzing a total of 93 apple-based products, 49 from conventional production and 44 from organic production, the results indicated a higher incidence of positive samples and higher concentrations of patulin in organic apple puree compared to conventional products (Piqué et al., 2013).

3. QUALITY

The growth of the organic food market is also due to consumers' beliefs that organic food is better, higher quality, more nutritious, and healthier compared to conventionally produced food (Jensen et al., 2014). The organic label on food products leads to a greater overall desire, willingness to pay, and a lower assessment of the caloric value of the food product (Schouteten et al., 2019; Besson et al., 2019). In general, consumers perceive fresh, unprocessed organic food as healthier than processed organic food (Prada et al., 2017).

According to Ditlevsen et al. (2019), consumers may perceive organic food as healthier than conventional food due to better nutritional status, higher levels of essential micronutrients, and a better macronutrient composition. Organic crops contained significantly more vitamin C, iron, magnesium, and phosphorus, and significantly fewer nitrates compared to conventional crops. Organic crops also contained fewer proteins, but with better quality (Worthington, 2001). In the meta-analysis by Średnicka-Tober et al. (2016), comparing organic and conventional meat products, the following results were obtained. For many nutritionally important compounds such as minerals, antioxidants, and individual fatty acids (FA), the database was too weak. However, significant differences in the fatty acid profile were found when data from all livestock types were combined. The concentrations of SFA and MUFA were similar or slightly lower in organic meat compared to conventional. Larger differences were found for total PUFA and n-3 PUFA, which were 23% and 47% higher in organic meat, respectively. In the study by Kalevska et al. (2016), a comparison was made between 60 organic and 60 conventionally raised lambs. The meat from the organic farming system had the most favorable fatty acid ratio and content, which was attributed to the farming system and feeding method. Differences in the average content of water, proteins, fats, carbohydrates, and minerals between the organic and conventional groups were statistically significant ($p < 0.05$). Overall, the results indicate that lamb meat from organic farming systems has higher meat quality compared to conventional systems. Also, sensory attributes (smell, juiciness, taste, aroma, texture, and tenderness) were significantly ($p < 0.01$) higher for organic system meat compared to conventional system meat (Kalevska et al., 2016).

In a meta-analysis of 170 scientific articles comparing organic and conventionally produced cow's milk, Średnicka-Tober et al. (2016) did not find significant differences in the total content of SFA and MUFA between organic and conventional milk. However, the content of total PUFA and n-3 PUFA was significantly higher in organic milk by 7% and 56%, respectively. The concentrations of α-linolenic acid (ALA), long-chain n-3 fatty acids (EPA+DPA+DHA), and conjugated linoleic acid were also significantly higher in organic milk. There was no significant difference in the total concentrations of n-6 PUFA and linoleic acid (LA), while the ratios of n-6:n-3 and LA:ALA were lower in organic milk. In organic milk, there were also significantly higher levels of α-tocopherol and Fe, but lower concentrations of I and Se. The analysis also indicated that the main reason for the differences in the milk composition is the animals' diet, whether pasture or feed. When producing goat white brine cheese from organic goat milk, two different types of starter cultures were used. A combined mesophilic and thermophilic starter culture (Lactococcus lactis ssp. lactis, Lactococcus lactis ssp. cremoris, Streptococcus thermophilus, and Lactobacillus bulgaricus) was used for the first type of cheese, and a thermophilic starter culture for the second type of cheese. The results indicated that the starter cultures used in the production process had the greatest impact on the differentiation of milk components during the aging process, and this difference was particularly emphasized in the sensory characteristics (Saveski et al., 2016).

In the study by Caris-Veyrat et al. (2004) assessing the content of antioxidant macronutrients in organic and conventionally grown tomatoes, a difference was observed in the results based on how they were expressed. Specifically, when the results were expressed for fresh matter, organic tomatoes had a higher content of vitamin C, carotenoids, and polyphenols (except for chlorogenic acid) compared to conventional tomatoes. However, when the results were expressed in dry matter, there was no significant difference in lycopene and naringenin content. In tomato puree, no difference was found in carotenoid content between the two growing methods, while the concentrations of vitamin C and polyphenols remained higher in the puree made from organic tomatoes. According to the study by Heimler et al. (2017), nitrogen in the soil affects the content of anthocyanins and flavonoids, and generally, a higher content of polyphenols is observed when fertilizers with lower nitrogen content are added to the soil. Agricultural practices with minimal input also influence the content of polyphenols in fruits. In a systematic review of literature by Dangour et al. (2009), based on 55 satisfactory studies, it was found that conventionally grown crops had significantly higher nitrogen content, while organically grown crops had significantly higher phosphorus content and higher titratable acidity, with no differences found for other tested parameters.

When comparing commercially packaged organic food purchased from online retailers in Italy with conventionally produced products, small differences were observed. Organic products such as pasta, rice, and cereals had lower energy value, protein, and higher saturated fats. Organic jams, chocolate spreads, and honey had lower energy value and carbohydrates and higher protein content. No differences were found in other food categories between organic and conventional products. Consequently, the study suggests that organic certification cannot be considered an indicator of overall better nutritional quality of the product (Dall'Asta et al., 2020).

There is a lack of scientific studies or evidence that organic food is significantly different from conventional food in terms of nutritional properties and health impact (Bernacchia et al., 2016). Studies often have inappropriate designs and imprecise sampling methods. It is particularly important to specify the source of the organic product and the degree of influence from factors such as climate, soil, harvest timing, growing conditions, farming practices, breed, etc. (Bourn & Prescott, 2002; Galgano et al., 2016).

4. HEALTH EFFECTS

There are a small number of studies on the health effects of consuming organic food compared to conventional food. Although these studies indicate the influence of the production system on the immune system of consumers, such effects are not easily interpreted as either positive or negative in terms of health (Mie & Wivstad, 2015). In their study, Bradbury et al. (2014) test the hypothesis that consuming organic food could reduce the risk of soft tissue sarcoma, breast cancer, non-Hodgkin lymphoma, and other common types of cancer in a study involving 623,080 middle-aged women from the UK. The women reported whether they consumed organic food and were followed for the occurrence of cancer over the next 9.3 years. 30% of the women reported that they never, 63% occasionally, and 7% always ate organic food. The results suggested little or no reduction in the incidence of cancer associated with consuming organic food, except possibly for non-Hodgkin lymphoma. In contrast, a study conducted by Baudry et al. (2018) on 68,946 participants from France, found that higher frequency of organic food consumption is associated with a reduced risk of cancer.

A cohort study in the Netherlands (n=2764) measured the consumption of organic food, eczema, and breathing difficulties in infants up to the age of 2 using repeated questionnaires. Blood samples from 815 infants at the age of 2 were analyzed for total and specific IgE. Eczema was present in 32% of infants, recurrent breathing difficulties in 11%, and prolonged breathing difficulties in 5%. By the age of 2, 27% of the children were sensitized to at least one allergen. Of all the children, 10% consumed a moderate amount of organic food while 6% consumed strictly organic food. Consumption of organic dairy products was associated with a lower risk of eczema, but no association was found with organic meat, fruits, vegetables, or eggs (Kummeling et al., 2008). According to Payet et al. (2021), a family history of allergies and allergies to cow's milk proteins up to 2 months of age had a strong positive influence when feeding with organic food during the complementary feeding period. However, feeding with organic food during the additional feeding period was not associated with respiratory diseases or eczema at the age of 5.5 years. According to Alexander et al. (2014), although indications of health benefits from organic food for the risk of atopic diseases in children and a positive effect of organic diet on general health in animal models have been reported, the evidence is still insufficient to draw a final conclusion.

5. CONCLUSION

The safety and nutritional value of food depend not only on the content of essential nutrients but also on the minimal content of harmful substances like pesticides. The use of pesticides is not allowed in organic production. The presence of pesticides in organic products is mostly the result of contamination from air, water, or equipment, which indicates long-term and excessive use of pesticides globally. Differences in nutritional characteristics between organic and conventional products are the subject of numerous studies. However, there is still no conclusive scientific evidence regarding the superiority of organic food compared to conventionally produced food. The differences that occur are most often attributed to factors such as the variety, climatic conditions, soil conditions, and growing practices, among others.

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ETHICAL DIMENSION OF SUSTAINABLE DEVELOPMENT OF AGRICULTURE – LEGISLATIVE APPROACHES

ЕТИЧКА ДИМЕНЗИЈА НА ОДРЖЛИВ РАЗВОЈ НА ЗЕМЈОДЕЛСТВОТО – ЗАКОНОДАВНИ ПРИСТАПИ

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Abstract: *Sustainable development of agriculture is a topic of debate and academic writing worldwide. Among their three pillars, economic, social and environmental, few studies have been written presenting the social equity of sustainability in agrofood system. The research aims to exploring the ethical dimension of sustainable development of agriculture, trying to answer the question „Is sustainable development equitable for all participants of agro-food system?". The answer is reaveled by reviewing the legislation in force protecting the operators of food chain against unfair trade practices and analyzing the results of the surveys showing the unethical situations in which participants are exposed to. Results show that the most common unfair trade practices are: reprisals and abuses, payment issues, contractual and communication problems, unjustified requirements, unjustified return of the products. Finally, the effects of unfair trade practices upon food system operators are presented.*

Key words: *sustainable agriculture, sustainable development, unfair trade practices*

Апстракт: *Одржливиот развој на земјоделството е тема на дебата и академско пишување ширум светот. Помеѓу нивните три столба, економски, социјален и еколошки, напишани се неколку студии кои ја прикажуваат социјалната еднаквост на одржливост во системот за земјоделска храна. Истражувањето има за цел да ја истражи етичката димензија на одржливиот развој на земјоделството, обидувајќи се да одговори на прашањето „Дали одржливиот развој е правичен за сите учесници во агро-прехранбениот систем?". Одговорот се открива со прегледување на важечката легислатива за заштита на операторите на синџирот на исхрана од нефер трговски практики и анализа на резултатите од анкетите кои покажуваат на неетичките ситуации во кои се изложени учесниците. Резултатите покажуваат дека најчести нефер трговски практики се: репресалии и злоупотреби, проблеми со плаќањето, договорни и комуникациски проблеми, неоправдани барања, неоправдано враќање на производите. Конечно, се претставени ефектите од нефер трговските практики врз операторите на системот за храна.*

Клучни зборови: *одржливо земјоделство, одржлив развој, нефер трговски практики*

1. INTRODUCTION

Sustainable development is a relevant area of study for research, worldwide. It encompasses three dimensions: economic, social and environmental, according to the three main issues of

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sustainable development: economic growth, environmental protection, and social equality (Taylor, 2016).
In recent years, there has been a surge in publications on the topic of sustainability to such an extent that “the science of sustainability or sustainable development” is seen as a distinct field of study (Schholman et al., 2012). Although there is an abundance of papers in this regard, the term sustainability remains an open concept with countless interpretations and understandings that are highly context-dependent.

The Sustainable Development Goals, SDGs, have been adopted by the United Nations in 2015 as a universal wake-up call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030 (Agenda 2030). Among the 17 SDGs, the goal number 2 is Zero Hunger, targeting to eradicating hunger, ensuring food security, improving nutrition and promoting sustainable agriculture. The research explores the sustainable development of agriculture, more precisely, the social aspects of it.

As regards the social dimension of sustainable development of agriculture, one question arises: Is sustainable development equitable for all participants of agro-food system? The case study of agriculture is taken into consideration, trying to answer the question: How ethic is the sustainable development of agriculture? The research starts from the hypothesis that the most vulnerable operators of the food system are small farmers and consumers. This hypothesis is based on two assumptions: they are less informed compared to large food producers and retailers and they have fewer financial resources. Thus, the objectives of this research are to identify the situations when food chains’ participants are exposed to unethical situations and to present the legislative regulations protecting them.

Unethical actions of the food chain operators are known as unfair trade practices. Concerns about unfair practices have often been associated with the field of competition and antitrust, dating back to the Sherman and Clayton Acts in the United States, enacted in the late 19th and early 20th centuries (Sasson, 2012; Dumitru et al., 2023). These laws were designed to regulate and limit forms of anticompetitive behavior, including unfair trade practices (Ibanez and Zapata, 2020; Dumitru et al., 2023).

Over time, concerns about unfair practices have spread to other areas, including the service sector, technology and, more recently, the agricultural sector (Cadilhon et al., 2006). In the European Union, the Unfair Commercial Practices Directive was adopted in 2005 and was later revised to include the agricultural and food sector. This has been called in response to power imbalances between different opperators of the supply chain, such as farmers and producers/retailers (Pinstrup-Andersen and Babinard, 2001).

In the food system, identifying and regulating unfair trading practices has become particularly relevant in recent years, where farmers, often with limited resources and low bargaining power, can be in a vulnerable position versus large retailers and processors (Giovanucci and Bowen, 2011; Dumitru et al., 2023). This is the reason why exploring the specific laws and regulations that protect farmers' interests and ensure a fairer business environment is needed and will be discussed in this paper.

The papers revises the regulation in the area of unfair trade practices in agrofood system, presenting the European and national reglementations. They are discussed in conection to current state of unfair trade practices experience by food system operators, declared in surveys. Finally, the conclusions regarding the implications of unethic actions upon small farmers and consumers are drawn.

2. MATERIALS AND METHODS

The European Union has developed Directive (EU) 2019/633 to address the issue of unfair trade practices between operators in the agro food supply chain. It has been developed to address significant inequalities in the bargaining power of suppliers and buyers of agricultural and food products, which can lead to unfair trading practices.

Directive (EU) 2019/633 of the European Parliament and of the Council on unfair trade practices between businesses in the agricultural and food supply chain sets a minimum Union standard of protection against unfair trading practices in order to reduce the occurrence of such practices which can have a negative impact on the standard of living of the agricultural community.

At national level, Romania has transposed the provisions of Directive (EU) 2019/633 through the Law 81/2022 on unfair trading practices between operators in the agricultural and food supply chain. This law establishes a list of prohibited unfair trading practices in relations between buyers and suppliers in the supply chain, by regulating payment terms, the powers and duties of the competition authority, designated to ensure the national application of the provisions of the directive, as well as the sanctions applicable to the perpetrator of the violation.

In Romania, the authority responsible for the application of the provisions of Directive (EU) 2019/633 and Law no. 81/2022 is the Competition Council. This authority has the competence to investigate and sanction violations of the legal provisions regarding unfair commercial practices within the agricultural and food supply chain.

A summarize of the Directive (EU) 2019/633 is presented in Table 1.

Table 1. Summary of unfair commercial practices under Directive (EU) 2019/633

Unfair practice name	***Explanations***
Payment Terms	For perishable agricultural and food products, payment terms cannot exceed 30 or 60 days, depending on the conditions
Order Cancellation	The buyer cannot cancel orders for perishable products without a reasonable period of notice (minimum 30 days).
Unilateral Changes	The buyer cannot unilaterally change the terms of a supply agreement.
Non-Sales Payments	The buyer cannot request payments that are not related to the sale of the products.
Payments for Damage or Loss	The buyer cannot request payments for damage to or loss of products on its premises
Written Confirmation of Agreement	The buyer must confirm the terms of a supply agreement in writing upon the supplier's request.
Unlawful Disclosure of Trade Secrets	The buyer cannot unlawfully disclose the supplier's trade secrets.
Commercial Retaliation	The buyer cannot threaten or carry out commercial retaliation against the supplier.
Compensation for complaints costs	The buyer cannot claim compensation for the costs of examining customer complaints.
Return of unsold products	The buyer cannot return unsold products without paying for them.
Payments for storage, display or listing	The supplier cannot be required to pay for the storage, display or listing of its products.
Payments for promotional discounts	The buyer cannot require the supplier to bear the cost of discounts on products sold in promotions.

Payments for advertising	The buyer cannot require the supplier to pay for advertising the products.
Payments for marketing services	The buyer cannot require the supplier to pay for marketing services.
Payments for fitting out sales premises	The buyer cannot require the supplier to pay for staff involved in fitting out sales premises.

Source: own processing upon Directive (EU) 2019/633 provisions

3. RESULTS AND DISCUSSIONS

As observed in Table 1, there are numerous situations in which unethical actions of food chain participants occur and affect other operators within the system. Following the application of the Directive (EU) 2019/633, the effects of its measures on the operators in the agro food chain have been analyzed using surveys. So far, surveys have been conducted in the following periods:

- 2020-2021: consisting of a total of 4104 respondents from all member countries of the U.E.;
- 2021-2022: consisting of a sample of 319 respondents from all member countries of the U.E.:
- 2022-2023: consisting of a sample of 164 respondents from all member countries.

The unfair trade practices identified have been grouped, for their better highlighting, in five categories, as follows: reprisals and abuses, payment issues, contractual and communication problems, unjustified requirements, unjustified return of the products.

The main results of the surveys show that, in those regarding reprisals, 18% of respondents reported that less than 20% of their transactions are reprisals from the buyer and 12% of respondents reported that less than 20% of their transactions are abusive use of the commercial secrets of a supplier by the buyer, in 2021. These values significantly decrease in 2022 to 16% and 5% respectively.

In terms of payment for deterioration and/or loss of agricultural and food products unjustified from buyer to supplier, about 15% of respondents reported that less of 20% of their transactions are affected by this situation, in 2021. The value remained almost the same for 2022.

As regards the contractual and communication problems, between 12% and 19% of respondents reported such problems for less than 20% of their transactions, depending on the problem reported: buyer's refusal to deliver a written confirmation (12%), cancellations of orders with short notice (13%) and unilateral changes of the contract (19%). These values decreased in 2023. Unjustified requirements refer, most of them, to the buyer’s request for the supplier to pay for different activities of marketing, such as advertising, merchandising, storage, unspecified in initial contracts.

As regards the unjustified return of the products, 15% of the respondents reported that this situation occurred in less than 20% of their transactions, in 2021, and only 1% reported the situation in more than 80%. These values dramatically decreased in 2022 to 7% and 0.5% respectively.
The unfair trade practices are a significant problem in the agricultural sector, having a profound impact on producers, consumers and the economy in general. These practices can bring substantial damage, undermining durability and equity within food supply chains (Bhaskaran and Raj, 2020). The negative impact manifests itself in several ways, including in affecting the income of the producers, the quality of the products and the confidence of consumers in the foods they buy (Lacroix and Vermeulen, 2001).

This can lead to an unbalanced relationship between producers and buyers, putting producers in a vulnerable position (Friendly and Denis, 2008). In many cases, producers may be forced to sell products at low prices, which reduces their income and affects the sustainability of the business. In addition, the terms and conditions imposed by buyers may be unfair, often without the possibility of negotiation, which disadvantages producers (Mena and Palazzo, 2012).
Moreover, unfair trade practices can also lead to the provision of inferior or misleading products to consumers, including false or insufficient labeling, manipulation of product information, or the use of substandard ingredients. Consumers may be misled and may purchase products that do not meet quality or safety standards (Grimwade, 2006).

The negative effects of unfair trade practices extend to the macroeconomic level. These practices can reduce the competitiveness and efficiency of the agricultural sector, which can ultimately affect economic growth (Uzunidis, 2018). In the long term, this can affect a country's food security and its ability to meet the nutritional needs of its population (Urata, 2020).

4. CONCLUSIONS

The paper analyzed the less explored pillar of sustainable development of agriculture, the social one. The European Union has developed Directive (EU) 2019/633 to address the issue of unfair trade practices between operators in the agro food supply chain. The results of previous research demonstrated that, following the application of the directive, unfair trade practices in agro-food chain still happened, but with a lower intensity and a decreasing trend. The most common unfair trade practices are reprisals and abuses, payment issues, contractual and communication problems, unjustified requirements, unjustified return of the products.

The legislative measures for combating unfair commercial practices have a common objective to protect the interests of producers, consumers and the economy in general. These measures contribute to the establishment of a fair and transparent commercial environment, in which abuses are prevented and sanctioned according to the law.

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FERMENTED MILK PRODUCTS AS FUNCTIONAL FOOD AND SOURCE OF PROBIOTICS

ФЕРМЕНТИРАНИ МЛЕЧНИ ПРОИЗВОДИ КАКО ФУНКЦИНАЛНА ХРАНА И ИЗВОР НА ПРОБИОТИЦИ

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Abstract: *Functional food refers to food whose components have a beneficial effect on one or more functions of the body. Fermented dairy products are used in human nutrition because they have significant nutritional and dietary value. The fermentation process changes some components of milk and creates new components, so that fermented products acquire new qualities. The fermentation process improves the bioavailability of nutrients, reduces lactose content and produces bioactive peptides with anti-inflammatory and antioxidant properties. The highest percentage of probiotics can be found in fermented dairy products such as yogurt, kefir and sour milk. Probiotic bacteria contribute to lowering cholesterol, preventing diarrhea, strengthening immunity, enabling better lactose tolerance, slowing the onset of osteoporosis, preventing colon cancer, and more. The proven properties of probiotics contribute to a greater presence and demand for these products on the market. Future research focuses on improving the stability of probiotics, developing personalized functional dairy products, and exploring synbiotic formulations that combine probiotics with prebiotics. This review highlights the importance of fermented dairy products as functional foods and their potential role in improving human health.*

Key words: *functional food, milk, fermented milk products, probiotics*

Апстракт: *Под функционална храна се подразбира храна чии што компоненти поволно делуваат на една или повеќе функции на организмот. Ферментираните млечни производи се користат во исхраната на луѓето бидејќи имаат значајна хранлива и диететска вредност. Со процесот на ферментација доаѓа до промена на некои состојки на млекото и создавање на нови состојки, така да ферментираните производа и добиваат нови квалитети. Процесот на ферментација ја подобрува биорасположливоста на хранливите материи, ја намалува содржината на лактоза и произведува биоактивни пептиди со антиинфламаторни и антиоксидативни својства. Најголем процент на пробиотици можеме да најдеме во ферментираните млечни производи како јогурт, кефир и кисело млеко. Пробиотските бактерии придонесуваат за намалување на холестеролот, ја спречуваат дијареата, го зајакнуваат имунитетот, овозможуваат подобро поднесување на лактозата, ја забавуваат појавата на отеопороза, го превенираат канцерот на дебелото црево и друго. Докажаните својства на пробиотиците придонесуваат за поголема застапеност и побарувачка на овие производи на пазарот. Идните истражувања се фокусираат на подобрување на стабилноста на пробиотиците, развој на персонализирани функционални млечни производи и истражување на синбиотски формулации кои комбинираат пробиотици со пребиотици. Овој преглед ја нагласува важноста на ферментираните млечни производи како функционална храна и нивната потенцијална улога во подобрувањето на човековото здравје.*

Клучни зборови: *функционална храна, млеко, ферментирани млечни производи, пробиотици*

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1. INTRODUCTION

Functional foods are foods that provide health benefits that go beyond their basic nutritional value. In recent years, functional foods have gained great popularity in nutrition. Numerous studies have shown that many consumers do not consume enough vitamins and minerals, nor dietary fiber, which are also necessary for the normal functioning of the body. Functional foods are highly nutritious and are associated with a number of powerful health benefits. For example, they can protect against disease, prevent nutrient deficiencies, and promote proper growth and development.

Since prehistoric times, fermentation has been used to meet the needs of food storage. Today, fermentation is still practiced worldwide to increase the shelf life of raw products and to obtain foods with more pleasant organoleptic characteristics and superior nutritional properties. Standardized fermentation processes have now been developed to improve the traditional fermentation method, which utilizes the microbial microflora naturally present on the substrate (Galimberti A, 2021).

Fermented dairy products are one of the oldest examples of functional foods, as they contain probiotics. Therefore, it is good to use fermented dairy products in the diet, as they have significant nutritional and dietary value. The fermentation process, which is caused by microorganisms, changes some components of milk and creates new ones, so that fermented products acquire new qualities. By using various lactic acid bacteria, lactose is broken down, and the product can also be consumed by lactose intolerant people.
Probiotics are those live, beneficial microorganisms that are not destroyed by stomach acid, bile, and digestive enzymes and successfully reach the large intestine alive where they are able to settle and multiply.

The aim of this paper is to investigate probiotic properties of fermented dairy foods, their nutritional composition and impact on health.

2. TYPES OF FERMENTED DAIRY PRODUCTS AND THEIR PROBIOTICS CULTURES

Fermented dairy products are obtained from the fermentation of milk, through the action of suitable and harmless microorganisms. In addition to lactic acid bacteria, fermented dairy products have bioactive compounds as well as bacteria derived metabolites produced during fermentation. Fermented dairy products, due to their special characteristics, are an excellent matrix for the incorporation of ingredients and nutrients that give the final product properties beyond purely nutritional, making them true functional foods. The base for the production of fermented dairy products is milk, which has a typical composition of ≈87.4% water, ≈4.7% lactose, ≈3.8% fat, ≈3.3% protein, ≈0.2% citrate, and ≈0.6% minerals. The pH of milk is usually between 6.5 and 6.7. The protein fraction is composed of ≈80% casein and 20% whey proteins. Thus, the nonfat dry matter of milk is between 8.5% and 9% (Schlimme, 1995). The transformation of lactose into lactic acid is the most important fact, in addition to other bioactive components. The most common strains of lactic acid bacteria used for fermentation of milk are *Streptococcus thermophilus*, usually in association with Bifidobacteria, such as *Bifidobacterium breve* C50, *Bifidobacterium lactis*, *Bifidobacterium longum* and *Bifidobacterium animalis*, or with Lactobacilli such as Lactobacillus acidophilus, *Lactobacillus rhamnosus*, *Lactobacillus johnsonii* and *Lactobacillus casei* (A. Granier, 2013).

During fermentation, lactic acid bacteria produce significant amounts of organic acids. Organic acids act as inhibitors of the rapid growth and multiplication of microorganisms. Lipophilic acids such as lactic and acetic acids in undissociated form can penetrate the microbial cell and lower the intracellular pH. Lactic acid bacteria can produce H2O2 in the presence of oxygen under the action of flavoprotein oxidase or NADH peroxidase. The concentration of H2O2 that can be increased to a level that acts antimicrobially, due to the lack of catalase activity of the bacteria. The H2O2 produced by lactic acid bacteria shows an inhibitory effect on Staphylococcus aureus and Pseudomonas sp. Its bactericidal effect can be attributed to the strong oxidative effect on the microbial cell and primarily on its proteins. Namely, it causes oxidation of SH- groups in the enzymes hexokinases, aldolases, and glyceraldehyde-3-phosphate dehydrogenase (Annick Bernalier, 1999).

2.1. Yogurt

Yogurt is a fermented dairy product obtained through the bacterial fermentation of milk, primarily using *Lactobacillus delbrueckii subsp. bulgaricus* and *Streptococcus thermophilus*. It is one of the most widely consumed functional foods due to its rich nutritional composition, probiotic properties, and numerous health benefits (Nyanzi R, 2021). Yogurt is produced by inoculating milk with live bacterial cultures, which convert lactose into lactic acid. This process lowers the pH, leading to milk protein coagulation and giving yogurt its characteristic texture and tangy flavor. Milk can be whole, low-fat, or skimmed milk. For pasteurization it is needed heat treatment (85–90°C for 15–30 minutes) to eliminate pathogens, then the milk is cooled to 40–45°C before bacterial inoculation. Fermentation starts when starter cultures are added, and fermentation occurs for 4–6 hours (Fisberg M., 2015). Yogurt is a rich source of essential nutrients, including: proteins (casein and whey proteins), calcium and phosphorus, B vitamins (B2, B12) and probiotics.

There are several types of yogurt:
Regular yogurt – Made from cow's milk with standard bacterial cultures.
Greek yogurt – Strained to remove whey, resulting in a thicker consistency and higher protein content.
Probiotic yogurt – Contains additional probiotic strains like Lactobacillus acidophilus and Bifidobacterium bifidum.
Plant-based yogurt – Made from almond, soy, or coconut milk for lactose-intolerant individuals.

2.2. Sour milk

Sour milk is a fermented dairy product obtained through the acidification of milk by lactic acid bacteria. It has been consumed for centuries across different cultures and is valued for its tangy taste, probiotic properties, and health benefits. Sour milk can be naturally fermented or produced using specific bacterial cultures. There are 3 types of Sour Milk:
Naturally fermented sour milk – Raw or pasteurized milk left to ferment naturally due to native lactic acid bacteria.

Cultured sour milk – Pasteurized milk inoculated with specific bacterial strains *like Lactobacillus acidophilus, Lactococcus lactis,* and *Streptococcus thermophilus* (Shuvarikov A. S., 2019).
Acidified milk – Milk soured by adding acids like vinegar or lemon juice, but lacking probiotic benefits.

Sour milk is a nutritious and easily digestible fermented dairy product with probiotic benefits. It has been traditionally used for digestive health, bone strength, and immune support. While it shares similarities with yogurt and kefir, it has a distinct microbial composition and taste.

Including sour milk in the diet can be a simple and effective way to improve gut health and overall well-being (Aryana K. J., 2017).

2.3. Kefir

An almost ideal probiotic dairy product may be kefir because probiotic strains have been isolated from several members of the typical flora (eg, *L. acidophilus, L. casei,* and *L. reuteri*). However, the market potential of this product is limited because the blown lids of the retail containers (the result of carbon dioxide production after fermentation) apparently signal spoilage to most consumers.

Kefir is a traditional fermented dairy drink with a slightly tangy, fizzy taste and a rich probiotic profile. It is made using kefir grains, which contain a symbiotic culture of bacteria and yeasts. Unlike yogurt, kefir has a broader spectrum of probiotics, including beneficial yeasts, making it a powerful functional food with various health benefits. Kefir is produced by fermenting milk with kefir grains, which consist of proteins, polysaccharides, and a diverse microbial community. The fermentation process occurs at room temperature (20–25°C) for 12–24 hours. Milk can be cow, goat, sheep, or plant-based milk (e.g., coconut or almond milk). Microbial activity converts lactose into lactic acid, alcohol, and carbon dioxide (Azizi N, 2021). Kefir contains over 30 strains of beneficial bacteria and yeasts, including the lacto acid bacteria: *Lactobacillus kefiri, Lactobacillus casei, Lactococcus lactis* and *Streptococcus thermophilus,*and the yeasts *Saccharomyces cerevisiae*, *Saccharomyces boulardii* and *Kluyveromyces marxianu.* These microbes work synergistically to support gut health, improve digestion, and provide antimicrobial properties (Leite A., 2013).

Kefir is a highly nutritious, probiotic-rich beverage that offers numerous health benefits, from improved digestion to enhanced immunity. Its unique microbial diversity sets it apart from other fermented dairy products, making it a powerful functional food. Regular consumption can support gut health, metabolic balance, and overall well-being.

3. PROBIOTICS IN FERMENTED MILK PRODUCTS AND THEIR HEALTH BENEFFITS

The term probiotic means "one or more cultures of microorganisms that have a beneficial effect on the human microflora". Probiotics are also called good bacteria because they have a beneficial effect on the immune system and help prevent infections.

Table 1. Probiotic Content in Different Fermented Milk Products

Fermented Product	***Main Probiotic Strains***	***Additional Benefits***
Yogurt	*Lactobacillus bulgaricus, Streptococcus thermophilus, Bifidobacterium lactis*	Supports digestion and boosts immunity
Kefir	*Lactobacillus kefiri, Bifidobacterium spp., Saccharomyces boulardii*	Contains beneficial yeasts; enhances gut health
Sour Mlik	*Lactococcus lactis, Lactobacillus acidophilus*	Supports gut microbiota balance

The largest percentage in the body is the group of lactic acid probiotics, namely *Bifidobacterium bifidum* and *Lactobacillus acidophilus*, which are used to produce yogurt and other fermented dairy products, which are called probiotics due to their abundance (Ziaei R., 2021). These microorganisms manifest their beneficial effects on human health through:

• Improving and strengthening the immune system by suppressing putrefactive processes in the intestines and helping to establish normal intestinal microflora
• Helping peristalsis and intestinal function
• Beneficial for stomach problems
• Helping to reduce the risk of osteoporosis and rheumatoid arthritis
• Lowering cholesterol levels
• Beneficial for skin problems and allergies
• Improving the nutritional balance of dairy products
• Helps with weight loss

The function and condition of the gastrointestinal tract is the basis for the well-being of the body. The intestinal microflora present in the human body is of great importance, primarily in increasing resistance and protecting against excessive proliferation of already present potentially pathogenic bacteria. Many factors such as diet, climate, geographical location, aging, drug therapy, especially with antibiotics, stressful situations, infections, can disrupt the normal balance.

L. acidophilus plays an important role in the processes of synthesis and assimilation of necessary vitamins in the intestinal tract. It is known to help eliminate toxins and harmful substances that are ingested with food and to eliminate pathogenic bacteria. This bacterium helps maintain normal pH in the intestinal system and plays an important role in preventing ulcers. It affects the improvement of chronic digestive problems, including constipation and diarrhea. It plays an important role in preventing the proliferation of Candida albicans (Gao H., 2022).

Bifidobacterium bifidum is normally found in the colon, helps absorb water from food and process other waste. It participates in reducing the pH value in the intestine, produces specific B vitamins and supports immune function (Chen J., 2021). Modern lifestyles contribute to improper nutrition, the use of antibiotics and other medications with their accumulation have their own negative effect in the body.

Based on literature data, it is believed that a large number of diseases begin in the colon through the process of autointoxication. End-products of metabolism, pathogenic microorganisms, and toxins found in the colon, if they enter the bloodstream, can cause various diseases.

The best-known bacteriocin from lactic acid bacteria is nisin, which is produced by *Lactococcus lactis subsp. lactis*. In recent decades, a large number of papers have been published on the production of bacteriocins by lactic acid bacteria. The mechanism of action of bacteriocins is reduced to their interaction with specific receptors on the surface of the microbial cell (Soltani S., 2021). The table lists the lactic acid bacteria and the bacteriocins they produce.

Table 2. Lactic acid bacteria producing bacteriocins

Type of bacteria	***Bactricin***
Lactococcus lactis subsp. cremoris	Lactostreptsin 5
Lactococcus lactis subsp. Lactis	Nisin, lacticin 481
Lactococcus lactis subsp. Diacetilactis	Lactococcin A, lactococcin B
Streptococcus salivarius subsp. thermophiles	Protein
Lactobacillus acidophilus	Acidolin, acidophilus, protein, antibiotic substance, lactocidin, acidocin A, acidocin B, lactocin B, acidophilin A

Lactobacillus brevis	Lactobacillin, brevicin 37
Lactobacillus dulbreckii subsp. Bulgrcus	Bulgaricin
Lactobacillus fermenti	fermenticin
Lactobacillus helveticus	Lactocin 27, helveticin J
Lactobacillus plantarum	Lactolin, plantaricin A, plantaricin SIK-83, plantaricin SA6
Lactobacillus reuteri	Rojterin
Lactobacillus sake	Sakacin A, lactacin S
Lactobacillus casei	caseicin 80
Pediococcus acidilactici	Pediocin AcN
Enterococcus faecium	Antibacterial substance, bacteriocin, enterocin 1146, enterocin 01

The benefits of regular intake of probiotics include a beneficial effect on the immune system, better integrity of the intestinal mucosa, reduced incidence and duration of intestinal infections, influence on the allergic response and a beneficial effect on digestion. It should be known that probiotics feed on undigested plant fibers - prebiotics. This means that there must be a sufficient presence of these plant fibers in the diet. They undergo complete fermentation by bacteria in the colon, and one of the products of this fermentation is lactic acid, which inhibits the proliferation of harmful bacteria.

4. HEALTH BENEFITS OF FERMENTED MILK PRODUCTS

Fermented milk products such as yogurt, kefir, sour milk and buttermilk have been consumed for centuries due to their nutritional value and probiotic content. Below are the key health benefits of fermented milk products.

•Gut health and digestion- probiotics (*Lactobacillus, Bifidobacterium* and *Streptococcus species*) help maintain a balanced gut microbiota, preventing digestive disorders. They aid in the breakdown of lactose, making them suitable for lactose-intolerant individuals. Probiotics help manage irritable bowel syndrome, bloating, constipation, and diarrhea. Fermentation increases the production of short-chain fatty acids, which support gut health and nutrient absorption (Hadjimbei E., 2022).

•Enhanced immune function- Probiotics in fermented milk products stimulate immune responses by increasing immunoglobulin A (IgA) and anti-inflammatory cytokines. Regular consumption reduces the risk of infections, colds, and respiratory illnesses. Certain strains, such as *Lactobacillus rhamnosus* and *Bifidobacterium lactis*, help modulate inflammation and allergic reactions.

•Bone and dental health- Rich in calcium, phosphorus, magnesium, and vitamin D, fermented dairy products strengthen bones and teeth. Regular consumption reduces the risk of osteoporosis and fractures, especially in older adults. Lactic acid helps improve calcium absorption, enhancing bone mineral density.

•Cardiovascular benefits- Probiotics in fermented dairy lower LDL (bad cholesterol) and increase HDL (good cholesterol). Some strains, such as *Lactobacillus reuteri*, help reduce hypertension and arterial inflammation. Regular consumption may lower the risk of heart disease and stroke.

•Weight management and metabolism- High protein content in yogurt and kefir promotes satiety, reducing overall calorie intake. Probiotics help regulate fat metabolism, reducing body fat accumulation. Fermented dairy products improve insulin sensitivity, lowering the risk of type 2 diabetes.

•Mental health and gut-brain connection- The gut microbiota influences mood, stress levels, and cognitive function. Probiotics, such as *Lactobacillus rhamnosus*, help regulate neurotransmitters like serotonin and GABA, reducing anxiety and depression (Yu L., 2020). A healthy gut microbiota is linked to better memory and stress resilience.

•Anti-inflammatory and antimicrobial effects- Probiotics reduce gut inflammation, helping manage conditions like Crohn's disease and ulcerative colitis. Lactic acid bacteria produce bacteriocins, which inhibit harmful pathogens like *Salmonella*, *E. coli* and *Helicobacter pylori*. Fermented dairy supports skin health, potentially reducing acne and eczema symptoms (Mori N., 2016).

•Reduced risk of type 2 diabetes- Fermented milk products regulate blood sugar levels and improve glucose metabolism. Some probiotics enhance insulin sensitivity, lowering diabetes risk.
A diet rich in yogurt and kefir has been associated with a lower prevalence of metabolic disorders (Alihosseini N., 2017).

•Detoxification and antioxidant effects- Probiotics help detoxify harmful substances, including heavy metals and toxins from processed foods. Fermented dairy contains antioxidants and bioactive peptides that help neutralize free radicals, reducing oxidative stress (Dahiya D., 2022).
Conclusion

Fermented milk products are nutrient-rich and probiotic-packed, offering numerous health benefits. They improve digestion, immunity, bone strength, heart health, mental well-being, and metabolism. Regular consumption can enhance gut microbiota balance and support overall health.

5. CHALLENGES AND FUTURE DIRECTIONS

Functional foods containing prebiotics and probiotics have sparked the interest of the dairy industry due to scientific evidence related to their positive health benefits. With the increasing popularity of probiotic products, consumers frequently demand that the health properties of probiotic strains be preserved in the products sold and that there is at least a theoretical chance that the health effects of the probiotic strains will be evident after consumption. To guarantee this, many important variables must be considered by the dairy industry. One is that sufficient numbers of probiotic cells survive throughout the shelf life of the product. Another is that the probiotic cells survive intestinal passage and establish themselves in the terminal ileum or in the large intestine in sufficient numbers to display their health effects. To ensure this, studies must show that adverse interactions with the food matrix or with the starter organisms of the dairy food do not play any role in this respect. Despite the many benefits, there are challenges associated with fermented dairy products as functional foods. Many probiotic strains are sensitive to heat, oxygen, acidity, and storage conditions, leading to reduced viability during processing and shelf life. Maintaining high bacterial counts ($\geq 10^6$ CFU/g) until consumption is a key challenge in dairy production. Encapsulation technologies and improved storage methods are needed to enhance probiotic survival. Some fermented dairy products, such as kefir, have a sour taste and unique texture, which may not be widely accepted by all consumers. Balancing health benefits with taste and texture improvements remains a key challenge for food scientists. Unlike conventional dairy, probiotic-containing fermented milk products require specific refrigeration conditions to maintain microbial activity. Some probiotic strains may lose potency over time, affecting their therapeutic benefits. Some individuals, especially those with weakened immune systems, may be at risk of infections from opportunistic probiotic strains (Dantas A., 2020). Overconsumption of certain probiotics may lead to gut dysbiosis, bloating, or intolerance in sensitive individuals. Ensuring strain-specific safety testing is essential for probiotic product development.

Scientists are exploring genetically engineered probiotics with enhanced survivability, functionality, and resistance to harsh conditions. Research on next-generation probiotics (NGPs), such as *Akkermansia muciniphila* and *Faecalibacterium prausnitzii*, could expand the benefits of fermented milk products (Abuqwider J. N., 2021). Studies shown that *A. muciniphila* modulates obesity by regulating metabolism and energy hemostasis and improving insulin sensitivity and glucose hemostasis. In addition, studies showed this microorganism enhances low grade inflammation by different mechanisms.

Packaging probiotic beverages is unique, as the aim is to maintain beneficial microbes while preventing product spoilage. Packaging plays a critical role in maintaining the efficacy, and by extension, product promise, of probiotic beverages (Lumby N., 2021). Encapsulation technologies (e.g., alginate, lipid-based carriers) are being developed to protect probiotics from heat, stomach acid, and oxygen exposure. Smart packaging with moisture or temperature indicators may help maintain optimal storage conditions and extend shelf life.
Advances in microbiome research and nutrigenomics may lead to personalized probiotic dairy products tailored to an individual's gut microbiota. The benefits acquired from a probiotic are personal, depending on the health status, dietary habit and prevailing GI microbiota. Personalized probiotics should be established to achieve precision administration of specific probiotic effects for targeted population. Globalization and urbanization of human activities have led to merging of dietary habit, thus effective probiotics should evolve in tandem (K, 2018). Functional dairy could be designed for specific populations, such as infants, athletes, or the elderly, with targeted probiotic strains.

AI and machine learning can optimize fermentation processes, predict probiotic viability, and personalize dietary recommendations. Big data analytics can help track consumer preferences and gut microbiome trends, shaping future probiotic product development. Research is expanding into synbiotic dairy products, which combine probiotics (live bacteria) and prebiotics (fibers that feed good bacteria) for enhanced gut health. Bioactive peptides and postbiotics (metabolites produced by probiotics) may become new functional ingredients in dairy-based and non-dairy fermented foods.

6. CONCLUSION

Fermented milk products are nutrient-rich and probiotic-packed, offering numerous health benefits. They improve digestion, immunity, bone strength, heart health, mental well-being, and metabolism. Regular consumption can enhance gut microbiota balance and support overall health. Probiotic bacteria work for the benefit of human health, contribute to lowering cholesterol, prevent diarrhea, strengthen immunity, enable better lactose tolerance, slow down the onset of osteoporosis, prevent colon cancer, and are useful in treating obesity. Fermented milk products and probiotics continue to evolve with advancements in food science, biotechnology, and personalized nutrition. Addressing stability, regulation, sustainability, and consumer acceptance will be critical for the future growth of the industry. Innovations in microencapsulation, plant-based fermentation, and AI-driven probiotic research will likely shape the next generation of functional dairy products. There is significant interest in expanding the range of foods containing probiotic microorganisms, from dairy products, baby food, fruit juices, cereal products, etc. The proven properties of probiotic strains of bacteria contribute to a greater presence of these products on the market.

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ETHICAL CHALLENGES IN THE MARKETING OF ORGANIC PRODUCTS IN SERBIA

ETIČKI IZAZOVI U MARKETINGU ORGANSKIH PROIZVODA U SRBIJI

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Abstract: *In recent years, the organic products market in Serbia had witnessed substantial growth, primarily driven by an increasing consumer awareness regarding health, sustainability and environmental concerns. This paper aims to highlight the critical need for safeguarding consumers against unethical advertising practices employed by companies marketing organic products. Employing comparative methodology the paper further analysis the application of ethical standards in the promotion of these products. While the marketing potential for organic product is significant, it is essential that such marketing practices adhere to ethical principles, encompassing transparency, accuracy of information and environmental responsibility.*

Key words: *marketing, ethics, organic products, sustainable development, agriculture*

Apstrakt: *U poslednjim godinama, tržište organskih proizvoda u Srbiji beleži značajan rast, prvenstveno usled sve veće svesti potrošača o zdravlju, održivosti i ekološkim pitanjima. Ovaj rad ima za cilj da istakne ključnu potrebu za zaštitom potrošača od neetičkih reklamnih praksi koje koriste kompanije prilikom promocije organskih proizvoda. Koristeći komparativnu metodologiju, rad dalje analizira primenu etičkih standarda u promociji ovih proizvoda. Iako marketing organskih proizvoda ima veliki potencijal, od suštinske je važnosti da takve marketinške prakse budu u skladu sa etičkim principima, uključujući transparentnost, tačnost informacija i ekološku odgovornost.*

Ključne reči: *marketing, etika, organski proizvodi, održivi razvoj, poljoprivreda*

1. INTRODUCTION

The growing environmental awareness has stimulated the demand for organic products that are grown and produced without the use of synthetic pesticides, fertilizers, or genetically modified organisms, i.e., with minimal harm to the environment and fewer chemicals. As the demand for organic products increases, companies in Serbia are adjusting their marketing strategies to consumers who prioritize health and environmental protection. These consumers seek natural, environmentally friendly alternatives to conventional products and are often willing to pay a higher price for them. With the growing popularity of organic products, there is a strengthening of ethical responsibility for businesses as well. Marketing strategies for organic products often use terms such as "natural", "sustainable" and "chemical-free" to attract consumers. At the same time, businesses should ensure that these claims are truthful and supported by certifications to

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avoid misleading consumers. The goal of this paper is to highlight the necessity of protecting consumers from unethical advertising practices related to these products. Many countries, including Serbia, have established certification programs that regulate the labeling and production of these products. This means that products must meet specific criteria to be labeled as organic. These standards ensure that organic products adhere to strict ecological and ethical guidelines. By aligning marketing messages with these certifications, companies help consumers make informed and ethical purchasing decisions. At the same time, they protect consumers from false advertising and ensure that companies are accountable for their claims.

2. MATERIALS AND METHODS

A comparative method was used in this study to establish similarities and differences between marketing strategies in the advertising practices of various organic and so-called "healthy" products by companies in Serbia, as well as a method of analyzing the implementation of ethical standards. Secondary data were used, and available literature on the topic was analyzed, as well as existing regulations related to the production and advertising of these products.

3. RESULTS AND DISCUSSION

The demand for organic products depends on numerous factors such as consumers' wealth, awareness of how food affects their health, marketing tools used by businesses, knowledge and awareness of organic products, and the quality and health safety of organic products (Najiib, M. et al., 2021). Marketing and certification of organic products play a vital role in organic production, ensuring specific methods in production and facilitating the identification and promotion of organic products (Pachaya, J.S., Ahivar, N.K., 2024).

Marketing of organic products is focused on strategies that involve raising awareness, communicating the advantages of organic agricultural practices, and building consumer trust in organic production. The goal is to communicate the unique properties of organic products, educate consumers about the ecological and health benefits of these products, and highlight the differences from conventional alternatives (Ferto, I., Zaien, S., 2021). A well-developed marketing strategy and the use of effective promotional tools aimed at a specific consumer segment contribute to increasing sales in the organic product market (Chrobocinska, K., Lotkowska, A., 2023). At the same time, it is crucial that official institutions are involved in food control and consumer education in this field. Organic product certification is a process that confirms and guarantees that a product meets specific organic standards. Such a certificate, i.e., an official organic label, informs consumers that the product complies with organic requirements and protects them from misleading marketing practices.

In Serbia, there is still a gap between the potential and the actual state of organic production (Šermešić, S. et al., 2024). The fact is that there are a limited number of public state and international databases that would continuously track the development of organic production in Serbia, and greater availability of updated data would allow for a precise assessment of the ethical challenges facing organic product marketing. The lack of up-to-date data from relevant institutions, combined with a limited number of publications and domestic scientific works on the subject, makes it difficult to provide an accurate overview of the situation in this field. In Serbia, "mainstream" production is still dominant, as evidenced by the number and types of government subsidies for certain products. Despite the lack of comprehensive data in the aforementioned area, it is possible to identify the basic ethical challenges in the marketing of organic products in Serbia from available data.

The institutional framework for organic product production is outlined in the United Nations document titled the "Brundtland Report" (WCED, 1987). This document outlines nearly all areas in which reforms related to sustainable development need to be implemented, from heavy industry and land and water pollution to the urgent need to protect natural resources. In particular, Chapter V titled "Food Sustainability" discusses the various challenges of irrational use of natural resources and plans for so-called "future food," which includes the application of a holistic approach to food production and sales. Based on this document, the European Union has adopted regulations that require producers to obtain specific certification to sell and present products as organic. National legislations of member countries, as well as regulatory bodies dealing with food safety, regulate which food will be labeled as organic. According to these regulations, the European Commission has also outlined specific marketing measures for these products (Regulation EU, 1308/2013). The goal of these measures is to stabilize the market and ensure the transparency of organic food production, as well as to ensure the competitiveness of these products through subsidies for specific sectors (especially fruit, vegetable, and wine production). This document sets out marketing standards, rules, and quality conditions for the production process, as well as rules of competition among producers engaged in organic production. The marketing of these products is subject to regulations that specifically address the ethical aspects of their advertising. There are advertising standards for specific products that must be followed when creating and implementing marketing campaigns, such as regulations related to marketing oils, bananas, wine, eggs, fruits and vegetables, meat, or hops. For example, there are regulations related to the marketing of olive oil (Regulation 29/12 and EEC 2568/91), bananas (Regulation 1333/2011), fruits and vegetables (Regulation 543/2011, 2019/934), wine (Regulation 2019/935), etc. These rules relate to individual characteristics of each product, such as geographical origin, traditional growing conditions, and the presentation and labeling of such products.

In line with EU countries, Serbia has adopted a set of standards and rules related to organic production to harmonize legal standards in this area. Although these standards are general and do not apply to specific products, they contain production and certification rules for organic products, with few addressing the marketing of these products (e.g., Regulation on the Documentation Submitted to the Control Organization for Certification and Conditions for Selling Organic Products, 2016). According to the Ministry of Agriculture, Forestry, and Water Management, organic production in Serbia has existed for more than thirty years. The legislative framework for production and marketing of these products is continuously being harmonized with EU legal frameworks. The first law on organic production was adopted in the 1990s during the time of the FRY, while the first law prepared in line with EU legislation was adopted more than a decade ago (Organic Production Law "Official Gazette of RS", no. 30/2010 and 17/2019). More than a decade ago, the National Association named Serbia Organica was also established (Simić I., 2020). The regulations for determining the ethical aspects of organic production marketing in Serbia are also important, including the Regulation on Control and Certification in Organic Production and Organic Production Methods ("Official Gazette of RS", no. 25/20), and the Regulation on Documentation Submitted to the Control Organization for Certification and Conditions for Selling Organic Products ("Official Gazette of RS", no. 88/16). The first of these regulations contains material provisions for marketing these products in terms of the appearance and content of the label (Article 130), while the second regulation specifies that organic products must be marketed in accordance with regulations governing organic production (Article 5). This indicates that in Serbia, rules governing the promotion of organic products are not clearly defined, and advertising of these products is conducted in the same manner as advertising for any other goods, subject to the general provisions of the Advertising Law (“Official Gazette of RS”, no. 6/2016, 52/2019).

It is clear that this normative and strategic approach does not align with market laws, as organic production, with some fluctuations in certain years, has shown growth, as seen in Chart 1 (Šermešić, S. et al., 2024).

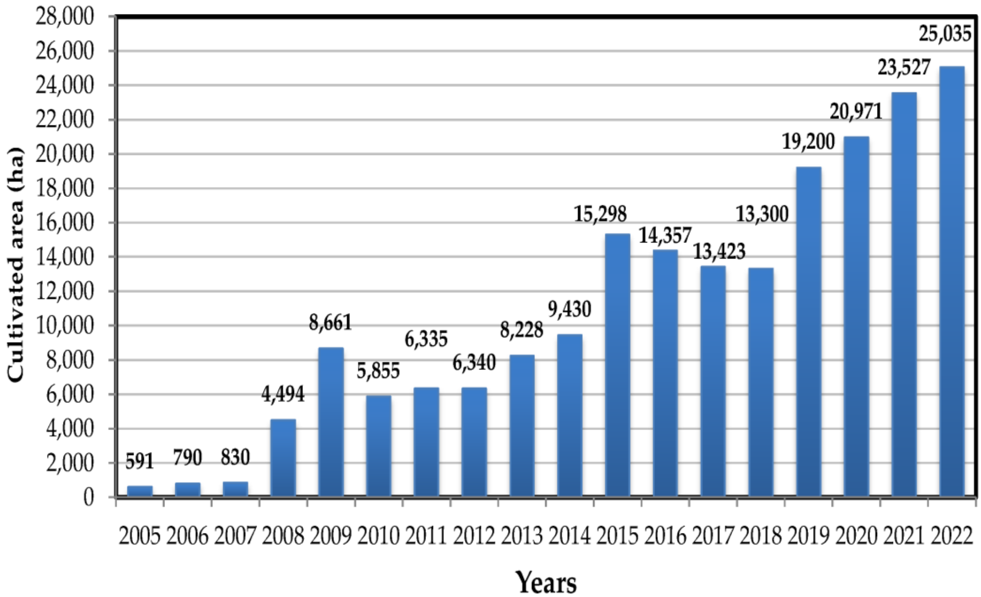

Chart 1. Changes in the Movement of Organic Production in Serbia

Practice has shown that organic products in Serbia are often purchased from "selected producers" whose products lack legally required labels but are sold as organic. Consumers usually buy these products directly from producers at rural farms or markets. Such purchases depend on personal beliefs and are often a result of the inability to distinguish between "healthy" and organic products. Since there is no precise regulation or data control on whether these products are truly healthier than others, purchasing and selecting these products will depend on the individual opinions of consumers and can often be subject to deception. For example, it happens that sellers of "organic" products without certification sell products purchased from conventional producers and then sell them as "organic" (https://zelenanit.rs/). The lack of response from relevant institutions, as well as insufficient consumer awareness regarding the distinction between healthy and organic products, can be seen in the case of research conducted by the Institute for Food Technology and Biochemistry at the Faculty of Agriculture in Belgrade, which examined the chemical composition of vegetables at several Belgrade markets. The analysis showed that vegetables grown "organically" were no better in terms of nutritionally significant elements than those obtained through conventional production (https://bizlife.rs/).

The ethical dilemma regarding what constitutes healthy versus organic products and their advertising is also fueled by consumers' belief that certain products are very healthy based on how they are presented. The problem with this type of advertising can be seen in products marketed as particularly healthy, yet containing various additives and stabilizers. This can create moral confusion in adopting healthy consumer habits and is an indicator of underdeveloped consumer awareness in Serbia about what constitutes healthy versus organic food. In the race for better market positioning, especially in the food sector, companies often mislead consumers with their marketing activities. It is not uncommon for product packaging to use formulations such as "this product was made without animal testing," which creates a feeling for the buyer that the purchase is "ecological," contributing to sustainable development, a healthy environment, and the preservation of nature. A similar example can be seen with companies promoting fair and ethical business practices, highlighting a mission to preserve nature (e.g., supporting zoos), which is actually just a marketing concept, not an ethical one (Low, W., Davenport, E., 2009). Purchasing such products and participating in the campaign does not guarantee that the product is healthy or organic. This approach to purchasing somewhat satisfies the moral need of the consumer to participate in nature preservation but raises another question regarding the marketing of organic products, which is the distinction between ethical and organic purchasing.

Differences in understanding ethical and organic purchasing are even more pronounced when it comes to marketing organic meat production. Academic discussions often revolve around the characteristics of ethical meat production and the challenges in marketing such products (Schäfer, M., 2019). When marketing these products, companies use marketing slogans such as "better animal welfare", "local production", "fair producer prices" (Ibidem). In this context, the crucial question is the individual approach to determining which product is considered healthy and ethical based on consumers' personal preferences. This is particularly relevant to the marketing of products with "halal" or "kosher" labels. It is clear that consumers of different religions with specific ethical approaches to food preparation and consumption will be more likely to purchase products advertised in accordance with their religious beliefs. This presents a particular challenge for marketing in terms of respecting the ethical demands of consumers (Zander, K., Stolz, H., Hamm, U., 2013). Accordingly, there are more opinions indicating the fact that ethical content in purchasing varies from person to person, leading to the thought that organic production is simply a set of rules for growing and producing certain items, with insufficient ethical content (McEachern, M.G., McClean P., 2002). To resolve these ethical issues, a holistic view of the ethical content of organic product marketing is necessary. (McEachern M.G., Carrigan, M., 2012).

4. CONCLUSION

Organic production in Serbia is still in the developmental phase, as evidenced by the slow growth of statistical indicators, the lack of regulation and strategic approach, as well as the insufficiently developed consumer awareness. Based on this, it is possible to suggest certain recommendations for marketing professionals, managers, consumers, and policy makers, as well as all stakeholders involved in this process.
Regarding the ethical and regulatory aspects of organic production in Serbia, it is possible to integrate individual acts and practices into a broader, conceptual approach, i.e., a strategy. This could increase consumer trust and assist policy makers and marketing professionals in approaching this topic more comprehensively. For this approach, it is necessary to harmonize and systematically apply methodology in the certification of organic products, as well as align with EU regulations. This would contribute to a clearer formulation of the ethical aspects of marketing and the positioning of these products in the market. Therefore, in addressing ethical dilemmas in organic production, it is essential to implement strict regulations, enhance transparency, and improve consumer education.

In line with the above, the marketing of organic products in Serbia faces numerous ethical challenges, ranging from misleading claims and the lack of proper certification to the lack of awareness regarding the importance of certified organic products. To resolve these ethical issues, it is essential for businesses in Serbia to adhere to clear standards, work on transparency, and create a fair and truly sustainable market for organic products. The ethical aspect of marketing organic products is vital for the future of organic production. In addition to the belief that a product is organic, there is today a continuous demand for products that have specific ethical qualities, such as humane treatment of animals, environmental preservation, and respect for the individual ethical principles of consumers.

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FIELD EFFICACY OF BIOFUNGICIDE EKSTRASOL F IN THE CONTROL OF BOTRYOTINIA FUCKELIANA AND MONILINIA SPP.

EFIKASNOST BIOFUNGICIDA EKSTRASOL F U POLJSKIM USLOVIMA U CILJU SUZBIJANJA BOTRYOTINIA FUCKELIANA I MONILINIA SPP.

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Abstract: *In order to control the causal agent of gray mold of grapevine (Botryotinia fuckeliana) and brown rot of plum (Monilinia spp.), the efficacy of biofungicide EKSTRASOL F (Bacillus subtilis Ch-13, Biogenesis) applied at 2.0 l/ha was evaluated during 2018 and 2019 in five localities in Serbia where a strong epidemic of the target diseases were expected. The trials were arranged as randomized plots according to instructions of standard EPPO methods. In both years, biofungicide EKSTRASOL F (50.0% - 61.5%) exhibited the good efficacy to control B. fuckeliana and Monilinia spp*

Key words: *biofungicide, EKSTRASOL F, Botryotinia fuckeliana, Monilinia spp., control*

Apstrakt: *U cilju suzbijanja prouzrokovača sive plesni vinove loze (Botryotinia fuckeliana)i mrke truleži šljive (Monilinia spp.), tokom 2018. i 2019. godine na pet lokaliteta u Republici Srbiji gde je očekivan visok intenzitet oboljenja, ispitivana je efikasnost biofungicida EKSTRASOL F (Bacillus subtilis Ch-13, Biogenesis) u količini primene od 2.0 l/ha. Ogledi su postavljeni i organizovani u skladu sa instrukcijama standardnih EPPO metoda po principu potupno slučajnog blok sistema. U obe godine ispitivanja utvrđena je dobra efikasnost biofungicida EKSTRASOL F (50.0% - 61.5%) u kontroli B. fuckeliana i Monilinia spp .*

Ključne reči: *biofungicid, EKSTRASOL F, Botryotinia fuckeliana, Monilinia spp., kontrola*

1. INTRODUCTION

Botryotinia fuckeliana (de Bary) is the causal agent of gray mold, an important disease that affects grapevine (Vitis vinifera L.) and causes significant yield and quality losses worldwide (Elemer and Michailides, 2007). Due to the economic importance of the disease, gray mold control is traditionally based on a routine application of synthetic fungicides (Altieri et al., 2023). The application of synthetic fungicide provide effective disease control but often leads to unnecessary spraying, causes an increase in the risk that the pathogen will develop fungicide-resistant populations, may leave fungicide residues on grapes and wines, and contributes to the intensive

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use of chemicals in viticulture with consequent negative impacts on human health and the environment (Altieri et al., 2023). In the recent years, a number of pesticides have been withdrawn from the market and makes control of gray mold even more dificult.

Brown rot is an economically important disease of stone fruit. The disease is mainly caused by Monilinia laxa, and Monilinia fructicola, while Monilinia fructigena is prevalent on pome fruit (Ogawa et al., 1995).

The control of Monilinia rot depends on an integrated strategy based on cultural practices, fungicide spray programme and, after harvest, on the maintenance of proper storage conditions. Moreover, no chemical treatments are allowed on stone fruit after harvest in European countries (Altieri et al., 2023).

Alternative strategies proposed for the control of Monilinia rots and gray mold include treatments based on biocontrol agents (BCAs) such as yeasts, bacteria and fungi (Altieri et al., 2023).

Application of beneficial bacterium Bacillus subtilis (Ehrenberg) Cohn, which produces extra cellular metabolites for competition and antibiosis, is a good alternative to chemical fungicides (Milijašević-Marčić et al., 2017). The bacterium is harmless to the environment and human health and is generally recognized as safe (GRAS) organism (Anonymous, 1999).

EKSTRASOL F is a microbiological biofungicide based on the bacterium Bacillus subtilis, strain Ch-13, which has been shown to have a wide spectrum of antagonistic activity against various species of phytopathogenic fungi and bacteria. This strain of B. Subtilis produces a large number of lytic enzymes and different metabolites that exhibit antifungal activity, and also stimulates the growth and development of plants by producing phytohormones, primarily auxin derivatives (Chebotar et al., 2009). According to the FRAC classification, species of the genus Bacillus have the code BM 02 and the occurrence of pathogen resistance has not yet been determined (FRAC, 2024).

The objective of this study was to determine the efficacy of EKSTRASOL F (Bacillus subtilis, strain Ch-13) against B. fuckeliana and Monilinia sp. under field conditions in Republic of Serbia.

2. MATERIAL AND METHODS

EKSTRASOL F and two commercial products (used as standard products) were compared with respect to their ability to reduce severity of gray mold of grape vine and brown rot of plum (Table 1). The application rates are listed in Tables 4 and 4. All trials were conducted in 2018 and 2019, in a privately owned vineyards and orchards (Table 2 and Table 3). The grapevine cv. Plovdina and plum cv. Stenly were used on all localities. The trials were set up according to instruction of EPPO standard PP 1/17(3) and PP 1/222(1), respectively.

Table 1. Products used in the study

Trade name	Active ingredient	Concentration of active ingredient	Formulation type	Manufacturer
Ekstrasol F	*Bacillus subtilis* Ch-13	1 x 10^8 CFU/mL	SL	BioGenesis d.o.o., Serbia

Polyversum*	*Pythium oligandrum*	30% *Pythium oligandrum* (1 x 10^6-10^7 oospora/g)	WP	Biopreparaty Co. Ltd., Czech Republic
Bellis**	Boscalid + pyraclostrobin	252 g/L + 128 g/kg	WG	BASF SE, Germany

*B. fuckeliana – referent product; ** Monilinia spp. – referent product

The tested products were applied using a knapsack sprayer (Solo 423, Germany), to simulate practical applications by farmers (water volume: 800-1000 liter/ha). Fungicide application dates and growth stage of grapevine and plum are shown in Tables 2 and 3.

Table 2. Fungicide application dates – grapevine (Botryotinia fuckeliana) (2018)

No.	Location (GPS)	Application 1		Application 2	
		Growth stage	Date	Growth stage	Date
1.	Slankamenački vinogradi (N 45 09 24.60; E 20 10 39.68)	BBCH 81*	15 August	BBCH 81**	05 September
2.	Grušić (N 44 37 20; E 019 33 39)	BBCH 85*	16 August	BBCH 85**	06 September

*Beginning of ripening: berries begin to develop variety-specific colour; ** Softening of berries

Table 3. Fungicide application dates – plum (Monilinia spp.) (2019)

No.	Location (GPS)	Application 1		Application 2	
		Growth stage	Date	Growt h stage	Date
1.	Pocerski Metković N 44 38 21.00; E 19 36 44.95)	BBCH 85*	01 August	BBCH 87**	12 August
2.	Smederevo (N 44 37 02.32; E 20 54 07.40)	BBCH 85*	31 July	BBCH 87**	09 August
3.	Padinska Skela (N 45 57 31.01; E 20 25 43.75)	BBCH 85*	31 July	BBCH 87**	09 August
4.	Slankamenački vinogradi (N 45 09 15.72; E 20 10 36.66)	BBCH 85*	1 August	BBCH 87**	12 August

*Colouring advanced; ** Fruit ripe for picking.

The occurrence of the gray mold was evaluated in accordance with the PP 1/17(3) method (EPPO, 2001), by evaluating 100 randomly sampled bunches in each plot, which were divided into two categories: infected and healthy.

The assessment of brown rot was carried out in accordance with the method PP 1/222(1) (EPPO, 2012) by sampling 50 fruits from each plot and incubating them first at a temperature of 0ºC for three days and then at a temperature of 25ºC until the appearance of disease symptoms. After incubation, the fruits were divided into two categories: infected and healthy.
Data were analysed by one-way completely randomized ANOVA, while the means were compared by using Duncan's test.

3. RESULTS AND DISSCUSSION

New strain *B. subtilis* Ch-13 (commercial name EKSTRASOL F) available in Serbia, was compared with chemical fungicide combination boscalid + pyraclostrobin and biofungicide *Pythium oligandrum.*

In Table 4 are shown data of the occurrence of gray mold on bunches at the two localities (Locality 1 and 2) (6.5±1.3% and 5.5±0.6% in the control, respectively). The results of the tests from both testing sites show that the efficacy of the preparation EKTRASOL F at an application rate of 2 l/ha was 50.0% and 54.5%, respectively. The difference in efficacy between the tested preparation and the standard (Polyversum) was statistically significant at both sites.

Table 4. Treatments, application rates, disease severity and efficacy of applied products - plum (Botryotinia fuckeliana) (2018)

Treatments	App. rates (l,kg/ha)	Locality 1.		Locality 2.	
		Dis. sever.	Effic. (%)	Dis. sever.	Effic. (%)
Control – untreated plants	-	6.5 b[1]	-	6.5 b	-
Ekstrasol F	2.0	3.3 a	50.0	2.5 a	50.0
Polyversum	0.5	3.5 a	46.2	2.8 a	46.2

[1]Mean values within columns followed by different letters are significantly ($p<0.05$) different according to Duncan's test.

In Table 5 are shown data of the occurrence of the brown rot on the four licalities (from 5.8±1.7% to 8.7±1.0%) in the untreated control. Based on the obtained results, it can be concluded that the tested biofungicide EKTRASOL F showed good efficiency (from 60.2% to 61.5%) in suppressing the *Monilinia* sp. of stone fruits. The difference in efficiency between the EKSTRASOL F and the standard (Bellis) at all four locations was statistically significant.

Table 5. Treatments, application rates, disease severity and efficacy of applied products - plum (*Monilinia* spp.) (2019).

Treatments	App. rates (l,kg/ha)	Locality 1.		Locality 2.		Locality 3.		Locality 4.	
		Dis. sever.	Effic. (%)	Dis. sever.	Effic. (%)	Dis. sever.	Effic. (%)	Dis. sever.	Effic. (%)
Control – untreated plants	-	6.8 c[1]	-	8.7 c	-	5.8 c	-	8.0	-
Ekstrasol F	2.0	2.7 b	64.5	3.5 b	60.2	2.2 b	64.3	3.1 b	65.9
Bellis	0.5	0.4 a	100.0	0.7 a	91.7	0.3 a	100.0	0.6 a	100.0

[1]Mean values within columns followed by different letters are significantly ($p<0.05$) different according to Duncan's test.

Gray mold is one of the most important diseases of grape vinr in Serbia. The level of infection by this disease varies remarkably from year to year.

The use of biocontrol agents (BCAs) represents a promising alternative to conventional methods for the management of gray mold in vineyards during the berry ripening stage. The main advantages of BCAs are the short preharvest interval and lack of chemical fungicide residues in wine (Altieri et al., 2023).

In presented trials, BCA based product EKSTRASOL F exhibited the good efficacy in the control of *B. fuckeliana*. Altieri et al., (2023) also reported that commercial BCAs (based on *Bacillus* species) are an effective alternative to conventional chemicals for the preharvest control of gray mold in vineyards. However, the same authors emphasis that the variability in BCA efficacy was closely related to the environmental conditions at the time of application and in the following days. Overall, the BCA efficacy increased with the degree days accumulated between BCA application in the vineyard and *B. fuckeliana* inoculation in the dry (no rain) periods. Rainfall and the associated drop in temperature caused a relevant reduction of BCA efficacy (Altieri et al., 2023).

The plum (*Prunus domestica* L.) is one of the most important fruit crops in Serbia. Brown rot caused by fungi *Monilinia laxa* and *M. fructigena* is one of the economically most important and challenging diseases to manage in both commercial and organic stone fruit production. In the presented studies, EKSTRASOL F showed very good efficay in the control *Monilinia* sp. and reduce incidence of postharvest rots.

Bellamy, et al. (2022) aslo confirmed good efficacy of tested BCAs (*Bacillus subtilis* - B91 and *Aureobasidium pullulans* - Y126) in the control brown rot. In the field condition they tested two microbial strains (B91 and Y126) and showed antagonistic properties against *M. laxa*. The experiment was carried out for two consecutive years in cherry orchards. When applied pre-harvest, both strains (B91 and Y126) reduced the incidence of post-harvest rots by 30% - 60% (Bellamy, et al. (2022).

4. CONCLUSION

The use of BCAs (*Bacillus subtilis* Ch-13) EKSTRASOL F in the control of *B. fuckeliana* and *Monilinia* pathogens is a good alternative to conventional fungicides and represents a key component in organic and integrated crop protection.

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IMPACT OF POTATO IMPORTS ON THE PRICE OF POTATOES IN NMK

ВЛИЈАНИЕ НА УВОЗОТ НА КОМПИР ВРЗ ЦЕНАТА НА КОМПИРОТ ВО РСМ

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Abstract: *This scientific paper analyzes the import and domestic production of potatoes in the Republic of North Macedonia in the period 2010-2019. The research is based on official statistical data for processing and interpreting the data. The main focus is given to the quantitative and value aspect of imports, as well as the dynamics of domestic production. In addition, a comparison is made between the import and domestic price of potatoes in order to assess the competitiveness of domestic production.The results show that the import of potatoes has a fluctuating trend, and domestic production faces challenges related to costs and market demand. The comparative analysis of prices indicates certain competitive disadvantages of domestic potatoes compared to imported ones. Based on the data obtained, possible directions for improving the competitiveness of domestic production are suggested through the modernization of agricultural practices, improvement of infrastructure and strategic measures to support local producers*.

Key words: *potato, import, domestic production, competitiveness, statistical analysis.*

Апстракт: *Овој научен труд го анализира увозот и домашното производство на компир во Република Северна Македонија во периодот 2010-2019 година. Истражувањето се заснова на официјални статистички податоци за обработка и интерпретација на податоците. Главен фокус е даден на количествениот и вредносниот аспект на увозот, како и на динамиката на домашното производство. Дополнително, се прави споредба меѓу увозната и домашната цена на компирот со цел да се оцени конкурентноста на домашното производство. Резултатите покажуваат дека увозот на компир има флуктуирачки тренд, а домашното производство се соочува со предизвици поврзани со трошоците и пазарната побарувачка. Споредбената анализа на цените укажува на одредени конкурентски недостатоци на домашниот компир во однос на увезениот. Врз основа на добиените податоци, се сугерираат можни насоки за подобрување на конкурентноста на домашното производство преку модернизација на земјоделските практики, подобрување на инфраструктурата и стратегиски мерки за поддршка на локалните производители.*

Клучни зборови: *компир, увоз, домашно производство, конкурентност, статистичка анализа*.

1. INTRODUCTION

Horticulture is one of the most important subsectors of agricultural production, with great export potential and is the basis for the operation of the vegetable processing industry, which is largely export-oriented. According to the data, it can be seen that the main horticultural crop is potatoes, which are grown on about 13,900 hectares, beans on about 13,600 hectares (this includes the area of beans and intercrops), peppers on about 8,500 hectares, melons on about 6,000 hectares, tomatoes and cabbage on about 5,000 hectares and other crops on smaller areas.[81]

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[81] https://www.stat.gov.mk , http://www.mzsv.gov.mk

Potato is a crop, which in its importance can be compared to wheat and corn, and in the more northern parts that do not have optimal conditions for their cultivation, it is in first place. Its fruit - the tuber - is of greatest importance for human nutrition, then as a raw material for industry and for livestock nutrition. It occupies a major place in human nutrition, because it is used to prepare a large number of appetizers, main dishes, sweets, and as a supplement. Boiled potatoes or its flour mixed with wheat flour produce very high-quality bread. The areas under potatoes in North Macedonia are over 13,000 ha, which are expanding almost every year. Average yields are around 13 t/ha. With the introduction of high-yielding foreign potato varieties (mainly from the Netherlands, France and Germany), potatoes are becoming more common, yields are increasing and they are becoming profitable.

The aim of the paper is to see the impact of potato imports on the price of domestic potato production.

2. DATA SOURCE AND WORKING METHOD

To achieve the set goal, we used official data from state institutions: the State Statistical Office (SSO), the Ministry of Agriculture, Forestry and Water Management (MAWF), the Agency for the Promotion of Agriculture, as well as data from 10 surveyed individual agricultural holdings in the country, we also used websites, namely www.zpis.gov.mk. The research covers the period from 2010 to 2019. We processed the data using statistical methods: quantity of potato production, areas under potatoes, value of the price of domestic production, import price of potatoes, wholesale and retail prices and a comparative method common to such agro-economic research.

3. RESEARCH RESULTS

3.1. Import of potato

Import is the transfer of goods across the state border, from an external source. The one who carries out the import is called the importer. Import in the recipient country is an export from the sending country. Import and export are the definition of financial transactions in international trade.According to data from the State Statistical Office, it is notable that imports are growing much faster than exports, because the deficit in food trade is increasing every year.

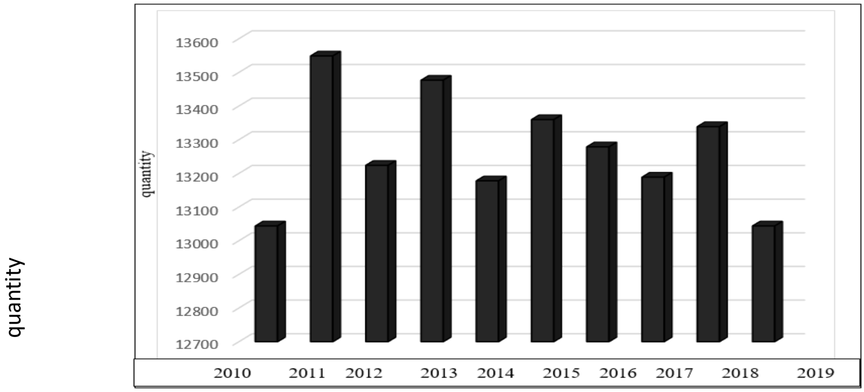
Table 1. Import quantity of potatoes, its value and average import price

Year of potato import	*Quantity in kg*	*Value in EUR*	*Average import price €/kg*
2010	1,919,493	1,053,946	0,55
2011	5,107,094	2,205,309	0,43
2012	6,441,770	1,977,319	0,31
2013	7,648,356	1,997,596	0,26
2014	4,250,702	1,738,548	0,41
2015	2,318,744	1,155,699	0,50
2016	1,872,753	965,916	0,52
2017	8,145,964	2,234,127	0,27
2018	4,719,130	1,532,796	0,32
2019	4,825,026	4,825,911	0,38

Source: https://www.stat.gov.mk, http://zpis.gov.mk

Potato imports to the Republic of North Macedonia change every year, and in addition to imports, the price itself also changes. From 2010 to 2019, the highest import was recorded in 2017, where the price was 16.6 denars per kilogram of potatoes, while the lowest import was recorded in 2010, where the price was 33.8 denars per kilogram.

3.2. Sown area of potatoes in NMK

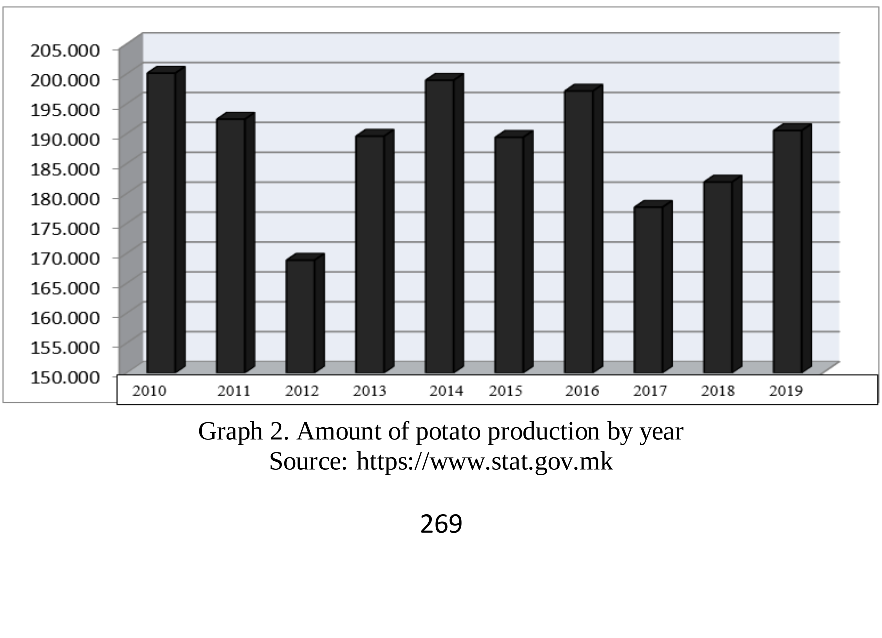


Graph 1. Quantity of potatoes by year
Source: https://www.stat.gov.mk

Sown area of potatoes in the period from 2010 to 2019. The largest amount was obtained in 2011 with 13,549 ha, and the smallest amount was registered in 2010 and 2019, i.e. 13,044 ha.

3.3. Potato production quantity

The production volume of horticultural crops ranges from 800 thousand tons to 1200 thousand tons depending on the climatic conditions in certain years. Comparative advantages in certain production regions contribute to its regional presence in the Southeast, East, Vardar and Skopje regions.Potato is the most common horticultural crop, which is sown on about 13,437 ha. The best contributions from potatoes are obtained when the average monthly air temperatures do not exceed the limit of 19 degrees, which means that temperature conditions are a very important factor for growing potatoes. For growing potatoes, it is desirable to use lightly loose soils that are rich in humus and have a weak acidic reaction pH= 5-6. For 1 ha of area, 1200 to 1300 kg is needed, or 60,000 tubers/ha. The price is about 120 den/kg. (Agricultural Promotion Agency).



Graph 2. Amount of potato production by year
Source: https://www.stat.gov.mk

The highest potato production in the Republic of Macedonia in the period from 2010 to 2019 was recorded in 2010 with a production of 200,124,894 tons, and the lowest quantity was recorded in 2012 with 168,858,184 tons of potatoes.

3.4. Wholesale and retail prices

Data on prices and quantities of agricultural products and livestock are collected through weekly surveys. Data on the selling price per net kilogram paid by the consumer at retail and wholesale markets are collected daily, on a market day for each market separately. Data on the highest, most frequent and lowest price are collected, and for wholesale markets, data on the quantities offered are also collected. Markets within markets are not included in the price monitoring.The most frequent price is the price that is most frequently repeated for a particular product, on a particular market, regardless of the quality of the product. Prices are expressed in denars per kilogram expressed to two decimal places.

Table 2. Domestic wholesale and retail price of potatoes

YEAR	*wholesale price (denars)*	**Retail (denars)**
2010	**16,40**	**22,11**
2011	**11,71**	**19,00**
2012	**10,00**	**23,80**
2013	**21,50**	**26,44**
2014	**12,60**	**18,90**
2015	**11,33**	**17,00**
2016	**8,22**	**15,47**
2017	**15,74**	**23,38**
2018	**14,00**	**24,70**
2019	**12,00**	**23,00**

Source: https://www.stat.gov.mk, http://www.mzsv.gov.mk

Wholesale and retail potato prices vary from 4.94 to 13.8 denars depending on the year. In the period from 2010 to 2019, the lowest wholesale potato price was in 2016, where the potato was 8.22 denars, and the highest price was recorded in 2013, where the price was 21.50 denars. Just like wholesale, the lowest retail price was in 2016, with 15.47 denars per kilogram, and the highest was in 2013, with 26.44 denars.

3.5. Analysis of the price of potato imports and domestic prices

According to research and analysis in the period 2010-2019, regarding the price of imported potatoes and the price of domestically produced potatoes, the analyses show that the price of imported potatoes is higher than domestic production during 2010-2019.

The price difference between the import price and the domestic price varies from 0.68 denars to 13.54 denars depending on the year in the period from 2010 to 2019. The lowest difference is in 2010 with only 0.68 denars, and the highest difference is in 2017 with 13.54 denars.

Table 3. The difference between the import price and the domestic price of potatoes

Year	*Import prices (denars)*	*Domestic wholesale price (denars)*	Difference (denars)
2010	**17,08**	**16,40**	**0,68**
2011	**20,74**	**11,71**	**9,03**
2012	**18,91**	**10,00**	**8,91**
2013	**27,45**	**21,50**	**5,95**
2014	**19,52**	**12,60**	**6,92**
2015	**17,69**	**11,33**	**6,36**
2016	**19,52**	**8,22**	**11,30**
2017	**29,28**	**15,74**	**13,54**
2018	**18,91**	**14,00**	**4,91**
2019	**25,01**	**12,00**	**13,01**

Source: https://www.stat.gov.mk,

4. CONCLUSION

Based on the results of the study, the following conclusions can be drawn:

1. Volatility in potato imports: The amount of imported potatoes varies significantly from year to year. The highest import was recorded in 2017 with 8,145,964 kg, while the lowest import was recorded in 2016 with 1,872,753 kg. These fluctuations can be attributed to various factors, including domestic production, demand and climatic conditions.

2. Stability of the sown areas: The sown areas with potatoes remain relatively stable, with small variations. The largest area was registered in 2011 (13,549 ha), and the smallest in 2010 and 2019 (13,044 ha). This indicates consistency in potato cultivation in the country.

3. Variations in production: Despite stable planted areas, potato production shows variations. The highest production was recorded in 2010 (200,124,894 tons), and the lowest in 2012 (168,858,184 tons). This can be explained by different agro-climatic conditions and cultivation practices.

4. Differences between import and domestic prices: In the analyzed period, the import price of potatoes is generally higher than the domestic wholesale price. The smallest difference was observed in 2010 (0.68 denars), and the largest in 2017 (13.54 denars). This indicates that, despite the higher import prices, there is a demand for imported potatoes, perhaps due to quality or insufficient domestic production.

5. Price fluctuations on the domestic market: Wholesale and retail potato prices on the domestic market show significant fluctuations. The lowest wholesale price was recorded in 2016 (8.22 denars), and the highest in 2013 (21.50 denars). A similar trend is observed in retail prices. These fluctuations may be due to changes in supply and demand, as well as import prices.

6. Support for increasing the competitiveness of producers: Providing financial and technical assistance for the modernization of production processes, introduction of new technologies and improvement of product quality. This can be achieved through programs to support business entities in the processing industry, such as the Program for Competitiveness, Innovation and Entrepreneurship.

7. Promotion of cluster association: Encouraging cooperation between potato producers, processors and distributors for joint market presence, sharing resources and knowledge, in order to improve market position and increase exports.

8. Support for the development of the processing industry: Investing in potato processing capacities, which will enable added value to the product and create new markets. This can be achieved by using funds from programs such as IPARD 2, which offer financial support for the modernization of processing capacities.

9. Improving export strategies: Developing strategies to promote exports through the creation of competitive products and reindustrialization. This includes investing in infrastructure and supporting firms to improve their competitiveness in the international market.

10. Education and training of farmers: Organizing trainings and seminars on modern potato growing techniques, cost management and marketing strategies, in order to increase the productivity and profitability of producers.

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Questionnaire: My survey with 10 major potato producers in Macedonia

POSSIBILITY OF USING SMART SYSTEMS IN IRRIGATION, AS A RESPONSE TO THE NEGATIVE IMPACT OF CLIMATE CHANGE

МОЖНОСТ ЗА КОРИСТЕЊЕ НА ПАМЕТНИ СИСТЕМИ ВО НАВОДНУВАЊЕТО, КАКО ОДГОВОР ОД НЕГАТИВНОТО ВЛИЈАНИЕ НА КЛИМАТСКИТЕ ПРОМЕНИ

Stojan Srbinoski, M.Sc., B.Sc.[82]

Abstract: *Climate change, which is a reality in everyday life, is increasingly posing a problem in the regular operation of irrigation systems. The reduced amount of precipitation directly affects the operation of irrigation systems, which are forced to look for ways to preserve the necessary amount of water for irrigation by mitigating the consequences of the occurrence of dry periods. By analyzing the available meteorological parameters (air temperature, changes in the precipitation regime), several scenarios have been obtained for possible changes in the already established temporal and spatial distribution of precipitation in certain geographical regions. As a result of the emergence of negative factors in the current operation of existing irrigation systems, it is necessary to introduce smart systems, which will improve the operation of existing irrigation systems.*

Key words: *Climate change, Drought periods, Irrigation systems, Meteorological parameters, Smart irrigation systems.*

Апстракт: *Климатските промени кои се реалност во секојдневниот живот, се повеќе преставуваат проблем во редовното функционирање на системите за наводнување. Намалената количина на паднатиот воден талог директно се одразува со негативни последици во работењето на системите за наводнување, кои се приморани да бараат начини на зачувување на поттебните количина вода за наводнување со ублажување на настанатите последици од појавата на сушните периоди. Со вршење на анализа на достапните метеоролошки параметри (температура на воздухот, промена на режимот на врнежите), добиени се повеќе сценарија за можните промени на веќе воспоставената временско просторна дистрибуција на врнежите во одредени географски региони. Како последица од појавувањето на негативните фактори во тековното работење на постојните ситеми за наводнување, потребно е воведување на паметни системи, со кои ќе се подобри функционирањето на постоечките системи за наводнување.*

Клучни зборови: *Климатски промени, Сушни периоди, Системи за наводнување, Метеоролошки параметри, Паметни системи за наводнување.*

1. INTRODUCTION

The last decade of the 20th century and the beginning of the 21st century are the warmest periods in the entire world in terms of climate. These are also the most specific periods in terms of weather and climate in the Republic of North Macedonia. Under the influence of natural conditions and under the influence of human activities in the last thirty years, climate changes have occurred on a global scale, as well as on the territory of Southeast Europe, as well as in the Republic of North

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Macedonia. Climate change can be clearly detected in long-term series of climatological data and is characterized primarily by an increase in air temperature, a change in the precipitation regime, as well as an increased frequency of extreme weather events and periods with extreme climate conditions (ECCs).

The territory of the Republic of North Macedonia falls within the Semi-Arid climate zone where continuous irrigation of agricultural crops during the growing season is necessary to obtain the required level of projected yields from agricultural areas. The main indicator for defining Semi-Arid climate zones is the Rainfall Factor, which is expressed as the ratio between average annual precipitation and average annual temperatures DF=H/T. The Rainfall Factor ranges between 40 and 60, indicating a chronic lack of necessary moisture in the soil and air (UHMR).

According to available statistical data, in 2019, a total of 128,000 hectares were irrigated on the territory of the Republic of North Macedonia, which represents only a small part of the total agricultural area. The total area of agricultural land is 1,271,400 hectares, while only 519,848 hectares are cultivated. The percentage of cultivated agricultural land that is irrigated is only 24.62%, which does not even represent a quarter of the agricultural areas that are actively cultivated. The area that is irrigated as part of the total agricultural area is only 10.07%.

In the past period of time, i.e. in the last decade of the 20th century and the beginning of the 21st century, frequent dry periods have been observed with reduced amounts of rain that are necessary during the vegetative period, on the one hand, and on the other hand, there is a constant need to increase agricultural yields per unit of hectare.

The decrease in precipitation in the last forty years compared to the period 1961-1990 on an annual basis is particularly pronounced in the period from 1987 to 1994, as well as in the years 2000, 2001 and 2011. The driest years for the period 1951-2020 and also the years for which most meteorological stations recorded the largest deviations in precipitation from average values are 1993, 2000 and 2011. It is characteristic that in the years between these periods, annual precipitation amounts that are higher than average values have been recorded, with 2014, 2010 and 2002 standing out. The absolute daily maximum of precipitation for the period 1951-1990 is 201.0 mm and was recorded in Gevgelija on June 5, 2004, and the highest monthly precipitation amount (389.6 mm) was measured in November 1985 at the Lazaropole meteorological station (UHMR).

The change in seasonal precipitation amounts during the year can best be observed with the extreme seasonal sums for summer and autumn precipitation. In the five years with the highest values of the summer precipitation amount for the period 1951-2020, 2020 stands out for Bitola and Prilep, while for Berovo 2020 is the year with the highest value of the summer precipitation amount. Characteristically, for the extreme values of the autumn precipitation amount, 2020 is in the rank of years with the five lowest values of the autumn precipitation amount for the meteorological stations Bitola, Prilep, Demir Kapija, Gevgelija, Berovo and Ohrid (UHMR period 1951-2020).

2. PURPOSE OF THE RESEARCH

Research into changes in seasonal precipitation amounts that deviate from the average precipitation values in the territory of the Republic of North Macedonia and their comparison with the minimum and maximum precipitation should provide an answer as to how many days the dry periods have increased. The research should determine the negative trends in seasonal precipitation amounts to provide the necessary amount of water for irrigation of agricultural areas in the vegetative period, in relation to the possibility of using smart systems in irrigation, as a need, or rather a response to the negative impact of climate change in agriculture in the Republic of Macedonia during the last decade of the 20th century and the beginning of the 21st century.

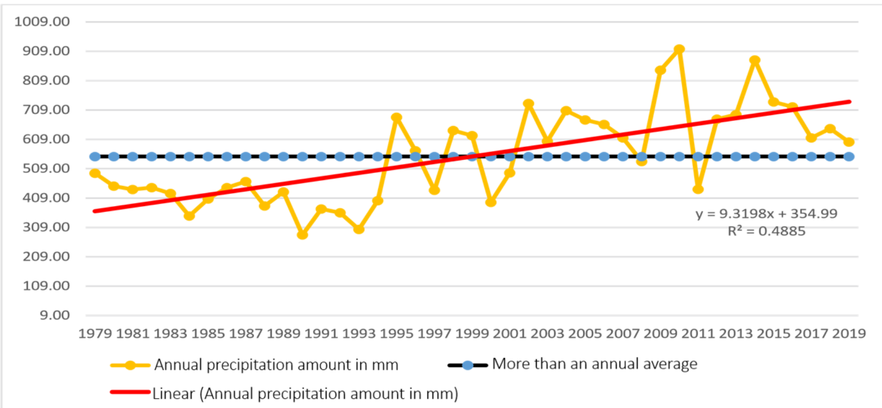
3. METHODS AND MATERIALS

The analysis of long-term series of available climate data analyzed in scientific research refers to:

1. Air temperature.
2. Changes in precipitation patterns.
3. Increased frequency of extreme weather events and periods of extreme climate conditions.

In the presented scientific paper, the emphasis of the analyses is given to the change in annual precipitation amounts and the occurrence of extreme values in a certain period, such as dry periods and periods that cause a decrease in agricultural production and periods with increased humidity, when there is a danger of flooding of agricultural areas. In analyzing the annual precipitation amount from 1951-2020, three scenarios were taken into account: low (drought), medium (optimal) and high (possibility of flooding).

Figure 1. Sum of annual precipitation in North Macedonia, in the period 1979-2019 in mm.



Source: Prepared for the development of the fourth national plan on climate change. https://klimatskipromeni.mk/article/31

The analysis of long-term precipitation series shows more complex patterns of change compared to temperature change. In the case of the low scenario, there is no clear signal of a change in precipitation in the future, except for an increase in precipitation for the months of September-October-November. For the other two scenarios, an annual decrease in precipitation is expected, caused by a significant decrease in summer precipitation. For the medium scenario, the annual decrease in precipitation is up to -20% with a decrease in summer precipitation of -30%, and for the high scenario, the decrease in annual precipitation is up to -30%, and -40% for summer precipitation by the end of the century. Also, the spring season (March-April-May) shows a constant pattern of decreasing precipitation throughout the century, but with a smaller amplitude. By mid-century, both scenarios show a decrease in summer precipitation, up to -30% in both scenarios. Figure 1 shows a graphical representation of the annual precipitation in North Macedonia, in the period 1979-2019 in mm.

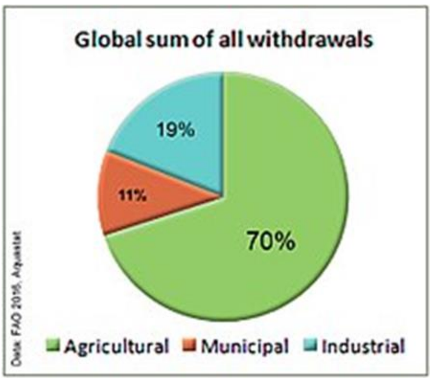
Due to the large spatial and temporal variability of extreme precipitation, there is no uniform pattern in their changes in the future, according to different scenarios. On the other hand, the two analyzed indices, daily maximum precipitation and the number of days with precipitation above

40 mm/day, show a generally positive change in the future, for all analyzed periods and scenarios. The upper limits of the change are a 60% increase in the number of days with precipitation above 40 mm/day and a 20% increase in the daily maximum accumulation of precipitation. The physical background of this change is the fact that a warmer atmosphere, which can hold more water vapor (7% more water vapor per 10 C warmer air), indicates a greater chance of more extreme precipitation, and thus a greater chance of storm occurrence (https://klimatskipromeni.mk/article/31).

The analysis of the index of consecutive dry days reveals that in the future the risk of drought will increase. In the near future the increase in the number of consecutive dry days is between 5 and 20 days, depending on the part of the country and the scenario. For the end of the century in the case of the high scenario the expected increase is over 30 days. This increase is directly related to the predicted decrease in summer precipitation, especially in the case of the medium and high scenario.

Agriculture accounts for about 70 percent of global freshwater use, contributing significantly to the increasing global freshwater shortage (OECD, 2020). As the global population is expected to increase to nine billion by 2050, demand for water resources will increase by an expected 55 percent (OECD, 2022). Future water demand from all sectors will require 25 percent to 40 percent of water to be reallocated from lower to higher productivity and employment activities, particularly in water-stressed regions. In most cases, such reallocation is expected to come from agriculture due to its high share of water use (United Nations Security Council, 2020). For Mediterranean and other dry climates, this poses a huge challenge for farmers (food producers) and those who feed them.

Figure 2. Water consumption in agriculture compared to other economic sectors



Source: Prepared for the development of the fourth national plan on climate change.

The problem is compounded by climate change causing higher temperatures, adding more water stress to water availability in dry regions, while irrigation itself also compounds the problem as the agricultural sector burns huge amounts of fossil fuels, such as diesel, to pump water around farms. Figure 2 provides a graphical representation of water consumption for selected industries.

Irrigation is an energy-intensive activity, as the water pumps needed to operate the system consume a lot of energy. The total power required for irrigation in southern Europe (including North Macedonia, Portugal, Spain, the south of France, Italy, Croatia, Bulgaria, Greece, Romania and Malta) is 16 GW per year. (Narvarte, 2017). If this were replaced by solar energy, over 16 million tons of CO_2 could be reduced per year (Narvarte, 2017).

Fossil fuel and electricity prices are rising. On the other hand, higher temperatures require more water to be pumped to fields so that farmers can grow their crops. Because of all this, the imperative to practice water- and energy-saving irrigation techniques is more urgent than ever. The use of smart, environmentally friendly irrigation technology helps farmers in climate-vulnerable regions adapt and strengthen their resilience to climate change, water scarcity, and energy crises (IFC, 2016).

However, the wider adoption and scaling up of smart irrigation in order to promote highly productive, yet climate-friendly agriculture requires partnerships with financial institutions, donors, governments, farmer groups, and equipment manufacturers (IFC, 2016).

Although irrigation systems are installed on approximately 10.07% to 14% of the utilized agricultural land in North Macedonia, the share of agricultural land that is irrigated is several times lower than in Mediterranean EU countries (Prepared for the development of the fourth national plan on climate change). In addition, due to the deteriorating irrigation systems, only 2.7% of the arable land is regularly irrigated (Prepared for the development of the fourth national plan on climate change). The irrational use of irrigation water has been identified as a weakness of North Macedonian agricultural production, and the need to introduce more smart irrigation, such as drip irrigation, has been highlighted by the new IPARD program (Prepared for the development of the fourth national plan on climate change). In short: North Macedonia urgently needs to improve, modernize and upgrade its irrigation systems. The government has initiated several large projects aimed at improving and installing resilient irrigation infrastructures, especially in the Bregalnica River basin.

Smart irrigation systems are cost-effective and clean energy solutions for agricultural water management, based on weather and soil data, that minimize the environmental footprint through efficient water use. This technology relies on accurate weather forecasts and early warning systems provided by agricultural meteorological stations that are automatically integrated with real-time monitoring platforms for key microclimatic conditions, as well as on-farm sensors that measure a range of parameters in the soil, air and crops. The sensors can detect soil moisture, humidity and temperature in the field and provide appropriate command signals to operate irrigation pumps (Al-Ali et al., 2019). There are three main categories of smart field sensors: (i) soil-based, (ii) weather-based and (iii) plant-mounted (Al-Ali et al., 2019).

These sophisticated sensors help determine the most appropriate time to irrigate and the amount of water needed. Some smart irrigation systems are based on the Internet of Things, equipped with sophisticated warning, monitoring and control features (Al-Ali et al., 2019); (Rout et al., 2018). Smart irrigation systems can also integrate and use soil, terrain, vegetation, hydrological and meteorological data provided by satellites or sensors and cameras mounted on aircraft and/or low-flying drones. Smart features can also include a decentralized advanced monitoring system, automatic performance analysis, detection and reporting of pipe network failures, all of which improve efficiency (Rapid assessment of the Climate Change Water-Food-Energy nexus in the Republic of North Macedonia).

The most advanced and environmentally friendly type of smart irrigation systems are the so-called solar-powered smart irrigation systems (SSPI). They operate using water pumps powered by electricity generated by the sun through solar panels (Harishankar et al., 2014). These systems are a great example of how technological means can be used to implement the WFEN concept in practice – because they are not only water-friendly, but also energy- and climate-friendly. SSPI systems provide a triple win: (i) zero carbon emissions, (ii) significant water savings, (iii) and lower energy bills (Future ENVIRO, 2021). Solar photovoltaic modules installed to power irrigation networks eliminate the carbon emissions that result from electricity generated from fossil fuels or from the use of diesel pumps. Smart sensors reduce water consumption, resulting in less energy needed to pump water. SSPI systems can be stationary or mobile and installed in all fields, including pastures. They are automated and independent of fossil fuels, electricity and human labor. The pump turns on itself with the first rays of the sun and pumps the water needed for irrigation to the end users (Rapid assessment of the Climate Change Water-Food-Energy nexus in the Republic of North Macedonia).

The new generation of SSPI systems is equipped with controllers that uniquely use solar energy to detect the weather and adjust irrigation according to conditions and season, providing plants with the precise irrigation they need to help them thrive. Some systems work on new, clean pumping technology that stabilizes the injection of energy into the system, which in turn stabilizes the irrigation process itself (FuturENVIRO, 2021). This technology can solve problems such as intermittency of solar energy when the sun is not shining and the opposite problem - overloading the local electrical grid.
Smart irrigation systems should contribute to revising the current irrigation calendars during the vegetative period of agricultural areas that have been applied since the 60s and 70s of the last century.

Smart irrigation systems will also contribute to correcting the calculation of total irrigation water needs, which is quite complex and difficult. In world practice, there are several methods and ways to calculate the balance of the required quantities of irrigation water. Those methods that are used in the current practice in the operation of irrigation systems are:

1. Method of Transpiration Coefficients and Soil Evaporation.
2. Method of Blemji and Kridl.
3. Method of utilizing the yield coefficient.
4. Method of utilizing the moisture deficit in the air.
5. Method of utilizing the temperature factor, i.e. Method of Charve.
6. Method of Ideal Precipitation.

All these methods will undergo corrections for the simple reason that they will receive real-time input data for local irrigation systems.
Measures to improve climate resilience are imperative to protect the country’s agricultural sector and ensure climate-resilient and low-carbon economic development and accession to the European Union. The climate in North Macedonia is strongly influenced by the large variation in altitude across the country. There have already been changes in average temperature and precipitation and an increase in the frequency and intensity of climate extremes such as floods and droughts in the past decade. In terms of crop production, the seasonal distribution of temperature and precipitation is more important than the annual average. The following table shows the projected climate impacts on crop yields by 2050. Table 1 provides a tabular overview of the yields of some agricultural crops in relation to projected climate impacts (Cutter, S., et al., 2009.).

From Table 1, it is clear that the upcoming changes in yields for the indicated agricultural crops in relation to climate change can be seen. This trend indicates the need to adapt agriculture to the actual situation on the ground. Without adaptation to the actual situation on the ground, the consequences for food production could be catastrophic.

Table 1. Yields of some agricultural crops in relation to projected climate impacts

Crops	Predicted climate impacts
Wheat	Rainfall will increase by up to 15% especially in the continental area, but will decrease by up to -3% in the Mediterranean area by 2040. Yields will then decrease by up to 25% between 2040 and 2050.
Corn	Irrigated maize could increase yields by 23% in the continental region, but reduce yields by 11% in the Mediterranean region. Rainfed maize is likely to reduce yields in both regions by up to 77%. For the Southeast region, maize yields are expected to decrease by 56% in 2025 and as much as 86% in 2050.
Grapes	The yield reduction of irrigated grapes will range between 3% - 39%, while the reduction of rainfed grapes could reach up to 53%.
Apples	Irrigated apples will increase yields by 15% especially in the continental area, while rainfed apples will likely reduce yields by up to 63%.
Vegetables	Irrigated vegetables can likely increase yields by 18%, while rainfed vegetables will reduce yields by up to 21%.

Source: Author, by (Cutter, S., et al., 2009.).

From Table 1, it is clear that the upcoming changes in yields for the indicated agricultural crops in relation to climate change can be seen. This trend indicates the need to adapt agriculture to the actual situation on the ground. Without adaptation to the actual situation on the ground, the consequences for food production could be catastrophic.

4. RESULTS AND DISCUSSION

Анализата на влијанието на климатските промени и нивното негативно влијание во досегашното работење на системите за наводнување во земјоделството, овозможува да се изведат следниве заклучоци.

1. In this presented scientific paper, the emphasis of the analyses is given to the change in annual precipitation amounts and the occurrence of extreme values in a certain period, such as dry periods and periods that cause a decrease in agricultural production and periods with increased humidity, when there is a risk of flooding of agricultural areas. In analyzing the annual precipitation amount from 1951-2020, three scenarios were taken into account: low (drought), medium (optimal) and high (possibility of flooding).
2. The analysis of long-term precipitation series shows more complex patterns of change compared to temperature changes. In the case of the low scenario, there is no clear signal for a change in precipitation in the future, except for an increase in precipitation for the months of September-October-November. For the other two scenarios, an annual decrease in precipitation is expected, caused by a significant decrease in summer precipitation. For the medium scenario, the annual precipitation decrease is up to -20% with a decrease in summer precipitation of -30%, and for the high scenario, the annual precipitation decrease is up to -30%, and -40% for summer precipitation by the end of the century. Also, the spring season (March-April-May) shows a constant pattern of precipitation decrease throughout the century, but with a smaller amplitude. By mid-century, both scenarios show a decrease in summer precipitation, up to -30% in both scenarios.
3. The analysis of the index of consecutive dry days reveals that in the future the risk of drought will increase. In the near future the increase in the number of consecutive dry days is between 5 and 20 days, depending on the part of the country and the scenario. For the end of the century in the case of the high scenario the expected increase is over 30 days. This increase

is directly related to the predicted decrease in summer precipitation, especially in the case of the medium and high scenario.

4. Although irrigation systems are installed on approximately 10.07% to 14% of the utilized agricultural land in North Macedonia, the share of agricultural land that is irrigated is several times lower than in the Mediterranean EU countries (Prepared for the development of the fourth national plan on climate change). In addition, due to the deteriorated irrigation systems, only 2.7% of the arable area is regularly irrigated (Prepared for the development of the fourth national plan on climate change). Irrational use of irrigation water has been identified as a weakness of North Macedonian agricultural production (Prepared for the development of the fourth national plan on climate change), and the need to introduce more smart irrigation, such as drip irrigation, has been highlighted by the new IPARD programme (Prepared for the development of the fourth national plan on climate change). In short: North Macedonia urgently needs to improve, modernise and upgrade its irrigation systems. The government has initiated several major projects aimed at improving and installing resilient irrigation infrastructure, particularly in the Bregalnica River basin.
5. Although irrigation systems are installed on approximately 10.07% to 14% of the utilized agricultural land in North Macedonia, the share of agricultural land that is irrigated is several times lower than in Mediterranean EU countries (Rapid assessment of the Climate Change Water-Food-Energy nexus in the Republic of North Macedonia). Additionally, due to deteriorating irrigation systems, only 2.7% of the arable land is regularly irrigated (Rapid assessment of the Climate Change Water-Food-Energy nexus in the Republic of North Macedonia). Irrational use of irrigation water has been identified as a weakness of North Macedonian agricultural production (Rapid assessment of the Climate Change Water-Food-Energy nexus in the Republic of North Macedonia), and the need to introduce more smart irrigation, such as drip irrigation, has been highlighted by the new IPARD programme (Rapid assessment of the Climate Change Water-Food-Energy nexus in the Republic of North Macedonia). In short: North Macedonia urgently needs to improve, modernise and upgrade its irrigation systems. The government has initiated several major projects aimed at improving and installing resilient irrigation infrastructure, particularly in the Bregalnica River basin.
6. The new generation of SSPI systems is equipped with controllers that uniquely use solar energy to detect the weather and adjust irrigation according to conditions and season, providing plants with the precise irrigation they need to help them thrive. Some systems work on new, clean pumping technology that stabilizes the energy injection into the system, which in turn stabilizes the irrigation process itself (Futur ENVIRO, 2021). This technology can solve problems such as intermittency of solar energy when the sun is not shining and the opposite problem of overloading the local electrical grid.

In order to maintain their functioning, existing irrigation systems in the territory of the Republic of North Macedonia must apply new technologies in their daily operations to provide the necessary quantities of water during the growing season.

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THE NUTRITIONAL AND THERAPEUTIC IMPACT OF BLACKCURRANT (*RIBES NIGRUM*) SEED OIL

НУТРИТИВНО И ТЕРАПЕВТСКО ВЛИЈАНИЕ НА МАСЛОТО ОД СЕМЕ ОД ЦРНА РИБИЗЛА (*RIBES NIGRUM*)

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Abstract: *In recent years, consumers have increasingly focused on a healthy lifestyle that brings positive health benefits. This trend stems from the growing awareness of the impact of diet and lifestyle on health, prompting people to turn towards natural and healthy products. The oil from black currant seeds (Ribes nigrum L.) is rich in essential fatty acids and antioxidants, which play a significant role in maintaining overall health and well-being. Black currant has considerable potential for new functional products, thanks to the nutritional and therapeutic properties of its seed oil, contributing to improved cardiovascular health, immune function, and general well-being. The aim of this paper is to provide a brief overview of the composition of black currant seed oil, its properties, production methods, perspectives on the use of by-products in the form of jam, juice, or powder, as well as the advantages of its use in functional nutrition and its health benefits.*

Key words: *Blackcurrant seed oil, antioxidants, functional food, essential fatty acids, agricultural by-products.*

Апстракт: *Во последниве години, потрошувачите сè повеќе се фокусираат на здрав начин на живот кој носи позитивни здравствени придобивки. Овој тренд произлегува од зголемената свесност за влијанието на исхраната и начинот на живот врз здравјето, што ги поттикнува луѓето да се ориентираат кон природни и здрави производи. Маслото од семето од црни рибизлаи (Ribes nigrum L.) се богати со есенцијални масни киселини и антиоксиданти, кои имаат значајно улога во одржувањето на целокупното здравје и благосостојба, Црната рибизла има значителен потенцијал за нови функционални производи, благодарение на нутритивните и терапевтските својства на нејзиното масло од семки, што придонесуваат за подобрување на кардиоваскуларното здравје, имунолошката функција и општата благосостојба. Целта на овој труд е да се даде краток преглед на составот на маслото од црна рибизла, неговите својства, начинот на производство, перспективи за користење на нуспоризводите во вид на џем,сок или прашок како и предностите од неговата употреба во функционална исхрана и нивните здравствени придобивки.*

Клучни зборови: *масло од семе од црна рибазла, антиоксиданти, функционална храна, есенцијални масни киселини, нус-продукти.*

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1. INTRODUCTION

Besides lifestyle and living conditions, nutrition represents one of the most important determinants of our health and well-being. Advances in understanding the effects of dietary ingredients that can have beneficial effects on the human body have made it possible to design and produce food with specific health-promoting effects, rich in various bioactive components. In recent years, many studies have been conducted on compounds that protect the body from harmful effects such as free radicals and reactive oxygen species. Functional foods can be produced by adding a specific bioactive component, modifying it, or increasing the concentration of the active ingredient. Vegetable oils are considered functional foods due to their natural composition, particularly due to the presence of unsaturated fatty acids (Jankuloska et al., 2020). Fats and oils are essential ingredients in a balanced diet as they are a primary source of energy and constitute 25% of daily energy needs. According to this researches (Ramadan et al., 2009; Mezzomo et al., 2010; Zubair et al., 2012) these oils have become attractive from a nutritional point of view due to their unique phytochemical composition and antioxidant properties. Scientific research confirmed that fats and oils contain various nutrients and fat-soluble vitamins A, D, E, and K found in food and are one of the most important sources of energy (Shahidi, Scrimgeour, 2005). The bioactive components in vegetable oils are essential fatty acids: α-linolenic acid (ALA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA), as well as other components: tocopherols and tocotrienols, sterols, and pigments. Seed oils belong to the group of oils with high biological value due to the favorable composition of fatty acids and various minor components that show positive effects on the human body, acting anti-inflammatory, diuretic, antimicrobial, antioxidant, etc. (Jankuloska et al., 2020). Many countries are making efforts to prevent chronic diseases such as heart disease, obesity, and diabetes and are revising dietary guidelines. Nutritional recommendations emphasize low-fat diets to reduce the risk of obesity and cardiovascular diseases. According to (Przybylski, McDonald, 1996; Dzisiak et al., 2004) a diet with increased intake of linoleic and linolenic acid increases HDL and reduces LDL levels. This paper will provide a brief overview of the composition of blackcurrant oil, its properties, the production method, and the benefits of its use in functional nutrition and the health benefits of blackcurrant oil and its derivatives.

1.1. Blackcurrant (Ribes nigrum)

Blackcurrants are berries belonging to the family Grossulariaceae. The blackcurrant (*Ribes nigrum L.)* represents seasonal fruits that have been widely used for the production of food products such as beverages, juices, and jams, as well as for direct consumption. According to (Rachtan-Janicka et al., 2021), they are known to contain many valuable components, including phenolic acids, flavonoids, anthocyanins, and ascorbic acid. Blackcurrant is a fruit that contains ascorbic acid, flavonoids, and the polyphenol anthocyanins delphinidin-3-rutinoside, delphinidin-3-glucoside, cyanidin-3-rutinoside, and cyanidin-3-glucoside (Yaqin et al., 2016). According to the conducted study, the composition of fatty acids in blackcurrant seed oil yielded the following results shown in Table 1. (Sovová, 2006).

According to the table below from the conducted study, it has been confirmed that black currant seed oil is rich in essential fatty acids, particularly linoleic acid. Additionally, according to other research, the sterol composition of black currant seed oil includes ß-sitosterol (70-85%), while the main tocopherols are α- and γ-tocopherols, with 320 and 647 mg/kg, respectively (Shahidi, 2000; Wettasinghe et al., 200).

Table 1. Composition of fatty acids in blackcurrant seed oil (Ribes Nigrum) (Sovová, 2006)

FATTY ACIDS	C-chain	Saponification (%)	Result (%)
Palmitic acid	C 16:0	3.00-9.00	6.60
Stearic acid	C18:0	1.00-4.00	1.30
Oleic acid	C18:1 (n-9)	8.00-18.00	12.50
Limoleic acid	C18:2	32.00-55.00	47.30
Alfa-Linolenic acid	C18:3	12.00-16.00	13.70
Gama-Linolenic acid	C18:3	Minimum 15.0	15.10
Stearidonic acid	C18:4	2.00-4.00	2.50

1.2. Extraction and Component Analysis of Blackcurrant Seed Oil

According to numerous studies, there are several methods for isolating chemical compounds or mixtures of biologically active compounds from plant materials that exhibit desired effects. Various techniques are used depending on the type of compound or group of compounds to be synthesized. In addition to conventional methods such as maceration (Ćujić et al., 2016; Jovanović et al., 2017), distillation (Yahya, Yunus, 2013), cold pressing (Hadjadj et al., 2014) or Soxhlet extraction, liquid-solid solvent extraction is also used, which requires either time or a large quantity of organic solvents. A literature review confirms that more sophiseticated, faster, and environmentally friendly methods have recently been used: Supercritical Fluid Extraction (SFE) (Mazurek et al., 2022), Ultrasonic Aqueous Enzymatic Method (Wang et al., 2023), and Microwave-Assisted Extraction (MAE). Supercritical fluid extraction is a powerful analytical tool that researchers (Danlami et al., 2014) use to isolate various components from different matrices. It allows for obtaining chemically pure extracts without residues of solvents and heavy metals. When it comes to blackcurrant oil, HPLC can be especially useful for analyzing its complex composition, which includes essential fatty acids like α-linolenic acid and γ-linolenic acid, as well as other compounds such as polyphenols (Yinrong, Lu, 2003). According to (Ardhi et al., 2024) on the residues of blackcurrant seeds from oil extraction confirms the presence of a range of polyphenols, dominated by four anthocyanins consisting of rutinosides and glucosides of delphinidin and cyanidin. Additionally, glucosides and rutinosides of myricetin and quercetin, kaempferol-3-glucoside, dihydroquercetin, and aureusidin, as well as phenolic acids 1-cinnamoyl and 1-p-coumaroyl-β-d-glucosides, are isolated. This method is particularly useful for analyzing the complex mixture of fatty acids and other bioactive compounds in blackcurrant oil, providing valuable information about its composition and potential health benefits. Tocopherols (α-, β-, γ- and δ-tocopherols) and tocotrienols (α-, β-, γ- and δ-tocotrienols) in fruit seed oils were determined by (Mel′nikov et al., 2004) using the normal-phase high-performance liquid chromatography (NP-HPLC) method. (Gąsior et al., 2009) confirmed that the dominant compound in the analyzed oils is citosterol in blackcurrant seed oil. Citosterol is an important phytosterol that reduces cholesterol absorption, helping to maintain low levels of total cholesterol in the peripheral bloodstream (Kritchevsky, Chen, 2005).

2. APPLICATION OF BLACKCURRANT FOOD TYPES

According to this review in Figure. 1 five common types of blackcurrant food (concentrate/extract/powder/juice powder/capsules from blackcurrant juice) were presented to summarize their practical applications in some real food matrices for the production of blackcurrant-containing functional food products.

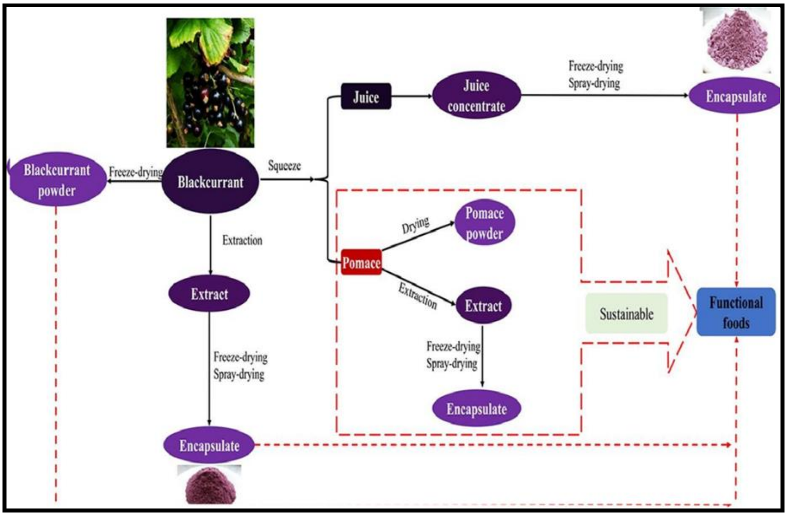

Figure 1. Five common types of blackcurrant food and their applications (Deferne et al., 1996)

Functional protein encapsulates have been developed using blackcurrant juice concentrate with sodium caseinate and whey protein isolate via spray-drying or freeze-drying. According to (Deferne et al., 1996) coatings enhance bioavailability of anthocyanins in blackcurrant concentrate. Studies showed that blackcurrant oil capsules reduce serum lipid concentrations and dietary supplements prevent hypertension and atopic dermatitis (Sovova, 2006; Rój, 2016, Wang et al., 2023). Phenolic antioxidants from blackcurrant seed residues enable recovery of valuable components from fruit processing by-products for the food industry. Pharmaceutical preparations made by (Nanashima et al., 2021), use vegetable oils with 18-carbon polyenoic fatty acids, and current oil production technology (cold pressing in nitrogen gas or supercritical CO_2 extraction) preserves their high biological and antioxidant activity.

3. HEALTH BENEFITS OF BLACKCURRANT DERIVED FOODS

In addition to these widely studied health benefits such as antioxidant, anti-inflammatory, neuroprotective actions, and anti-cancer properties, several studies (Kritchevsky et al., 2005; Jovanović et al., 2017) have reported new health benefits of blackcurrant, such as vasculoprotective effects where blackcurrant extract can provide beneficial health effects by preserving the blood vessels of diabetic patients, hypocholesterolemic effects, where blackcurrant extract can inhibit cholesterol absorption, suppresses the expression of hydroxymethylglutaryl-CoA reductase, and promotes the uptake of low-density lipoproteins through the oxidation of low-density lipoprotein receptors. While high levels of saturated fatty acids may increase the stability of the oil, they are often considered nutritionally undesirable because they increase HDL cholesterol levels, affecting the LDL to HDL ratio. Diets rich in linoleic and linolenic acid increase HDL and reduce LDL. Some reports indicate positive effects on lipid metabolism due to the anthocyanins contained in the blackcurrant extract (Yahya et al., 2013). Among these new health benefits according to (Wu et al., 2021), claims that, regulating postprandial hyperglycemia is of great interest and importance due to its association with type-2 diabetes mellitus, which investigated the inhibitory activities of α-amylase and α-glucosidase of blackcurrant extracts from blackcurrant powder-containing pastes. This conclusion was partly consistent with the finding that blackcurrant anthocyanins regulate postprandial hyperglycemia by inhibiting α-glucosidase activity, and salivary α-amylase activity was mainly modulated by blackcurrant anthocyanins and other phenols. Incorporating blackcurrant powder into cereal foods has the potential to reduce the associated risk of developing T2DM (Anna et al., 2009).

4. CONCLUSION

The occurrence of diseases due to improper diet and modern lifestyle leads to a significant increase in healthcare costs. Prevention, through the promotion of functional food, has proven to be a more effective and economical strategy for reducing these risks. The food industry faces a significant challenge in incorporating bioactive components from vegetable oils into functional products to reduce the risk of diseases. Nutritionists and health institutions promote changes in dietary habits to improve the health of the population. The food industry must follow the needs of consumers and introduce new technologies to obtain high-quality and safe functional products. Blackcurrant seed oil is an example of an oil with high biological value, containing polyunsaturated fatty acids and antioxidants. Its nutritional and therapeutic properties make it useful for cardiovascular health, immune function, and overall well-being. Research focuses on eco-friendly and economical methods of oil extraction to ensure high quality and purity. The by-products from berry processing, such as seeds, can be used to produce high-value biomolecules. In conclusion, promoting functional food and using bioactive components from vegetable oils from blackcurrant seeds offer significant opportunities for improving the health and well-being of the population, as well as reducing healthcare costs.

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SOCIO-ECONOMIC AND SOCIO-CULTURAL IMPACT OF TOURIST ATTRACTIONS – EVENT TOURISM ON SERBIA'S ECONOMIC PROSPERITY WITH A SPECIAL FOCUS ON THE RURAL AREAS OF ŠUMADIJA

DRUŠTVENO-EKONOMSKI I SOCIO-KULTURNI UTICAJ TURISTIČKIH ATRAKCIJA – MANIFESTACIONOG TURIZMA NA EKONOMSKI PROSPERITET SRBIJE SA POSEBNIM OSVRTOM NA RURALNA PODRUČJA ŠUMADIJE

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Abstract: *Tourism, as a contemporary socio-economic phenomenon characterized by mass participation and dynamism, is closely interconnected with various economic sectors, including hospitality, trade, agriculture, and industry. This interrelation underscores its interdisciplinary nature.*
Serbia's tourism events are fundamentally rooted in tradition, offering diverse programs and a well-established identity, making them a crucial component of the country's extensive tourism portfolio. This study aims to comprehensively examine and analyze the historical development of tourism events, their role and significance, resource valorization programs, and their socio-economic, socio-cultural, recreational, and environmental impact on the economic prosperity of the Šumadija region. Due to their multifunctional nature, Serbian tourism events can be systematically classified into the following categories:
•Economic events,• Entertainment and tourism events,•Scientific and professional events,•Religious events, •Political and historical events,•Sports events, and•Children's events (Bjeljac Ž., 2010).
Every country is distinguished by its customs, culture, religion, traditions, and unique elements such as handicrafts, gastronomy, souvenirs, and traditional crafts.
This research focuses on the existing tourist attractions in the Šumadija region, as well as the potential valorization of sites with significant tourism potential for both domestic and international visitors.
The primary objective of this study is to propose measures and recommendations for further development of tourism attractions, with an emphasis on promotion, marketing strategies, and increasing public awareness. The ultimate goal is to position Serbia's tourism events among the most prominent destinations on the global tourism map.

Key words: *tourism, events, attractiveness, potential, valorization, offer*

Apstrakt: *Turizam, kao savremeni društveno-ekonomski fenomen koji karakteriše masovno učešće i dinamika, usko je povezan sa različitim privrednim sektorima, uključujući ugostiteljstvo, trgovinu, poljoprivredu i industriju. Ovaj međusobni odnos naglašava njegovu interdisciplinarnost.*

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Turistički događaji u Srbiji su fundamentalno ukorenjeni u tradiciji, nudeći raznovrsne programe i dobro uspostavljen identitet, što ih čini ključnom komponentom obimnog turističkog portfelja zemlje. Ova studija ima za cilj da sveobuhvatno ispita i analizira istorijski razvoj turističkih događaja, njihovu ulogu i značaj, programe valorizacije resursa i njihov socio-ekonomski, sociokulturni, rekreativni i ekološki uticaj na ekonomski prosperitet Šumadijskog regiona. Zbog svoje multifunkcionalne prirode, srpske turističke manifestacije se sistematski mogu svrstati u sledeće kategorije:
•Privredni događaji,• Zabavne i turističke manifestacije,•Naučne i stručne manifestacije,•Verske manifestacije,•Politička i istorijska dešavanja,•Sportska dešavanja i•Dečja dešavanja (Bjeljac Ž., 2010).
Svaka zemlja se odlikuje svojim običajima, kulturom, religijom, tradicijom i jedinstvenim elementima kao što su rukotvorine, gastronomija, suveniri i tradicionalni zanati.
Ovo istraživanje se fokusira na postojeće turističke atrakcije u Šumadijskom regionu, kao i na potencijalnu valorizaciju lokaliteta sa značajnim turističkim potencijalom za domaće i strane posetioce.
Primarni cilj ove studije je predlaganje mjera i preporuka za dalji razvoj turističkih atrakcija, sa akcentom na promociju, marketinške strategije i podizanje svijesti javnosti. Krajnji cilj je da se turističke manifestacije Srbije pozicioniraju među najistaknutije destinacije na globalnoj turističkoj mapi.

Ključne reči: *turizam, manifestacije, atraktivnost, potencijal, valorizacija, ponuda*

1. INTRODUCTION

Tourism has become the world's largest industry, driven by the globalization of capital, labor, transportation, communication, technology, and finance. These factors have positioned tourism as a key driver of economic and regional development in every country. In the modern era, tourism is experiencing significant growth due to improved connectivity and easier access to information. Consequently, the development of tourism has become an essential theoretical and practical strategy within contemporary economics and related disciplines. Organizing specialized forms of tourism, such as event tourism, creates opportunities to attract more domestic and international tourists, thereby boosting overall economic performance through increased visitor numbers, extended stays, higher service utilization, and overall consumption.

This study focuses on the potential for the development of the Šumadija region through the principles and factors that either stimulate or limit the impact of event tourism in rural areas. The research identifies and evaluates objective factors that influence the application and analysis of tourism development potential. Šumadija's natural and human resources, developed economy, and strategic location contribute to a positive image of the region as the geographic center of the Republic of Serbia. However, its current tourism offerings are underutilized, necessitating targeted initiatives to establish a unified tourism package and destination appeal for both domestic and international visitors.

The main objective of this study is to assess the current level of event tourism development in rural areas of Šumadija as a tourist destination and to explore its future growth potential. Additionally, this form of tourism can serve as a key factor in enhancing Šumadija's competitiveness within Serbia's tourism market, as well as in neighboring countries. A crucial aspect of this development is the preservation of cultural and historical landmarks, facilitated through active involvement of the local population. As a central region, Šumadija symbolizes historical heritage, and its continued development must contribute to reinforcing a positive regional identity.

Tourism has both positive and negative effects on destinations, making its overall impact difficult to quantify. Several once-popular tourist destinations have lost their appeal due to shifting global tourism trends. Overdevelopment and environmental degradation, often linked to traditional tourism models, can significantly damage a destination's appeal. Throughout the 20th century, scholars warned that global progress in economic development and population growth would encounter certain physical limitations, leading to the emergence of the concept of sustainable development. This concept prioritizes meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. Tourism is gradually reaching its developmental peak, and the costs of its expansion have risen accordingly. While efforts continue to mitigate its negative effects, global sustainable tourism projects are increasingly gaining traction. These initiatives focus on the valorization of sustainable resources while continuously improving tourism quality across all segments.

The social, economic, and cultural conditions in the Republic of Serbia, along with varying levels of development across regions, cities, and rural areas, necessitate a thorough analysis of Šumadija's potential as a tourist destination. It is essential to identify appropriate solutions for the economic advancement of this region, as well as to enhance the competitiveness of tourism-related businesses and activities, which represent a fundamental sector of the economy.

Events play a crucial role in attracting tourists, thereby influencing the development of tourism and tourist destinations, as well as contributing to Serbia's overall economic activity. Effective branding can positively impact potential event attendees and shape a favorable image of the destination. In Serbia, the growing number of visitors further motivates institutions, organizations, and relevant authorities to invest in the restoration and preservation of historical sites and their improvement. Recently, the tourism offering has become increasingly diverse, adapting to the needs, demands, and specific preferences of modern tourists—who are experienced, well-informed, unpredictable, and versatile. These changes have led to the development of specialized and thematic forms of tourism, which significantly contribute to the growth of rural areas as tourist destinations that might not otherwise exist in the tourism market. Events, as distinct attractions, serve as synonymous markers of certain destinations, as tourists often visit specifically for them.

Event tourism is among the most dynamic and rapidly growing segments of the tourism industry. Events play a significant role in fostering connections between people from various backgrounds. Through entertainment and social interactions—which are not necessarily limited to seasonal activities—tourists experience unique and memorable moments. This study explores events and their significance, the role and characteristics of event tourism, with a particular focus on those held in the rural areas of Šumadija. The tourism offer in Šumadija generates revenue through tourist traffic, as visitors are drawn to diverse experiences, including culture, tradition, entertainment, recreation, and archaeological sites. The preservation of cultural and historical landmarks plays a crucial role in the development of event tourism in the region.

This type of tourism stimulates the growth of tourist flows and is valued for its positive economic effects, contributing to the quality and competitiveness of tourism both in the domestic and international markets. The connection between tourism and event organization—whether ethnographic, artistic, entertainment, or economic—aligns with various forms of tourism, such as hunting, excursion, or mountain tourism. Additionally, events held near lakes or rivers can be associated with nautical or fishing tourism. Most of these events take place in smaller municipalities or rural areas, thereby encouraging the development of rural and gastronomic tourism. Events that incorporate natural and geographical elements of their locations contribute to environmental conservation, enhance social engagement, and foster community participation in tourism activities. One of the challenges smaller communities face, aside from infrastructure limitations, is the lack of socio-cultural activities. Events offer significant benefits by involving local residents in the organization of competitions (e.g., best-decorated yard, best homemade pastry), as well as in the creation and sale of souvenirs and traditional handicrafts (e.g., saddle-making, blacksmithing, wool processing). Many events are held annually, becoming an essential part of the tourism offer. Promoting tourism events simultaneously promotes the destination itself, and vice versa. When visitors have a positive experience, they are likely to return and recommend the event and destination to family and friends. It is nearly impossible to separate events from tourism and the economy, as they are intrinsically interconnected.

The region of Šumadija is home to numerous tourist attractions located in rural areas. These attractions and the mountains in this region provide natural and cultural prerequisites for the development of event tourism. Events held in rural areas must be improved each year with the aim of enhancing quality. To achieve this, it is necessary to establish standards for event organization, as well as parameters for program content and accompanying elements such as infrastructure, accommodation capacities, security, and hygiene conditions. Particularly interesting is the inclusion of organic food in the tourism offering, as Šumadija has great potential for organic production due to its unpolluted soil, favorable climate, and a large number of agricultural producers. Consequently, the gastronomic offer can also be developed, which serves as a strong motivation for both domestic and foreign tourists to visit Serbian villages. This factor could encourage young people to remain in rural areas, thereby influencing the demographic landscape of Šumadija's countryside.

The current state of event tourism in Šumadija's rural areas highlights several characteristics: the existing tourism offer with its shortcomings, incentives, and current marketing strategies. Demand and trends in tourism present opportunities for the development of this type of tourism. The potential for expanding event tourism in these areas is considerable, yet further support from local governments, relevant ministries, and the Government of the Republic of Serbia is essential. Tourism events, as a tourism product, can be viewed as "enterprises" since they essentially promote and market the product to consumers. (Bjeljac Ž., 2010)

In recent years, tourism attractions have been garnering increasing attention from both domestic and foreign tourists, particularly those events of economic, artistic, and ethnographic significance. These types of events are closely tied to Serbia's anthropogenic heritage, thereby creating favorable conditions for the development of rural and gastronomic tourism.
(Ivanović, 2007) "Serbia is becoming increasingly rich in such events, ranging from long-standing traditions carried out for decades to newly planned ones, demonstrating that there are practically no limitations in terms of themes, occasions, or objectives—only the imagination of the organizers sets the boundaries."

1. Accessibility and transport connectivity of the location
2. Tourism offer (accommodation, entertainment facilities, transport)
3. Organization of tourism and policies

Regarding the categorization of tourism events, Getz (2004) argues that events can be classified into three distinct groups based on their tourism attractiveness. In Serbia, such events include:

- Economic and tourism events dedicated to agricultural products – gastronomic festivals
- Ethnographic events – folklore and customs
- Religious events – church and monastery celebrations, gatherings (Bjeljac Ž., 2007)

The inadequate Gastronomic tourism is best promoted through event tourism. (Bjeljac et al., 2003)

In recent years, tourist interest in organic and highly nutritious food has increased. This results in yet another correlation between gastronomic and rural tourism. Numerous cultural events, such as enogastronomic festivals like "Oplenac Harvest in Topola," "Mowing on Rajac," and "Grape Harvest in Stragari," attract tourists, while the traditional way of life and the cult of hospitality offer a wide range of gastronomic specialties: Pršutijada (Mačkat), Slaninijada (Kačarevo), Roštiljijada (Leskovac, Vrnjačka Banja), Sirijada (Pirot, Nova Varoš, Sjenica), Pasuljijada (Kraljevo, Pirot, Velika Plana), Pitijada (Čačak), Čvarkijada (Valjevo), and others. Gastronomic tourism, together with wine tourism, forms enogastronomic tourism. Among the wine festivals that significantly boost Serbia's tourism, the Festival of Šumadija Wines stands out—a festival where many renowned winemakers from Šumadija share their knowledge and extensive experience from their wine cellars while promoting diverse wine varieties to local visitors.

Event tourism has both social and economic impacts on the economic prosperity of our country. Its social significance is reflected in the positive influence on the cultural and educational level of the population, as it encourages people to engage in tourism-related travel, thereby increasing visits to cultural and historical landmarks as well as art galleries.

According to the English author Medlik, when determining the economic significance of this type of tourism, three groups of factors should be taken into account:

1. Climatic conditions,
2. cultural and historical heritage, and
3. natural beauty

Categorization and classification of tourism events remain insufficiently present in our country. Further classification allows for the identification of three categories of events that attract visitors:

1. Events of independent tourism value
2. Events as a significant element of the tourism offer
3. Events in underdeveloped areas of Serbia

Tourism events play a crucial role as a tourism product within the marketing mix. Promotion is a key factor in the successful organization of events. In foreign literature, numerous examples of successful tourism event promotion can be found. For instance, Houle (2002) emphasizes entertainment, excitement, and entrepreneurship as key factors for effective promotion. Other authors (Kobašić, 1989; Bakić, Unković, 1991; Catherwood et al., 1992; Jago, 2002; Ćurčić, 2010) highlight elements such as product, price, location, public relations, and positioning as essential for successful promotion.

In Serbia, the most commonly applied marketing mix instruments for the realization of tourism attractions include economic advertising, public relations, and publicity.

2. MATERIAL AND METHODS

The methods used in this research provide the best foundation for the development of tourism events and the sustainable development of tourism. The following methods were applied in the study:

1. FAS Method – where F encompasses factors related to climate, terrain, soil, flora, and fauna. Terrain, climate, and soil can positively influence the development of event and enogastronomic tourism. All these factors are crucial for the development of rural tourism (leisure, recreation, entertainment, handicrafts, visits to enogastronomic events). When organizing events, it is essential to consider:

- A well-chosen location, ensuring accessibility for visitors traveling from distant destinations,
- The ambiance of the location,
- Adequate transport infrastructure for access to tourist attractions, and
- The extent to which the location aligns with the nature of the event.

Human resources are also a key factor in the development of event tourism (Bjeljac Ž., 2010). Personnel must be well-trained and qualified for roles as managers and event organizers (artistic, entertainment, and economic) and for designing experiences that allow visitors to enjoy and explore culture, customs, and folklore. Among the overall tourism offerings, fairs and festivals stand out as platforms for showcasing artistic and scientific achievements, as well as traditional fairs such as "*Zveče dukati, šušti svila*" ("Ducats rattle, silk rustles", the fair in Topola).

2. A – The second element of the FAS method refers to attractiveness, which is reflected in culture, tradition, and enogastronomic events. The expected outcomes of organizing such events include economic benefits for both the local population and visitors.

Šumadija is rich in cultural and historical heritage. In addition to fairs and festivals, exhibitions (such as art exhibitions) also play a significant role. Prominent events include "Oplenac Grape Harvest in Topola," "Plum Days in Stragari," and "I Passed Through Levač, I Passed Through Šumadija" in Belušić, among others. Of a total of 33 events, 29.64% have an artistic character, followed by sports events (21.25%), economic events (17.66%), entertainment events (12%), and ethnographic events (12.28%) (Bjeljac et al., 2004).

3. S – The third element of the FAS method refers to state support in terms of loan approvals, the adequate implementation of economic policies, and investments in transport infrastructure. Greater state involvement is necessary to support a larger number of events and fairs, invest in marketing mix instruments, define branding strategies, and strengthen transport infrastructure.

Based on a SWOT analysis, the research identified all the strengths and weaknesses related to tourism events.

Table 1. SWOT Analysis

STRENGTHS	WEAKNESSES
– Favorable conditions for the development of tourism events in Serbia – High quality of tourist attractions (folklore, traditional crafts) – Rich cultural heritage (wine museums, art exhibitions) – Ethnographic events – International road connections (E-75, E-70)	– Inadequate transport infrastructure – Underdeveloped image – Insufficient financial resources – Insufficient training of personnel

A questionnaire consisting of 10 questions, both open-ended and closed-ended, was created. The questionnaire focused on issues related to tourism events in Šumadija (enogastronomic and rural tourism). The survey was conducted electronically and through personal contact. Data were collected from employees and random passersby using a random sampling method. By applying a SWOT analysis, all strengths and weaknesses were identified, aiming to find better solutions, suggestions, and programs that would contribute to the further and faster development of Serbia's tourist attractions.

3. RESEARCH RESULTS

If we start from the observation that agriculture has increasingly gained importance in recent years, statistical indicators suggest that an adequate solution for the improvement and development of organic and wine production, which is an inevitable part of tourism events (enogastronomic tourism), has yet to be achieved. Based on the foregoing, the following hypothesis is formulated:

H1 – Tourist attitudes influence the development of enogastronomic tourism and tourism events in Šumadija.

The questionnaire for analyzing the enogastronomic tourism product and events in Šumadija, aimed at satisfying tourists, was conducted in two ways:

1. Face-to-face – i.e., personal contact with random passersby, wineries, and agencies, and
2. Electronically – i.e., by sending emails.

To carry out the research, a Likert scale from 1 to 5 was used, where (1 – strongly disagree, and 5 – strongly agree). During the research, the statistical software SPSS 19.0 (Statistical Package for the Social Sciences 19.0) was used.

Table 2. Tourist Opinions Impact the Development of Enogastronomic Tourism in Šumadija

		Frequency	Percentages
Valid	No	40	36.4
	Yes	69	62.7
	Total	109	99.1
Missing	System	1	9
Total		110	100.0

Out of 136 respondents, 109 provided answers to the survey, meaning 62.7% stated that this type of tourism (enogastronomy) has the potential to develop in the territory of the Republic of Serbia.

There are tourists who have moved beyond the hedonistic form of vacation based on adventure (nautical tourism), who do not require an adequate enogastronomic experience, but instead seek a return to natural extremes.

Table 3. Relationship Between Opinions on the Development of Enogastronomic Tourism and Gender of the Respondents

		Gender of Respondents		Total
		Male	Female	
Development of Enogastronomic Tourism	No Number	18	22	40
	% within variable Development of Enogastronomic Tourism	45.0%	55.0%	100.0%
	% within variable Gender of Respondents	40.0%	34.4%	36.7%
	Yes Number	27	42	69
	% within variable Development of Enogastronomic Tourism	39.1%	60.9%	100.0%
	% within variable Gender of Respondents	60.0%	65,6%	63.3%
Total Number		45	64	109
% within variable Development of Enogastronomic Tourism		41.3%	58.7%	100.0%
% within variable Gender of Respondents		100.0%	100.0%	100.0%

From the presented data (T20), we can highlight a representative parameter of the Chi-square test and display it as follows:

Chi-Square Test Based on the Previous Data

	Value	Degrees of freedom	Asymptotic Significance (2-sided)	Exact Significance (2-sided)	Exact Significance (2-sided)
Pearson's Chi-Square Test	0.360	1	0.549		
Yates' Continuity Correction	0.158	1	0.691		
Likelihood Ratio	0.359	1	0.549		
Fisher's Exact Test					
Mantel-Haenszel Test	0.357			0.553	0.344
Valid Cases	109	1	0.550		

To present the trends of the examined parameters more clearly, we highlight the symmetry measures:

Symmetry Measures Based on the Previous Data

Measure	Value	Approximate Significance
Phi (ϕ)	0.057	0.549
Cramér's V	0.057	0.549
Valid cases	109	

Table 4. The Influence of Respondents' Age on the Opinion about the Development of Enogastronomic Tourism

Development of Enogastronomic Tourism		Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	Degrees of Freedom	Significance	Statistic	Degrees of Freedom	Significance
Age	No	0.140	40	0.048	0.912	40	0.004
	Yes	0.098	69	0.171	0.948	69	0.006

Test Statistics Based on Previous Data

	Years
Mann-Whitney Test	1050.500
Wilcoxon Sum of Ranks	3465.500
Asymptotic Significance (Two-Tailed)	,038

To present the movement of the investigated parameters more convincingly, we will highlight the median calculated based on the previously provided data:

Median Based on the Obtained Data

Development of Enogastronomic Tourism	Age
No	47.00
Yes	37.00
Total	40.00

The second hypothesis we started from referred to 60 respondents from the Šumadija region.

H2 – Natural and anthropogenic resources are crucial for the development of enogastronomy (Table 5).

Table 5. The impact of resource necessity ratings on respondents' views about considering themselves enogastronomic tourists

	Do you consider yourself an enogastronomic tourist?	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	Degrees of Freedom	Significance	Statistic	Degrees of Freedom	Significance
Necessity rating of clean water as a resource	No	,359	37	,000	,635	37	**,000**
	Yes	,235	54	**,000**	,847	54	,000
Necessity rating of preserved nature as a resource	Yes	,243	54	**,000**	,764	54	,000
Necessity rating of developed agriculture as a resource	No	,253	37	,000	,846	37	**,000**
	Yes	,377	54	**,000**	,629	54	,000
Necessity rating of cellars and wine routes	Yes	,216	54	**,000**	,870	54	,000
Necessity rating of rural festivals	No	,365	37	,000	,708	37	**,000**
	Yes	,302	54	**,000**	,765	54	,000

After testing the normality of distribution, it was determined that none of the resource ratings follow a normal distribution in the groups that consider themselves enogastronomic tourists and those who do not (all significances are below 0.0005). Thus, the conditions for applying the Mann-Whitney test were met.

In the following sections, the following hypotheses will be analyzed:

H-3: Enogastronomy as a goal of rural tourism in Šumadija

H-3a: The hospitality of the local population is essential for the development of both tourist events and enogastronomic tourism in Šumadija.

Table 6. Relationship between tourists' preferences on what attracts them to choose a tourist destination and the perception of enogastronomic tourism as a key driver of tourism development in Šumadija

		What can attract tourists to choose a tourist destination?				
		Enogastronomic Events	Hospitality	Infrastructure	Indigenous Grape Varieties	Total
	No	0	17	8	0	25
	Frequency within the variable Enogastronomic Tourism as a Key Driver of Tourism Development in Šumadija	0.0%	68.0%	32.0%	0.0%	100.0%
	% within variable What Can Attract Tourists to Choose a Tourist Event?	0.0%	85.0%	61.5%	0.0%	26.9%
	Yes	30	3	5	30	68
	Frequency within the variable Enogastronomic Tourism as a Key Driver of Tourism Development in Šumadija	44.1%	4.4%	7.4%	44.1%	100.0%
	% within variable What Can Attract Tourists to Choose a Tourist Event?	100.0%	15.0%	38.5%	100.0%	73.1%
	Total	30	20	13	30	93
	Frequency within the variable Enogastronomic Tourism as a Key Driver of Tourism Development in Šumadija	32.3%	21.5%	14.0%	32.3%	100.0%
	% within variable What Can Attract Tourists to Choose a Tourist Event?	100.0%	100.0%	100.0%	100.0%	100.0%

H3-b The most profitable investment for the development of enogastronomic tourism and events could be found in the production of healthy food.

Table 7. Relationship Between Investment Areas and Respondents' Opinions on Whether Enogastronomic Tourism Can Be a Driver of Tourism Development in Šumadija.

		Supplementary Business			Total
		Food and Medicinal Herbs	Tourist Facilities	Souvenirs and Handmade Products	
Enogastronomic Tourism as a Key Driver of Tourism Development in Šumadija	No	1	12	0	13
	Frequency within the variable Enogastronomic Tourism as a Key Driver of Tourism Development in Šumadija	7.7%	92.3%	0.0%	100.0%
	% within variable Supplementary Business	3.6%	50.0%	0.0%	17.1%
	Yes	27	12	24	63
	Frequency within the variable Enogastronomic Tourism as a Key Driver of Tourism Development in Šumadija	42.9%	19.0%	38.1%	100.0%
	% within variable Supplementary Business	96.4%	50.0%	100.0%	82.9%
Total		28	24	24	76
Frequency within the variable Enogastronomic Tourism as a Key Driver of Tourism Development in Šumadija		36.8%	31.6%	31.6%	100.0%
% within variable Supplementary Business		100.0%	100.0%	100.0%	100.0%

From the presented data we can extract the representative parameter Chi-square test and present it as follows:

Chi-Square Test Results Based on the Collected Data:

	Value	Degrees of Freedom	Asymptotic Significance (two-tailed)
Pearson Chi-Square	26.884	2	0.000
Likelihood Ratio (L-R)	27.648	2	0.000
Mantel-Haenszel Test	0.013	1	0.908
Valid Cases	76		

Eneogastronomic tourism, as a distinct form of tourism, is closely linked to agriculture and craftsmanship, and its impact is reflected in the overall social development of Serbia.

The research questions were focused on rural and enogastronomic tourism. The study was conducted both through face-to-face interactions and electronically. The investigation began with the hypothesis H3 – that the most profitable investment for the development of enogastronomic tourism lies in the production of healthy food (Table 24). However, all of the aforementioned factors have a negative impact on the development of this type of tourism in the Šumadija region.

4. CONCLUSION

In Šumadija, one can observe the exceptionally high importance of certain events, which, through their long-standing tradition, the attractiveness of their programs, the ambiance, and the established image, represent a significant segment of the tourism offer and an extremely important element in the development of selective forms of tourism. However, Serbia faces challenges such as underdeveloped infrastructure, insufficient financial resources, inadequate marketing and management, insufficient training of staff, and an undefined brand.

The research results on this topic are found in the precisely defined strategy for the development of enogastronomic tourism in Šumadija, as well as in raising awareness about wine to a higher level through magazines, brochures, billboards, TV, and seminars.

Šumadija, in addition to its rich cultural and historical heritage (old crafts, wine and gastronomic events, museums of viticulture), is primarily known for its authentic gastronomic specialties (cheese, kaymak, zeljanica, proja, and others).

The gastronomic offer of rural areas represents a part of the material culture through which one can learn about the folklore, customs, and traditions of a nation, as well as its specialties.

- Event tourism can enable greater earnings and an increase in the country's tourism demand in the future.
- Financial investments are necessary to develop transport infrastructure (for events held in rural areas).
- Strengthening the marketing mix instruments (product, price, distribution, promotion).
- Environmental impacts from organizing events are negative due to pollution (waste from food and beverages). Therefore, environmental forums are organized to raise public awareness regarding environmental protection.

- The ecological "cost-benefit" analysis is the most effective tool for achieving positive outcomes.
- There is an inadequacy of qualified professionals, so greater support from the government and local authorities is essential in organizing seminars, courses, and training programs.
- The government must become more involved in promoting untapped potential, and tourism agencies should include visits to appropriate locations in their arrangements, showcasing the treasures of Šumadija that should be valorized.
- Investments in promotional activities contribute to greater popularization of events (Oplenac Grape Harvest, the Fair in Topola).

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THE IMPORTANCE OF RURAL TOURISM AND AGRICULTURE FOR THE DEVELOPMENT OF THE NORTHERN REGION OF MONTENEGRO

ZNAČAJ RURALNOG TURIZMA I POLJOPRIVREDE ZA RAZVOJ SJEVERNOG REGIONA CRNE GORE

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Abstract: *The development of rural areas in Montenegro is based on improving the development of agriculture and rural tourism. The northern region has extremely favorable conditions for the development of rural tourism, and on the other hand, the region is facing unfavorable demographic processes. The goal of the work is to point out the challenges and problems faced by agricultural producers who want to engage in rural tourism on family farms. Through the conversation in the focus group, we learned about the problems on family farms, which are related to the practice of rural tourism.*

Key words: *rural tourism, agriculture, demography, economy*

Apstrakt: *Razvoj ruralnih područja u Crnoj Gori zasniva se na unapređenju razvoja poljoprivrede i ruralnog turizma. Sjeverni region ima izuzetno povoljne uslove za razvoj ruralnog turizma, a sa druge strane region se suočava sa nepovoljnim demografskim procesima. Cilj rada je da ukaze na izazove i probleme sa kojima se susreću poljoprivredni proizvođači koji žele da se na porodičnim gazdinstvima bave ruralnim turizmom. Kroz razgovor u fokus grupi došlo se do saznanja o problemima na porodičnim gazdinstvima, a koji se odnose na bavljenje ruralnim turizmom.*

Ključne reči: *ruralni turizam, poljoprivreda, demografija, ekonomija*

1. INTRODUCTION

Montenegro covers an area of 13 812 km2, and according to the last population census of Montenegro from 2011, 620 029 people live in Montenegro in three regions. According to the preliminary results of the census of population, households and apartments in 2023, published by the (Statistical Office of Montenegro, 2023), 633 158 inhabitants live in Montenegro. The population density is an average of 44.76 inhabitants per km^2. Agriculture and tourism represent strategic branches of development in Montenegro. The northern region covers 52.9% of the country's surface, but has a lower population density of 26.6 inhabitants per km^2. According to the OECD[91] methodology, 59.7% of the population in the northern region lives in rural areas, and

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[91] According to the OECD methodology, municipalities in Montenegro are classified as follows: predominantly rural, medium rural, while Cetinje, Podgorica and Budva are on the very border between medium rural and urban municipalities.

40.3% in urban areas. In contrast, the central and southern regions, which are moderately developed, have a higher share of the population in urban areas 79.6% in the central region and 58.3% along the coast. This distribution emphasizes the lower population density and rural character of the northern region of Montenegro compared to the more urbanized coastal and central areas.

Agricultural production in Montenegro has a long tradition and, thanks to its natural resources, can represent the backbone of economic development. However, there are limiting factors for the development of the Montenegrin countryside, namely the fragmentation of agricultural land and the structure of its use. Structural changes in the population in the rural areas of Montenegro, which occurred after the Second World War, had a significant impact on the further development of agriculture in Montenegro. The family farm as the nucleus of agricultural development best reflects the changes that occurred in the mentioned period, because the number of farms decreased and according to the latest preliminary results of the Census of Agriculture in 2024, their number is 26,711. If they are compared with the data of the census of agriculture from 2010, according to national criteria, a decrease of as much as 46% was recorded (Statistical Office of Montenegro, 2024). The trend of decreasing the number of agricultural farms is worrying, especially if you take into account the fact that almost all agricultural production takes place on farms.

Depopulation, unfavorable age and educational structure are the main characteristics of rural areas in the north of Montenegro. According to the preliminary data of the agricultural census in 2024, the average age of farm owners is 59 years, which is higher than in the previous census in 2010, when it was 57 years old. Almost 87.5% of the owners of farms are men, while women as owners of farms are represented only at the level of about 12.5%. The reasons for women's weak interest in staying in rural areas are as follows: women in the countryside are rarely property owners, they are rarely in the position of head of the household, i.e. less often they have the role of decision-making on agricultural production and the role of responsibility for the economic risks of doing business on the farm (Despotović et al. 2015).

In the modern study of the development of tourism in the world, rural tourism appears as its very significant and growing segment (Antić et al., 2015). Rural space is the basic resource for the development of rural tourism and this tourism activity relies on the need of city dwellers for peace, clean air, healthy food and space for outdoor recreation (Nickerson et al., 2001). Rural tourism is used for terms related to tourist products and services that are directly related to the agricultural (agrarian) environment, agricultural products and staying in a rural environment (Cánoves et al., 2004; Donaldson, Momsen, 2011).

Taking into account the existing situation in rural areas in the north of Montenegro, one of the solutions to the problem can be the development of rural tourism. The connection between agriculture as the oldest activity and rural tourism as the youngest activity can contribute to the development of the north of Montenegro. Preservation of agricultural resources and the development of rural tourism as a supplementary activity on farms can contribute to an increase in total income and a greater interest in people staying in the countryside. This should be one of the most important goals of the development of rural areas in the northern area of Montenegro.

2. MATERIAL AND METHODS

Data from the Monstat Statistics Authority, as well as scientific and professional works from the subject area, were used in the preparation of the paper. The paper used the "desk research" method, which refers to the analysis of material collected during the research process. The focus group method was used to collect data on the topic of rural tourism. It is a qualitative research method that aimed to encourage an in-depth discussion on the given topic, so that the respondents could express their views on the development of rural tourism on farms as concretely and clearly as possible.

3. RESULTS AND DISCUSSION

The northern region of Montenegro has outstanding natural prerequisites for the development of rural tourism. Rural tourism should represent a lever for economic development and raising the standard of living in rural communities in the northern region of Montenegro. Through the development of rural tourism, the possibility of selling agricultural products at the doorstep opens up (Petrović and Grujović, 2015). Taking into account the accelerated pace of life in urban areas, more and more tourists choose to vacation in rural areas, which are recognized for their traditional hospitality. Human resources are necessary for the implementation of rural tourism development measures. In this regard, it should be noted that modern family farming in Montenegro is "old". This is supported by the fact that 65.7% of the total labor force on farms is over 45 years old. The share of male workforce in the total workforce is 60.41%. Comparing the female and male workforce in relative amounts based on age groups, within the female workforce the percentage of people over 45 years old is 66.60%, while the share of the male workforce is 65.30%. Common for the female and male workforce is that the largest participation by age group is people aged 65 and over, in the female workforce they participate with 23.72%, and in the male workforce 23.50%. The very small percentage of the workforce under the age of 24, which amounts to 6.83% of the total workforce, is worrying.

Table 1. Labor force in Montenegro on agricultural farms by gender and age

Indicator		Total	Below 24 years	Between 24 i 34 years	Between 35 i 44 years	Between 45 i 54 years	Between 55 i 64 years	65 years and older
Family farming farms	Women	38 936	2 545	4 182	6 387	8 388	8 198	9 236
	Men	59 405	4 172	7 158	8 288	13 174	11 651	13 962

Source: Statistical Office of Montenegro, Structure of agricultural holdings, 2010

In Montenegro, there are pronounced migratory movements from the northern part to the central and southern part.

Table 2. Net migration by region, 2011-2020

Years	Northern	Central	Seaside
		Net migration	
2011	-1 407	768	639
2015	-1 189	671	518
2020	-907	541	366

Source: Statistical Office of Montenegro (2025). Migration within Montenegro, Announcements for period 2011-2020

The data from the table indicate that the northern region is emptying, while the central and coastal regions have a positive balance. The rural area, which covers most of the territory of Montenegro, is characterized by a lag in economic development and underdeveloped supporting infrastructure, including the availability of services and ensuring living and working conditions, which has led to the depopulation of rural areas and the lack of interest by young families to live and work in rural areas. In Montenegro, there are many rural areas with poorly developed traffic, social and economic infrastructure. Encouraging the development and improvement of basic infrastructure is one of the prerequisites for the development of even economic growth in the rural area and the improvement of the socio-economic living conditions of the rural population in Montenegro, in order to prevent the depopulation of villages and simultaneously use the natural potential for food production (Ministry of Agriculture, Forestry and Water Management, 2023). For the further development and improvement of life in rural areas, the economic empowerment of women is necessary, as they represent a key factor for the development of agriculture and rural tourism. Social equality, meeting basic health and educational needs are key elements for faster development of rural areas (Duran et.al., 2015). In addition to the prominent problems facing the northern region of Montenegro, on the other hand, numerous natural and cultural sights, beautiful landscapes, untouched nature, etc. should be highlighted. In the northern region, there are national parks, cultural and historical monuments, and the famous canyon of the Tara River. All these are extremely favorable bases for the development of rural tourism in the northern region of Montenegro. Potential capacities exist, but it is necessary to valorize them in the right way. For the northern part of Montenegro, it is very important to point out katuns. Katuns represent a unique cultural demonstration of the nomadic life of herders at high altitudes. These are temporary settlements where shepherds live during the summer months when their cattle graze on pastures (Spasojević, 2006). That is why katuns can represent one of the most important aspects of the development of rural tourism.

In 2019, the Ministry of Sustainable Development and Tourism conducted an analysis of external and internal factors that can affect the development of rural tourism. Through the SWOT analysis, the chances, limitations, opportunities and advantages of the development of rural tourism in Montenegro are shown.

Table 3. SWOT analysis of sustainable rural tourism in Montenegro

Strengths	Weaknesses
A great wealth of natural beauty	Awareness of the importance of engaging in rural tourism has not been developed among the population
Adventure tourism offer	Insufficiently developed road structure
Rural destinations that are not sufficiently explored	Lack of knowledge and skills for dealing with rural tourism
Rural destinations that are not sufficiently explored	There are no discounts for beginners in tourism
Hospitality of local people	There is not enough initiative in regard improving the offer and networking at at the local level
The country is a candidate for admission to the EU	Adequate promotion is not present tourist offers in the rural area tourism
	A small percentage of rural households meets the requirements of the parties visitors
	There is no cooperation between private and public sector
	The presence of large differences in view quality of service in rural tourism
	The tourist infrastructure is inadequate
	The procedures are not known relevant when it comes to rural tourism
Opportunities	**Threats**
Increase in international demand for nature-oriented tourism	Continuous depopulation of villages

Increase in international demand for new unexplored destinations	Tendency towards the development of mass Tourism infrastructure construction process in the northern region that needs it debt, and this is caused by high costs
Visitors want to consume organic food	There are no sufficiently developed capacities intended for the preparation and implementation of projects EU
Saturation with known destinations	There is a conflict between protection and development
Developing agriculture through the development of rural tourism	No entry control was performed visitors to protected areas
State aid and EU aid (IPARD II)	There are conflicts between initiatives and projects of sustainable rural tourism and investment projects within others sector of the economy
Strengthening the awareness of rural communities to the fact that the development of their environments conditioned by the mobilization of local resources and diversification of activities	Static and lack of local capacities self-government

Source: Ministry of Sustainable Development and Tourism, 2019

The completed SWOT analysis indicates the key points that slow down the development of rural tourism. The lack of skilled workers and knowledge among the local population is very worrying, and from that aspect, it is necessary to take a number of steps in order to solve these problems. Also, it is important to note that the key factors in this process are local self-governments, which must provide all kinds of logistics to the local population who express their desire to engage in rural tourism on agricultural farms. Diversification of activities on family farms is an opportunity to increase total income and increase profits on farms. One of the significant problems faced by farms is accommodation capacity. The design of accommodation for tourists should follow traditional construction methods, as well as use traditional materials (Antić et al. 2015). Tourism generates new business opportunities and represents the third largest socio-economic activity. Rural tourism is becoming increasingly important in Europe and beyond (Albacete-Saez et al., 2007; Iorio & Corsale, 2010). In order to overcome the problems with accommodation capacities, the experience of Italy can be used, which was initially focused on the renovation of existing buildings and their internal arrangement. Such an approach did not require the occupation of new land (De Montis et al., 2015).

In order to see the problems from the point of view of direct interested parties, a focus group discussion was conducted with rural women engaged in agriculture, who are interested in diversifying activities on farms. From the point of view of education, rural women are very interested in acquiring knowledge and skills in various fields, especially in the field of marketing and digital skills. Women are aware that they are not computer literate enough to present their own tourist and gastronomic offer.

Each of them pointed out that they do not have the opportunity to create a website, that they do not have a driving test that would significantly facilitate their access to cities in order to obtain the necessary permits and the like. All this affects the insufficient visibility of their farms and that it is necessary to first prepare the residents for tourism. Women were chosen for the focus groups for the reason that they represent the backbone of the development of rural tourism, because it is illusory to expect that farms where only men live, and there are quite a few of them in the north of Montenegro, start the process of diversification.

Through the development of rural tourism, rural women see the possibility of selling their products: homemade juices, jams, etc., which would contribute to their economic empowerment. However, although they have the will and desire to initiate change, they face obstacles and barriers. Their main problem is that they are not property owners and cannot register the tourist offer in their name. For the possible renovation of accommodation facilities or expansion, they need credit, which they cannot get because they do not own the property. Rural women are mostly excluded from the decision-making process on income management and investments on farms. The unsatisfactory economic status of rural women affects the degree of migratory movements from rural to urban areas. What could be concluded from the conversation is that each of them does not have enough self-confidence to start developing new content on farms. This is primarily due to lack of leadership skills.

In the coming period, it is very important to pay attention to the education of rural women, through various trainings, courses, organizing the work of driving schools in rural areas, opening social services, which will improve their living conditions. Organizing fairs, exhibitions and other manifestations can contribute to better communication between women and their mutual assistance. The mutual exchange of experience around the same ideas can be inspiring and influence the circle of those interested in the development of tourism to expand, which would greatly contribute to the development of rural communities. In this way, the existing natural resources would not only represent a potential but also a real basis for improving the quality of life on family farms.

The limitations that women face relate primarily to the availability of information, because it often happens that they find out about events very late or not at all. That is why they need association and strengthening of communication networks in order to solve these problems.

Discussions in the focus group showed, on the one hand, the readiness of rural women to start the transformation process on their farms, and on the other hand, the barriers and limitations they face were reported. Their key problem is the fact that they are not property owners. In order to overcome these problems, it is necessary for the state and local governments to stimulate female entrepreneurship even more through more favorable loans, lower interest rates, longer grace periods, etc., in order to start changing patriarchal patterns of behavior and thinking. These patterns are deeply rooted in Montenegro, where it is still understood that the sister renounces property in the name of the brother, etc. Economic measures and continuous work on these issues can influence the empowerment of rural women and strengthen their self-confidence, because they are very aware of what it means to diversify farms through the development of rural tourism.

Recognizing the potential of the rural areas of Montenegro, i.e. wanting to enable their tourism valorization, primarily the legal and sub-legal regulations for this segment of the tourist offer were improved. Providers of services in rural tourism, i.e. rural households, were offered a legal basis in order to simplify their registration procedure. The relevant Ministry has published brochures: Small guide for rural households, Brochure with all registered households and Dictionary intended for easier communication between households and guests (in seven language variants). Due to the consequences of the COVID-19 pandemic, the Program was not fully implemented (Ministry of Economic Development of Montenegro, 2022).

In the previous period, strong support for the development of rural tourism was provided through the provision of financial resources by the Ministry responsible for tourism affairs and the Ministry responsible for agriculture, forestry and water management, aimed not only at increasing the number of rural households, but also at diversifying and specializing the offer, which is an essential component for the further development of this form of tourism. Through IPARD II program implemented by the Ministry responsible for agriculture, forestry and water management, through measure 7, Diversification of farms and business development, sub-measure / Public call: Support for investments for the development of rural tourism - support is provided to interested persons who want to invest in rural areas in the direction of the development of the tourist offer. In addition to the above, the goal is to encourage employment, create new and preserve existing jobs through the development of business activities and the valorization of natural and agricultural goods, the promotion of healthy and organic food, as well as encouraging economic activity and mitigating the trend of migration from rural areas. In addition to the above, through the Program for the Development of Agriculture and Rural Areas of Montenegro within the framework of IPARD III 2021-2027 (IPARD III program), the use of European pre-accession funds will be enabled through IPA III - the area of agriculture and rural development policy.

For the implementation of the IPARD III program, more than €80 million in non-reimbursable support will be available to farmers, of which €63 million are EU funds, while national co-financing amounts to around €19 million. With the contribution of users of the IPARD III program, of over €50 million, over €130 million will be invested in Montenegrin agriculture in the program period 2021-2027. year (Ministry of Economic Development of Montenegro, 2022).

As a result of investment and implementation of Strategy measures in Montenegro, the number of farms engaged in tourism has increased. There were 60 registered rural households in Montenegro in 2019, while in 2021 there were 189, which confirms the already established trend of development of this type of tourism and the direction of future development policies in tourism. The development of tourism slowed down significantly in 2020 due to the emergence of COVID-19.

The key question is whether young people will be interested in staying in the countryside and engaging in agriculture and tourism. According to research by Smolović (2022), young people are not really interested in agriculture and life in the countryside, especially those young people who were born in the village. They see their perspective outside of rural communities. Young people agree that there are potentials, but they do not see themselves in jobs in the fields of agriculture and tourism. Therefore, human resources are the key to the success of the future development of the northern region of Montenegro.

4. CONCLUSION

Montenegro has a favorable geographical position, it has significant natural resources, and this provides it with the opportunity for the development of rural tourism. Agriculture and tourism are strategic branches of the development of Montenegro. The northern region has significant natural resources, but the rate of depopulation and migration towards the central and southern regions of Montenegro is pronounced. Due to demographic processes, the northern region is being emptied and rural areas remain almost deserted. Almost all agricultural production takes place on family farms, where the average age of the owner of the farm is 59 years. Young people are not interested in returning to rural communities, and younger women are oriented towards going to urban centers.

One of the weaknesses and problems faced by rural areas in the northern region of Montenegro are infrastructure problems, fragmented land holdings and unused agricultural areas. The lack of professional staff represents a significant problem in order to implement new rural policies. There are forms of support from the Ministry of Agriculture, Forestry and Water Management, then through IPARD II and III, but due to the lack of trained personnel, the funds cannot be fully utilized. Diversification is the key to the development of rural communities, because the development of rural tourism opens up opportunities for direct sales of agricultural products. Such a direction of development contributes to the development of the wider social community and encourages the development of other branches of the economy. The experiences of developed countries have shown that the development of rural areas is encouraged by the simultaneous development of non-agricultural activities and agriculture. The state and local self-governments must constantly devise incentive measures to interest young people in returning to rural communities and thus make the northern region desirable for young people to live and work in.

Through focus group discussions with rural women, it was learned that they are interested in the development of tourism, but they pointed out the limitations and barriers they face. First of all, these are insufficient knowledge and skills in the field of marketing and information technology. They are ready for education, they have expressed requests to pass the visa exam, because that way they would be independent. They admit that they lack self-confidence and that they need leadership skills and experience. They see their chances through association, exchange of information, organizing events, etc. They highlighted property ownership as an important factor. In order to have the possibility to obtain financial resources for equipping accommodation facilities, it is necessary for them to have ownership of some real estate. These are the consequences of patriarchal patterns and behavior that imply that women (sisters) always give up their property in the name of their brother.

In order to properly valorize existing natural conditions, stronger and better cooperation between ministries and local self-governments in the field of rural tourism development is necessary. It is necessary to quickly identify key problems and quickly solve them, starting with infrastructure, renovation of existing accommodation capacities, planning of new ones, etc. The synergy of all institutions can give the result that the northern region of Montenegro is not only a potential for the development of rural tourism, but a region that significantly economically valorizes its natural wealth.

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PSYCHO-SOCIAL PREDICTORS OF SUPPORT FOR RURAL TOURISM ON A SAMPLE OF THE SERBIAN POPULATION

PSIHOSOCIJALNI PREDIKTORI PODRŠKE RURALNOM TURIZMU NA UZORKU STANOVNIŠTVA SRBIJE

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Abstract: *The aim of this cross-sectional study was to examine the relative predictive contribution of variables (personal economic benefit, empowerment of the type: political, psychological, social empowerment, contribution to the community and effects of tourism) to the prediction of the variance of support for rural tourism development among the population in the Republic of Serbia. A total of (N sample = 240) participants participated in the study – 54% women and 46% men, aged 18 - 65 years, with an average age (M = 43.24 years, SD = 5.67). Data were collected online using the Support for Tourism Development Scale and the Questionnaire on Attitudes Towards Tourism Development. Cronbach's alpha coefficients of the analyzed variables indicate satisfactory psychometric characteristics (reliability) and the possibility of their further application with participants in the Serbian-speaking area. The results of multiple regression analysis, with 57% of the variance explained, suggest that only two independent variables psychological empowerment (β =.80, $p \geq .05$) and community contribution β = .63, $p \geq .05$) statistically significantly contribute to the perception of support for rural tourism development. Methodological limitations, relevant theoretical and practical implications of the findings, and directions for future research with a longitudinal design are analyzed.*

Keywords: *community contribution, economic benefit, psychological empowerment, rural tourism*

Sažetak: *Cilj ove transverzalne studije bio je ispitivanje relativnog prediktorskog doprinosa varijabli (lična ekonomska korist, osnaživanje tipa: političko, psihološko, socijalno osnaživanje, doprinos zajednici i efekti turizma) predikciji varijanse podrški razvoja ruralnog turizma kod populacije u Republici Srbiji. U istraživanju je učestvovalo ukupno (N uzorak = 240) ispitanika – 54% žena i 46% muškaraca, u dobu od 18 – 65 godine, uz prosečnu starost (AS = 43.24 godina, SD = 5.67). Podaci su prikupljeni metodom online pomoću Skale podrški razvoju turizma i Upitnika o stavovima prema razvoju turizma. Kronbahovi alfa koeficijenti analiziranih varijabli ukazuju na zadovoljavajuću psihometrijsku karakteristiku (pouzdanost) i mogućnost njihove dalje primene kod ispitanika na srpskom govornom području. Rezultati multiple regresione analize, uz 57% objašnjene varijanse, sugerišu da samo dve nezvisne varijable psihološko osnaživanje (β =.80, $p \geq 05$) i doprinos zajednici β = .63, $p \geq .05$) statistički značajno doprinose percepciji podrške razvoja ruralnog turizma. Analizirani su metodološki nedostaci, relevantne teorijske i praktične implikacije dobijenih nalaza, te pravci za buduća istraživanja s longitudinalnim nacrtom.*

***Ključne reči*:** *doprinos zajednici, ekonomska korist, psihološko osnaživanje, ruralni turizam*

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1. INTRODUCTION

Tourism is a dominant source of economic development in the world. For its continuous growth and development, its concept – sustainable *rural tourism* – requires a high-quality and healthy natural environment, which includes components of ecological, economic and social development in order to establish their long-term balance (Ćosić, Ivanović, 2024a). The terms "rural tourism" and "sustainable tourism" are essentially synonyms, suggesting a direct and mutual correlation between tourism and the rural environment and cultures within which they are manifested. Although rural tourism is the subject of considerable discussion, a single consensus on defining its concept has not yet been reached (Chen, et al, 2024; Sobarna et al., 2025). The reason for this is also found in the very striking distinctions of rural space that result from its climatic characteristics, terrain configuration, geomorphological features, vegetation cover, crucial natural factors, and the characteristic social features that define it.

From a historical perspective, the term sustainable rural tourism first appeared in ancient China (1100 BC) where emperors understood that forests, mountains and rivers must be used rationally in accordance with the laws of nature. Also, in ancient times (ancient Greeks and Romans) they discussed various causes of environmental degradation, e.g. deforestation and exploitation of mineral resources. In addition, in ancient Egypt, Babylon and Persia, activities identical to current forms of tourism were recorded, and the primary motives were interest in rare and unexplained natural phenomena and religious practices of the time (Chon, Hao, 2025).

Rural/sustainable natural environment attracts tourists because of the nature in which they have security, freedom and balance, which they lack in their urban living environments (Ivanović & Ćosić, 2023; Piras, Pedes, 2025). The aforementioned authors emphasize that the current hectic lifestyle causes an increasing demand for vacations that allow people peace, relaxation and a return to nature. Therefore, this form of tourism involves the most relevant specific form that is primarily manifested in the most remote locations from urban destinations and attractive tourist destinations (Dewi et al., 2025; Mulyana et al., 2025).

Tourism in rural areas correlates economic, social and environmental development factors, and has a positive impact on employment and economic and cultural development of rural areas (Bhandari et al, 2024; Han et al 2025). The previous development of rural tourism in Serbian destinations has been largely left to individual entrepreneurial initiative and modest generators of social financing, which has resulted in the spontaneous development of a heterogeneous and partial tourist offer based on differentiated and specific forms. However, rural tourism can become one of the key drivers of the development of rural destinations, taking into account a sustainable development model based on a balance of economic, environmental and social sustainability (Agus, Saleh, 2025; Cherian, Natarajamurthy, 2024; Ramaano, 2025). This form of tourism is a relevant component of integral and sustainable rural development, and an important factor in encouraging the development of local activities in the countryside, retaining the population and creating new jobs.

Serbian rural tourism is in its infancy due to decades of neglect of rural areas and family farms. However, political transformations of the socio-economic system in the second decade of the 21st century were an incentive for the development of this form of tourism in the Republic of Serbia (Ćosić, Ivanović, 2024b; Vujić, 2023). In our country, new tourism infrastructure is being intensively built, connecting the most remote parts of the territory, creating new offers and products, developing technology, and increasingly expanding economic activities to a larger number of services, desires and needs of people. In addition, the main effects of tourism dominate: economic, environmental and social impact.

Given that the relationships between the variables: personal economic benefit, political empowerment, psychological empowerment, social empowerment, contribution to community and tourism effects have not been examined in the Serbian sample, the aim of this cross-sectional study was to examine the influence of psychological and social variables in predicting support for the development of rural tourism in the Serbian-speaking area. Based on the presented results of foreign studies, two alternative *hypotheses* were tested: the predictor psychological empowerment probably positively and statistically significantly contributes to the support of the local population for the sustainable development of tourism (H_1) and the redactor contribution to the community positively and statistically significantly affects the support of the local population for the sustainable development of tourism (H_2).

2. MATERIAL AND METHODS

2.1. Participants

The final pertinent sample (N = 350) in the conducted online study consists of citizens of both sexes from different municipalities and cities of the Republic of Serbia, with an age range of 18 to 70 years (N_{women} = 190 and N_{men} = 160). The average age of the participants is (M = 43.24 years, SD = 5.67_{years}). The criterion for selecting participants was age over 18 and use of social networks and a fully completed measuring instrument.

The educational qualifications of the participants are as follows: the largest number of participants has (secondary education = 50.60%), (30.18% primary school) and (20.22% higher education or university). The survey was conducted during February 2025. The structure of the working status of the participants is as follows: (employed = 48%), (unemployed = 2%), (students = 24%), and (pensioners = 26%).

2.2. Research procedure

The link to the measuring instruments was distributed via the Internet via addresses available from personal contacts. After giving informed consent, the participants were asked to forward the invitation to participate with the instruments designed in the digital version to other *Facebook* friends via electronic technology using the platform (*Google Forms*). The battery of measuring instruments completed *online* could not be correlated with the identity of the participants, because instead of names and e-mails, the participants entered their passwords using all available characters. At the beginning of the research, the participants were given brief explanations in electronic form about how to respond, and they could quit at any time without any consequences. By sharing the link, the *online* survey lasted about 20 minutes. The digital research on the Serbian population was approved by the Ethics Committee of the Serbian Academy of Innovation Sciences in Belgrade.

2.3. Measuring instruments

The Support for Tourism Development Scale (Ranasinghe, et al., 2019) and the Questionnaire on Attitudes Towards Tourism Development (Woosnam, 2012) included 15 questions distributed in three categories. The first set of questions was dichotomous in nature, with participants answering YES or NO, depending on personal reasons and attitudes. The second set of questions included statements related to economic, political, social and psychological empowerment, as well as the effects of tourism and contribution to the community. In addition, items correlated with tourism development support and items correlated with sustainable tourism were provided. The above statements were rated using a five-point Likert-type scale (1 = *strongly disagree*, 2 = *mostly* *disagree,* 3 = *neither agree nor disagree,* 4 = *mostly agree,* 5 = *strongly agree*). The last set of questions included socio-demographic characteristics of the participants. Psychometric analysis showed that the reliability of the instruments in this research is satisfactory, because the values of the Cronbach's Alpha coefficient were: for the Support for Tourism Development Scale (α = 83) and for the Questionnaire on Attitudes Towards Tourism Development (α = .78).

3. RESULTS AND DISCUSSION

3.1. Descriptive analysis

Table 1. shows the basic descriptive parameters for the following variables: personal economic gain, political empowerment, psychological empowerment, social empowerment, contribution to the community, effects of tourism, support for tourism development and sustainable tourism development.

Table 1. Descriptive statistical parameters and reliability coefficients of the used variables

Variables	*M*	*SD*	α	*Sk*	*Ku*
Personal economic gain	3.38	1.26	.75	.27	.88
Political empowerment	2.18	1.16	.86	.55	.29
Psychological empowerment	4.20	64	.79	.43	.56
Social empowerment	3.27	1.01	.90	.38	.33
Contribution to the community	3.19	1.03	.77	.64	..48
Effects of tourism	3.80	.95	.84	.82	.69
Support for tourism development			.76	.71	.95
Sustainable tourism development			.82	.85	.87

Legend. M = arithmetic mean; *SD* = standard deviation; *Sk* = skewness; *Ku* = kurtosis; Standard error value (*SE*) of indicator *Sk* is 0.10, and of *Ku* is 0.20.

Based on the empirically calculated arithmetic means in the descriptive matrix, it is observed that participants on average have the maximum pronounced effects of tourism (M = 3.80), and the minimum political empowerment (AS = 2.18), while the maximum variability of the results was achieved on the variable (personal economic gain = 12.40), and the minimum on the variable (psychological empowerment = .64). The Gaussian distribution of the obtained data was tested according to the criteria of skewness and kurtosis. The obtained coefficients of skewness and kurtosis of the observed variables vary within the optimal dispersion interval of two standard deviations ± 2 from the normal/bell-shaped distribution, which is a prerequisite for conducting subsequent statistical multivariate analyses in data processing (Kline, 2023).

3.2. Correlation analysis

In order to define statistically significant quantitative agreement between all pairs of independent variables (economic gain, political empowerment, psychological empowerment, social empowerment, contribution to the community, tourism effects) and the dependent variable (support for tourism development), Pearson correlation coefficients were calculated (Table 2).

Table 2. Intercorrelations of the examined variables

Variables	1	2	3	4	5	6	7
1. Personal economic gain	–						
2. Political empowerment	.40**	–					
3.Psychological empowerment	.41**	.26**	–				
4. Social empowerment	.24**	.49**	.61**	–			
5.Contribution to the community	.28**	.30**	.44**	.39**	–		
6. Effects of tourism	.40**	.15*	.28**	.17*	.27**	–	
7. Support for tourism development	.30**	.20*	.65**	.38**	.54**	.19*	–

Annotation: Statistical significance at the level ** $p \leq .01$; * $p \leq .05$.

By looking at the correlation matrix, it was observed that the values of the linear correlation coefficients of the measured variables mainly range between low or moderate intensity, ranging from .15 to .65. First, a weak and statistically positive correlation is observed between the variables of *personal economic gain* and *support*. Then, with a similar intensity and direction, a statistical interaction is observed between the variables of *political empowerment* and *support*. In relation to the first two pairs of bivariate correlations, the third construct of *psychological empowerment* showed an intense and statistically significant positive cohesion with the variable of *support*. In addition, a moderate and positive co-dependence was defined between the variables of *social empowerment* and *support*, as well as between the variables of *contribution to the community* and *support*. Finally, a weak and statistically relevant positive co-dependence was established for the variables of *tourism effects* and *support*. The obtained bivariate correlations, with positive signs, suggest that participants who manifest a higher degree of perceived personal economic benefit, political empowerment, psychological empowerment, social empowerment, and effects of tourism also have greater support for tourism development.

The obtained Pearson correlation coefficients show an intense statistically significant positive interaction between the constructs of tourism development support and sustainable tourism development. This suggests that participants who manifest a higher perception of tourism development support have a more positive attitude towards sustainable development.

Table 3. shows correlation analysis of the construct of support and sustainable tourism development.

Table 3. Correlation of the variables of support and sustainable tourism development

Variables	Support for sustainable development	Sustainable development
Support for tourism development	–	
Sustainable development	.69	–

Annotation: Statistical significance at the level ** $p \leq .01$;

Before applying hierarchical regression analysis, it was checked whether the conditions for its implementation were met. First, the variance inflation factors (VIF) and tolerance indices (TOL) were calculated, and it was found that they were within acceptable values: tolerance values were greater than 0.1, and variance increment factor (VIF) values were less than 10. Therefore, it was concluded that the analyzed predictors do not indicate a problem of interpretation of multicollinearity among variables, and the prerequisites for applying hierarchical regression analysis were met (Tabachnick, Fidell, 2019).

3.3. Prediction of support for tourism development

In order to examine the contribution of predictors of personal economic gain, political empowerment, psychological empowerment, social empowerment, contribution to the community, and tourism impacts in explaining the variance of the criterion variable of tourism development support, multiple linear regression analysis was applied (Table 4).

Table 4. Multiple linear regression model for predicting support for tourism development

Prediktori	β	β (SE)
Personal economic gain	.18*	.14
Political empowerment	-.20*	.19
Psychological empowerment	.80**	.16
Social empowerment	-.21*	.17
Contribution to the community	.74**	15
Effects of tourism	-.19*	.18
R .35		
R^2 .57		

Legend. *β* = Standardized regression partial Beta coefficient; *R* = coefficient of multiple correlation, *R²* = coefficient of multiple determination; β *SE* = The standard error of estimate of the regression parameter; ** $p \leq 0.01$, * $p \leq 0.05$.

In the analyzed regression model, it is observed that the set of predictor variables (*psychological empowerment* (β =.80, p ≥ 05) and *contribution to the community* (β = .74, p ≥ . 05) statistically significantly predict the criterion of support for tourism development. On the other hand, the predictors of *personal economic gain* (β =.20, p = 35), *political empowerment* (β =-.20, p = .45), *social empowerment* (β =-.21, p = .54) and effects of tourism (β =. -19, p = 27) do not have a significant impact on support for tourism development. The analyzed multiple regression explains 57% of the variance in support for tourism development. The applied regression diagnostics, with small values of the measure of variability of the standard error of estimate, indicates the representativeness of the regression model, and that the predictor variables *psychological empowerment* and *contribution to the community* are not the result of chance, since they stochastically significantly contribute to explaining the variability of support for tourism development. In doing so, it should be borne in mind that the multiple regression model, despite a significant level of probability, did not explain 43% of the residual variability in support for tourism development. Therefore, it is recommended for future research with a longitudinal design to examine some other predictor variables in the Serbian population as potential determinants of variability in the construct of support for tourism development.

The obtained descriptive and correlation-regression results in this research are consistent with the findings in empirical studies (Birkić et al., 2019; Khalid et al., 2019; Moghavvemi et al., 2017; Ranasinghe, Pradeepamali, 2019).

Finally, in this regression transversal design, at a statistical error risk level of 5% or 1%, the obtained beta weights, with the associated standard errors of estimate, show that the applied measuring instruments are adequate for use on the Serbian population, thus confirming the tested *alternative hypotheses*: the expectation that the predictor psychological empowerment positively and statistically significantly contributes to the support of the local population for the sustainable development of tourism (H_1) and the assumption that the predictor contribution to the community positively and statistically significantly affects the support of the local population for the sustainable development of tourism (H_2).

The conducted empirical cross-sectional research has certain *methodological limitations*. The first limitation is the pertinent sample and the relatively short time of surveying participants, so in future research with a longitudinal design, a longer period of time is necessary to collect participants' responses. Considering the regression findings of the conducted research and their negative attitude towards the factor of political empowerment and the effects of tourism in supporting sustainable tourism development, future research should examine the generators of poor ratings for the aforementioned predictors, i.e. define the causes for negative attitudes towards individual items. Based on the empirical study conducted, and in order to identify the generators of the correlation between empowerment and support, it is recommended that greater attention be paid to negatively rated predictors. Given that the psychological and social contributions of tourism are in direct interaction, it is important to more fully examine why one construct has a positive and the other a negative correlation value. More precisely, it is necessary to examine the cohesion between individual empowerment and community empowerment in predicting the development of sustainable tourism. When researching predictors, the desire of participants to participate in decision-making related to tourism should be examined, to define their readiness to actively participate if given such a chance. It is also proposed to divide the variables of each of the aforementioned constructs into positive and negative in order to define what has the maximum impact on dissatisfaction, i.e. improving local community relations and promoting the development of sustainable tourism.

4. CONCLUSION

The function of the local population is a complex topic, since there are differentiated factors that contribute to the attitudes and behavior of individuals in predicting sustainable tourism development. Tourism involves positive and negative influences that contribute to the formation of the population's attitudes towards tourism and tourists, where often, if attention is not paid to community and professional management, conflicts and negative implications manifest. At that time, a sustainable way of developing tourism attempts to establish a balance, i.e. draws attention to the satisfaction of the participants with nature and society. The selection of empowerment factors attempts to identify the essence of the examined issue in order to determine which predictors of empowerment and to what extent they contribute to the support of the development of sustainable tourism among the local population. The conducted study emphasized the relevance of the support of the local population that has been established in previous research. It was concluded that without the support of the local population, there is no sustainable tourism. The analyzed constructs of empowerment in this research are partly significant in influencing the support of the local population.

The obtained regression equation, with the minimum standard error of estimate, established that the independent variables (psychological empowerment and contribution to the community) have a statistically significant and positive correlation with support for tourism development, while the other predictors (personal economic gain, political empowerment, social empowerment and effects of tourism) have some intensity of interaction with support, but are not statistically relevant. The considered predictors show that the local population believes that it is not the most relevant participant in tourism. Therefore, in order to play a more important role, specific regulations should be included, e.g. spatial burden, accessibility for the local population and living conditions. The local population is a dominant segment of tourism development, with its relevance manifested in the following components: forming an atmosphere, community culture, customs, lifestyle, cultural and historical tradition, and creating a community pleasant to live in, building a tourist offer for tourists, etc. In the implementation of quality and sustainable tourism, it is necessary to achieve interactive cooperation between the local population and tourists, where attention is paid to legal regulations and environmental protection. Finally, local people have the maximum potential to stop tourism activities in their community if they do not see prosperity. Their support is crucial to make tourists feel comfortable in providing a quality and original experience in their place.

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DEVELOPMENT OF ORGANIC PRODUCTION IN THE EU: IMPLEMENTATION OF THE PLAN UNTIL 2027.

РАЗВОЈ НА ОРГАНСКОТО ПРОИЗВОДСТВО ВО ЕУ: СПРОВЕДУВАЊЕ НА ПЛАНОТ ДО 2027 ГОДИНА.

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Abstract: *Modern food production technology is a major problem today due to the numerous negative economic, social and, above all, environmental consequences it causes, which call into question the very survival of human society. Therefore, the turn of an increasing number of producers towards organic production is understandable, as is the need for people to consciously change their diet towards these products. Organic production fully supports the concept of sustainable development. It is the only method of production that combines traditional and modern, relying primarily on natural materials that come from the farm, while also contributing to the ecological balance of natural systems. In May 2020, the European Commission published its 'farm to fork' strategy – 'for a fair, healthy and environmentally friendly food system' – along with the EU biodiversity strategy, as part of the implementation of the European Green Deal. In those strategies the Commission set a target of 25 % of the EU's agricultural land to be under organic farming by 2030, as well as a significant increase in organic aquaculture. These targets aim to contribute to improving the sustainability of the food system, to reverse biodiversity loss and to reduce the use of chemical substances in the form of pesticides and fertilizers.*

Key words: *Organic production, strategy, sustainable development, environmental awareness*

Апстракт: *Современата технологија за производство на храна претставува голем проблем денес поради бројните негативни економски, социјални и, пред сè, еколошки последици што ги предизвикува, кои го доведуваат во прашање самиот опстанок на човечкото општество. Затоа, се подразбира зголемениот број производители што се насочуваат кон органско производство, како и потребата луѓето свесно да ја променат својата исхрана кон овие производи. Органското производство целосно го поддржува концептот на одржлив развој. Тоа е единствениот метод на производство што ги комбинира традиционалното и современото, потпирајќи се првенствено на природни материјали што доаѓаат од фармата, а воедно придонесува и за еколошката рамнотежа на природните системи. Во мај 2020 година, Европската комисија ја објави својата стратегија „од фарма до трпеза“ – „за праведен, здрав и еколошки пријателски систем на храна“ – заедно со стратегијата на ЕУ за биодиверзитет, како дел од спроведувањето на Европскиот зелен договор. Во тие стратегии, Комисијата постави цел до 2030 година 25 % од земјоделското земјиште во ЕУ да биде под органско земјоделство, како и значително зголемување на органската аквакултура. Овие цели имаат за цел да придонесат за подобрување на одржливоста на прехранбениот систем, да го запрат губењето на биодиверзитетот и да ја намалат употребата на хемиски супстанции во форма на пестициди и ѓубрива.*

Ključne reči: *Органско производство, стратегија, одржлив развој, еколошка свест*

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1. INTRODUCTION

In the modern world, the problem of hunger and food scarcity is becoming increasingly urgent, with estimates indicating that one in ten people on the planet suffers from malnutrition. According to United Nations data, more than 815 million people worldwide are battling hunger, and alarming statistics show that nearly 20,000 people die every day from the consequences of food shortage. Most of these individuals live in developing countries, particularly in Africa and some parts of Asia, where children are the most vulnerable. Alarmingly, 3/4 of those who die from hunger are children, and one in four children in developing countries is malnourished.

One of the key challenges in addressing the hunger problem lies in the enormous amounts of food that are wasted each year, totaling 1.3 billion tons or approximately 300 billion dollars. This food loss highlights the need for strengthening international solidarity and changing the approach to food production, trade, and distribution. In this context, the importance of human nutrition and health should be a priority in political decision-making, rather than profit.

Additionally, the industrialization of agriculture and the use of chemicals, such as pesticides, pose serious risks to the environment and human health. Inadequate application of pesticides and antibiotics in livestock farming not only disrupts ecological balance but also threatens food safety. In this regard, it is crucial to promote sustainable agricultural practices that not only increase yields but also preserve environmental health.

Europe and the world have a significant role in addressing the issues of hunger and food scarcity. Strengthening international solidarity through food production, trade, and distribution programs can contribute to reducing the number of people suffering from hunger. Political decisions must prioritize human needs and food security over profit. (Dabbert, 2013)

It is also essential to work on educating farmers about the proper use of pest control measures and animal health, as well as the importance of preserving biodiversity. Investing in research and the development of new, sustainable technologies can help improve agricultural production and reduce waste. Annually, 1.3 billion tons of food are wasted, indicating the need for more efficient distribution systems and reducing losses in the supply chain.

The global community must work together to ensure the availability of healthy food for all. This requires synergy between governments, non-governmental organizations, the private sector, and communities. Only through joint efforts can we create a more sustainable, equitable, and healthier world. This introduction lays the groundwork for further analysis to explore the causes and consequences of these issues, as well as possible solutions that could contribute to sustainable development and the reduction of hunger in the world.

In conclusion, the problem of hunger and food scarcity requires a comprehensive approach that includes policy change, education, and international cooperation. Sustainable agriculture, which relies on natural resources and ecological practices, can significantly contribute to reducing hunger and improving food quality. It is necessary to promote local initiatives that focus on food production without the use of harmful chemicals. Collaboration between countries, international organizations, and the non-governmental sector can help develop strategies that will enable a more equitable distribution of food and reduce waste. This collective action can ensure that resources are used more efficiently, thereby reducing hunger and improving health for people worldwide (Yussefi, Willer, 2003).

2. OVERVIEW OF THE 2021-2027 ACTION PLAN

The Commission for the Development of Organic Production, from a review of the results of the public consultations held in 2020, concludes that by building on the previous Action Plan 2014-

2020 and the entry into force of the new regulatory framework for organic production (Regulation (EU) 2018/848) in 2022, legal certainty for organic production, distribution and consumption is strengthened (European Committee of the Regions, EU).

In particular underscores that:
- organic farming currently accounts for 8.5 % of the EU's total utilised agricultural area (UAA). This represents an increase in the area under organic farming by almost 66 % in the period between 2009 and 2019; (From 8.3 million ha in 2009 to 13.8 million ha in 2019.)
   - organic retail sales have doubled in value over the same period; (From €18 billion in 2010 to more than €41 billion in 2019.)
   - current projections based on existing policies and trends predict growth in the organic sector over the next decade, reaching 15 % to 18 % of agricultural land by 2030;
   - land farmed organically is claimed to have about 30 % more biodiversity than land farmed conventionally.

Another notable observation included in analysis is that organic farming is more costly, as organic farmers use natural processes and avoid the use of synthetic products. It also states that although yields are lower, organic farmers often enjoy better incomes as organic products are usually sold at higher prices that conventional ones. On the consumption side, findings from the Eurobarometer 2020 special reportindicate that 56 % of those surveyed stated that they were aware of the EU organic logo, while 66 % of respondents declared that they were ready to pay up to 10 % more for agricultural products produced with a limited carbon footprint. (Eurobarometer 504) The action plan lists 23 actions structured around three axes as summarised in Table 1.

3. STIMULATING DEMAND AND SECURING CONSUMER TRUST

This axis focuses on enhancing demand for organic products to incentivize farmers to transition to organic production. This will involve utilizing the EU's agricultural promotion policy, which currently allocates 27% of its budget to organic production.

Key actions highlighted include:
   - The role of public canteens in promoting organic food.
   - The potential of green public procurement when organizing public contracts.
   - Initiatives to strengthen the EU school scheme by exploring ways to increase the distribution of organic products.
   - Efforts to prevent food fraud and enhance traceability and transparency, such as developing a database of certificates for all EU operators.
   - Establishing partnerships with businesses interested in promoting organic products as part of their corporate social responsibility.

4. STIMULATING CONVERSION AND REINFORCING THE VALUE CHAIN

While not the only tool, the Common Agricultural Policy (CAP) is a vital instrument for supporting the transition to organic farming. The action plan encourages Member States to fully leverage the instruments available under the new CAP in their national strategic plans to accelerate this transition, including new eco-schemes and rural development funds.

To achieve this goal, the Commission has begun assessing the specific circumstances and needs of each Member State since 2023 and has provided targeted support through technical assistance, best practice exchanges, and the strengthening of farm advisory services to promote knowledge sharing. EU demonstration farm networks will be established to disseminate best practices and enable educational institutions to develop courses on organic farming. Additionally, efforts will be made to improve the availability of market data on organic production.

To promote short organic supply chains, the Commission will encourage Member States to support the development and implementation of "bio-districts." These are designated areas where farmers, the public, tourism operators, and public authorities collaborate for the sustainable management of local resources based on organic principles. Other actions under this axis include measures to promote gender equality and the inclusion of young farmers in organic farming initiatives. The Commission also supports research and innovation on alternative protein sources for organic livestock farming, including the adoption of algae initiatives (Koesling, 2008).

Table 1. Summary of actions by axis in the action plan for the development of organic production

Stimulating demand and ensuring consumer trust	**Stimulating conversion / reinforcing the value chain**	**Improving the contribution of organic farming to sustainability**
Information and communication	Optimal use of new CAP and CFP instruments; national strategic plans for aquaculture	Pilot network of climate positive organic holdings, carbon farming (2022)
Agricultural promotion (EU organic logo)	Sector analysis to increase market transparency	Genetic biodiversity and higher yields: demonstration farm networks, AKIS, EIP-AGRI
Promotion of organic products in public canteens and green public procurement (GPP)	Stepping up of collection of market data and extension to EU market observatories' analysis.	Alternatives to contentious inputs and other plant protection products.
Reinforcement of organic school schemes and study on real price of food	Organisation of the food chain, including protection against unfair trading practices	Enhanced animal welfare in the context of the Animal Welfare Platform
Fight against fraudulent practices at all levels	Better information on group certification	Efficient use of resources: biodegradable plastic
Database of certificates of all EU operators	Small-volume processing and shorttrade circuit: bio-districts	Efficient and sustainable use of water, increased use of renewable energy and clean transport
Action to improve traceability	Fostering of social inclusion in rural areas that promote gender equality and young farmers	
Efforts to engage the private sector: retailers, wholesalers, catering services, etc.	Organic animal nutrition: alternative protein and vitamin sources and organic feed additives	
	Reinforcing organic aquaculture	

Notes to Table 1: CAP: common agricultural policy; CFP: common fisheries policy; AKIS-agriculture knowledge and innovation system; EIP-AGRI: agricultural European innovation partnership.

(https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/farming/documents/organic-rules-faqs_en_1.pdf)

5. ENHANCING THE CONTRIBUTION OF ORGANIC AGRICULTURE TO SUSTAINABILITY

Recognizing the potential of organic agriculture in mitigating climate change, a pilot network of climate-positive organic farms will be established to facilitate the exchange of best practices. To further enhance the contribution of organic agriculture to sustainability, at least 30% of the upcoming calls related to the "Agriculture, Forestry and Rural Areas" intervention area of Cluster 6 of Horizon Europe will focus on topics relevant to the organic sector. (De Oliveira, 2023)

This funding will support the preservation of plant genetic resources, ensure the availability of organic seeds, and develop organic heterogeneous plant reproduction material. It will also stimulate research and innovation to improve organic yields and develop alternatives to contentious inputs in organic farming. Other actions will focus on improving animal welfare in organic production and promoting the efficient and sustainable use of water, along with an increase in renewable energy usage while minimizing nutrient release.

6. ASSESSMENT AND PERSPECTIVES

Several sources provide insights into the relevance, coherence, and consistency of the action plan measures, including the European Commission's consultations, feedback from key stakeholders, and work conducted by the European Committee of the Regions (CoR) and the European Economic and Social Committee (EESC).

In 2021, a summary of 840 consultation responses from organizations, stakeholders, and citizens across 41 EU countries and 14 non-EU countries was published. The consensus revealed a clear need for actions to stimulate organic product production, such as:
https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/farming/documents/organic-rules-faqs_en_1.pdf

- Providing training and advice to facilitate the transition to organic farming (91% of respondents).
- Strengthening local and small-scale processing and short food supply chains (90%).
- Supporting the bargaining power of organic producers.
- Improving information and data on the organic market.
- Ensuring support from the CAP.

There was strong agreement on the necessity of raising awareness about the environmental and climate benefits of organic farming, with high support for the EU school scheme, greater availability of organic products from retailers, and increased public procurement of organic products. Additionally, 91% agreed that information about organic products should be transparent and accessible to consumers. Respondents recognized the need for public authorities to ensure compliance with organic production rules and to conduct more campaigns promoting the EU organic logo. Over half of the respondents (59%) believed national authorities should primarily promote organic production. (https://www.organicseurope.bio/)

IFOAM Organics Europe, the European umbrella organization for organic food and farming, welcomed the action plan shortly after its publication, noting its "push-pull" approach aimed at balancing increased production with demand for organic products. The organization viewed the new action plan as a significant improvement over its predecessor, as it includes more specific actions with timelines.

A subsequent analysis by IFOAM examined the challenges and implications of the targets set by the organic action plan for the CAP and Member States' expenditures. It concluded that total CAP spending on organic farming should increase three to five times, from the current 3% to 9-15% of farm spending. Member States with lower support levels for organic farming may need to consider a 5-10 fold increase in expenditures dedicated to the organic sector to contribute fairly to the overall EU target of 25%. (https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/farming/documents/organic-rules-faqs_en_1.pdf)

Copa Cogeca, representing farmers and agri-cooperatives, expressed general support for the action plan's market-driven strategy but subsequently published a detailed position paper outlining the challenges from farmers' and producers' perspectives. They emphasized that meeting the ambitious targets would require public policy support, investment in research and innovation to enhance organic seed and plant protection, and increased European production of organic protein feed for livestock.

Eurocommerce, representing national retail, wholesale, and international trade sectors, welcomed the action plan, noting that consumer sales of organic production had grown over 120% in the last decade and would continue to do so with appropriate accompanying measures.

The Organic Processing and Trade Association Europe (OPTA) supported the action plan's focus on a demand-driven approach, including financial support for promotion and organic products in public procurement, as well as the emphasis on national organic plans for each Member State. In a paper published in September 2020, OPTA outlined its own list of 20 actions for a successful transition to 25% organic by 2030, emphasizing the need to reduce the price gap between organic and conventional food by internalizing environmental costs into food prices.
(https://www.organicseurope.bio/)

In its response to the Commission's consultation, the European Landowners Organization (ELO) cautioned that a dramatic shift from conventional to organic farming could have unintended consequences. They highlighted that increased competition in organic food production might challenge the existing price premium on organic products, leading to income instability for farms. They also noted that achieving the EU's current food production target of 25% organic farms would necessitate a shift in land use, potentially requiring untouched areas to be converted for farming.

7. CONCLUSION

Organic farming represents an efficient and profitable means to enable water conservation alongside agriculture. The introduction of organic products into the mass food supply is crucial for developing and structuring local organic farming. The CoR has proposed doubling the area of land used for organic farming compared to 2017, aiming for at least 30% of the utilized agricultural area. It is essential for Member States to implement the action plan through their national CAP strategic plans. The CoR has also recommended reducing VAT on organic, local, and seasonal products and encouraging the inclusion of a significant proportion of such products in the mass catering sector.

The Council recognized the significant contributions of organic farming to environmental protection, biodiversity, climate change mitigation, and animal welfare. Acknowledging the varying stages of organic farming development among Member States, each Member State should contribute to the collective effort to achieve the target of 25% of EU agricultural land under organic farming.

While organic farming and production will play a vital role in national strategic plans, the adoption of national organic action plans by Member States should remain a voluntary decision. Organic agriculture is a key component of the European Green Deal, which implements both the "farm to fork" and biodiversity strategies. The European Parliament's resolution on the European Green Deal highlighted the potential for agriculture to help the EU reduce emissions through sustainable practices, including organic farming.

Moving forward, much will depend on how well Member States provide for organic agriculture and production by implementing the action plan through their national CAP strategic plans. Other influencing factors will include the response from the farming community and changes in consumer behavior. This analysis of the action plan highlights the range of policies impacting the future of the organic sector, encompassing sustainability, health, climate, agricultural promotion, public procurement, the EU schools scheme, training and education, research and innovation, taxation, and environmental biodiversity.

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https://www.organicseurope.bio/

DIGITALIZATION AND INNOVATIONS IN AGRICULTURE: CHALLENGES AND OPPORTUNITIES FOR SUSTAINABLE PRODUCTION

DIGITALIZACIJA I INOVACIJE U POLJOPRIVREDI: IZAZOVI I MOGUĆNOSTI ZA ODRŽIVU PROIZVODNJU

Nikola Jovanović, MSc,[96]

Abstract: *The paper shows the development of GSM technologies from the beginning to the 5th generation, with an emphasis on the 4th generation, on which the SMS Scale 4G device is based.*
In the second part of the paper, the author identified and described the problems in modern beekeeping related to climate change and the disappearance of honey plants and trees. The problems of each important bee pasture in our climate (acacia, linden, sunflower and meadow) were analyzed in detail and explained how SMS Scale could help beekeepers in their sustainable production.
The third part refers to the SMS Scale device itself, its origin and development up to the last, fourth generation. Concluding considerations refer to the future development of similar devices.
This work can serve as a basis for further innovation in digital technologies in some of the branches of agricultural production.

Key words: *SMS Scale, GSM, innovations, agriculture, beekeeping.*

Apstrakt: *Rad prikazuje razvoj GSM tehnologija, od nastanka do 5. generacije, sa naglaskom na 4. generaciju na kojoj je zasnovan uređaj SMS Vaga 4G.*
U drugom delu rada je autor identifikovao i opisao probleme u savremenom pčelarstvu koji se odnose na klimatske promene i nestanak medonosnog bilja i drveća. Detaljno su analizirani problemi svake značajne pčelarske paše u našem podneblju (bagrem, lipa, suncokret i livada) i obrazloženo kako bi SMS Vaga mogla pomoći pčelarima u njihovoj održivoj proizvodnji.
Treći deo se odnosi na sam uređaj SMS Vaga, opisan je njen nastanak i razvoj do poslednje, četvrte generacije. Zaključna razmatranja se odnose na budući razvoj sličnih uređaja.
Ovaj rad može poslužiti kao osnov za dalje inoviranje u digitalne tehnologije u nekoj od grana poljoprivredne proizvodnje.

Ključne reči*: SMS Vaga, GSM, inovacije, poljoprivreda, pčelarstvo.*

1. INTRODUCTION

The aim of this paper is to show the working mode of the 4th generation SMS Scale, its advantages compared to earlier versions, as well as its importance in sustainable honey production.

In the first part of the paper, I will briefly describe the development of GSM technologies up to the latest generation, with special emphasis on 4G, which is used in this example.

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The second part of the paper will analyze the problems that beekeepers encounter on bee pastures in Serbia and surrounding countries, determine their causes and propose solutions brought by SMS Scale in the field of digitization and sustainable honey production.

Then I will present the SMS Scale 4th generation, the functions it has and how it differs from earlier versions. Particular attention should be paid to the problems that the scale, as a new and innovative product, solves within the framework of sustainable honey production in years that are not very favorable for beekeepers.

The final considerations refer to the further development of similar devices and their importance (we can say the necessity) in the coming years

2. OVERVIEW OF GSM DEVELOPMENT

In the early eighties of the 20th century, European countries led the way in the development of mobile telephony, but due to different network standards, they were not compatible with each other. In 1982, the EU started their standardization in order to create a single system for the whole of Europe. For this purpose, the group GSM (Group Special Mobile) was founded to manage this project.
It was not until 1987 that the technical specifications for GSM were defined. They define radio frequencies, signal coding, protocols, etc…

The first GSM network in the world started operating in Finland in 1991. Because of its advantages, GSM quickly took precedence over similar technologies, including analog ones. A new SMS (Short Message Service) service for sending short text messages was soon established.

During the nineties, additional frequency bands were introduced in the form of "GSM 900" and "GSM 1800", and the mobile network expanded to Asia, Africa and North America.

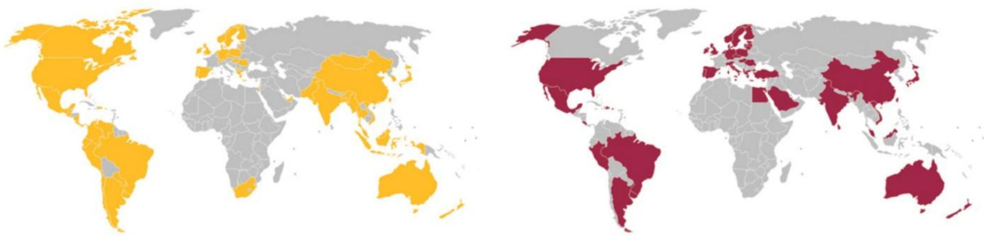

Figure 1: Countries where at least one mobile operator will shut down 2G service by 2025 are colored yellow. Countries where at least one mobile operator will shut down 3G service by 2025 are colored burgundy.

At the beginning of the 2000s, GPRS (General Packet Radio Service) was developed for the Internet via GSM, which was later succeeded by EDGE (Enhanced Data rates for GSM Evolution) with higher data transmission speed, and MMS (Multimedia Messaging Service) appeared for multimedia transmission. New technologies, such as 3G and 4G, enabled greater capacities and faster data transmission about fifteen years ago.

The latest 5G technology is the latest to enter commercial use amid numerous controversies around the world. It brought even higher speeds, lower latency and great possibilities for IoT.

Over time, older technologies go into oblivion, so the 3G network is slowly dying out in the world. GSM 2G is still in use due to its advantages and cheap maintenance in rural and sparsely populated areas.

3. 4G AS THE MOST COMMON TECHNOLOGY IN THE WORLD

4G and LTE (Long Term Evolution) are often used as synonyms, although they are 2 different networks. 4G is the fourth generation of mobile communications that succeeded 3G (Universal Mobile Telecommunication Systems) and the third and a half generation (HSDPA). LTE represented an intermediate step towards the 4th generation, the speed is higher than that of 3G, but still less than the minimum necessary for a 4G network.

The advantages of 4G technology are that it allows users many times higher data transfer speeds (theoretically up to 1 GBPS) and low latency. High speeds serve faster Internet traffic, high-definition video streaming, and other applications that require high data throughput.
At the same time, the latency (waiting time between receiving and sending data) is significantly reduced, which is good for online games and video and audio calls.

4G technology uses different bands: 700 MHz, 800 MHz, 1800 MHz, 2600 MHz... It is more stable than the 3G network and provides greater coverage in places with a high density of users. At the same time, 4G is compatible with 2G and 3G networks, so its users can use mobile services and the Internet from older standards, but at lower speeds.

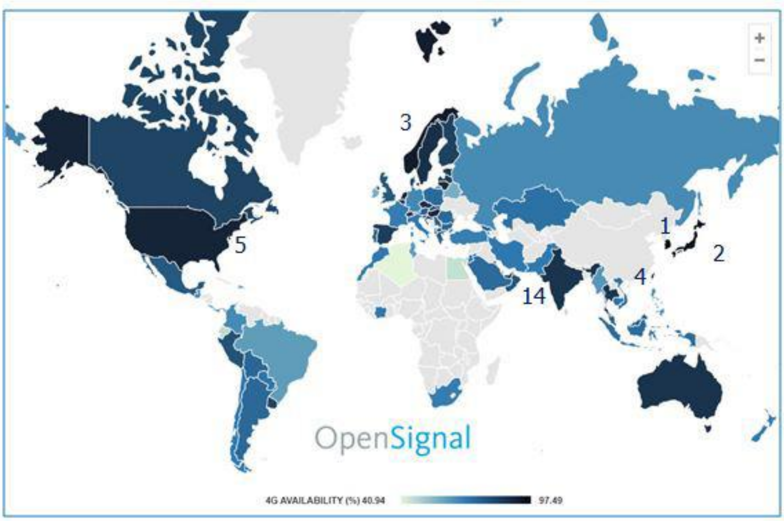

Figure 2: 4G network coverage in the world according to data from the Open Signal Foundation.

Although the accelerated development of the infrastructure for the 5G network began a few years ago, 4G is still the dominant technology in the world with 5.17 billion users in 2024 (according to the data of the stista.com website) and will remain relevant in the future.

4. PROBLEMS WE SOLVE

In the honey collection season, professional beekeepers move their hives to locations where they assume the bee pasture will be better. Specialized vehicles in the form of trailer-platforms, containers, buses and trucks are even used for this purpose.

Some twenty years ago, the need arose to create a device that would send data to the beekeeper from a remote location about the honey yield, weather conditions, etc... so that he could move his hives in time in case of an unsatisfactory yield. Such a device is called simply - sms scale.

In the last decade, beekeeping has been facing big problems when it comes to bee pasture. Rapid global climate change is dramatically affecting honey yields. In addition, there are some problems of a purely local character. I will mention only some examples of the negative impact on bee pastures and honey plants in Serbia and neighboring countries.

- **Acacia pasture** - the most important source of honey in Serbia and some neighboring countries. In terms of quality, among the best in Europe, Serbian acacia honey is exported, where it is mixed with other honeys in foreign markets to increase their quality. Pure acacia honey, without admixtures of other plants, has little chance of containing allergens that would negatively affect the consumer. Climate change has the greatest negative impact on the yield of acacia pasture. Mild and dry winters do not provide enough moisture for the acacia, which is necessary for it to bloom at its full capacity in the spring. A warm early spring often forces acacias to bloom before day and night temperatures stabilize, so it is common for frost to damage newly opened flowers. Cold nights at the time of flowering of acacia with temperatures lower than 11 degrees Celsius do not allow the developed flowers to honey in sufficient quantity. It is not a rare case that after the initial heat during the flowering of acacia, a cold wave occurs which, carrying rain and wind, simply does not allow the bees to collect acacia nectar. Beekeepers there resort to moving to the 2nd and 3rd acacias, which bloom later at higher altitudes.

- **Linden pasture** - most abundant in Mačva and on Furška gora. The linden pasture begins immediately after the acacias bloom and the bee colonies are still in full force. The weather conditions are more stable compared to the acacia flowering period, the days and nights are warmer, which creates ideal conditions for moving to the linden. The problem that beekeepers encounter, especially on Fruška gora, is the excessive felling of linden forests in recent years. It can easily happen that the place where they moved in earlier years is completely changed. Cutting down the forest leads to changes in the microclimate in a certain location, so the data sent by the sensors from the scale are valuable to the beekeeper. Moving to a location just a few kilometers away, with a different microclimate, can bring multiple profits to the beekeeper. Beekeepers in Croatia have a similar problem with the felling of chestnut forests.

- **Sunflower** - along with oilseed rape, one of the two largest pastures on industrial crops. Beekeepers who move to sunflowers leave their hives for a month at the location, so it is not important for them to move them further (as is the case with the 1st and 2nd acacia), but it is important for them that the bees are safe. The types of sunflowers that are sown have changed over time, and from the earlier varieties that flowered profusely, we now have hybrids that do not flower as much as they used to. In addition, with the increased use of spraying agents, the deaths of bees on sunflowers are becoming more frequent and extensive. Losses of up to 100% of bee colonies on sunflower pastures have been recorded. The functions offered by our SMS Scale allow the beekeeper to see the drop in weight in the hive and timely inform the owner about death or destruction (which can occur as a result of spraying plant crops). With the low purchase price of sunflower honey and the high possibility of bee suffering, more and more beekeepers are giving up on this pasture, and only new technological innovations, such as the sms scale, can provide them with some kind of security.

- **Meadow pasture** - can be organized anywhere, near the beekeeper's home, at the location where the acacia pasture has passed, there is no need for mandatory relocation, and the bees will fill the hives with meadow honey. However, professional beekeepers will move their bees to locations

that are known for meadow grazing, such as Pešterska plateau, Vlasin lake and the like. However, this type of beekeeping also faces problems, and one of the main ones is demographic. Namely, the best meadow pastures are on the higher grounds, which are known for cattle breeding. Open-range livestock allows the meadow to regenerate when large and small livestock graze the meadow plants. The livestock crisis in Serbia affects beekeeping because there are fewer livestock to graze, and households in the villages that raise livestock are slowly shutting down. The demographic structure is such that the older population mostly lives in those villages, while the young go to the cities, so the katuns stop and go out. In a meadow where cattle do not graze, bushes start to grow after a few years, the meadow transforms into a thicket where meadow honey plants do not grow. If there is a drought during the meadow bee grazing period (another negative impact of climate change on beekeeping), it will have a negative impact on the wintering of bees. In dry years, there is not enough pollen and the drought favors the development of Varroa, a bee parasite. Societies that winter with little pollen and a lot of Varroa die or, if they survive, are very weak in the spring and unable to produce more honey.
In conditions of increasing reduction of bee pasture, various functions of sms scales can contribute to sustainable beekeeping. Using the sms scale:

- in case of unsatisfactory grazing, the beekeeper can change the location of the hives to one where the yield of honey will be better.
- the scale saves money and time that the beekeeper would spend on visiting the apiary.
- with the help of alarm sensors (microswitches, magnetic sensors and motion detectors) the beekeeper can protect his hives, vehicle or apiary from theft.
- monitor food consumption during the winter so that the bees do not starve to death.

5. DEVELOPMENT OF SMS SCALE

The first SMS Scales were created twenty years ago due to the need of beekeepers to get information about honey intake from the field. Over time, various sensors were added to measure atmospheric conditions and protect against theft. For the most part, further development stopped there. We found such a situation when we appeared on the market in 2012.

The first generation of our scale was sold in only about 30 copies with the following functions:

- operating mode
- mode of operation
- adding basic parameters to SMS messages
- measurement of honey yield
- notification via SMS message about battery discharge
- protection of beehives from theft
- GSM location service
- e-mail

Even then, our device brought some innovations compared to similar devices on the market. In the following year, we are developing the 2nd generation to which new functions have been added:

- multilingualism
- adding users by SMS
- notifications
- adding new sequels (for which we were awarded the 3rd prize for innovation at the 6th state beekeeping fair)
- net notice
- protection of SMS Scale against theft
- credit check SMS Scale through SMS messages

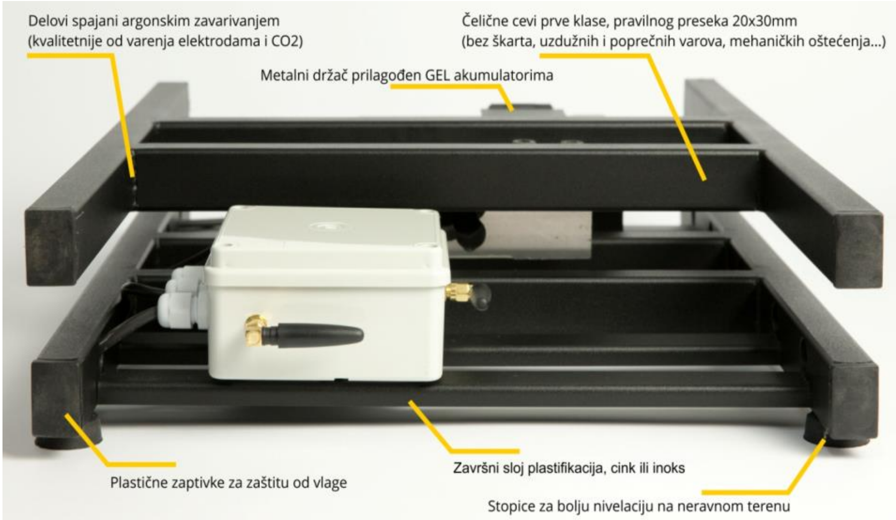

Figure 3. SMS Scale Hardware

At the same time, we are entering the process of SMS Scale branding, certification and registering the scale as a small patent with the Intellectual Property Office of the Republic of Serbia under order number 1456 U1.

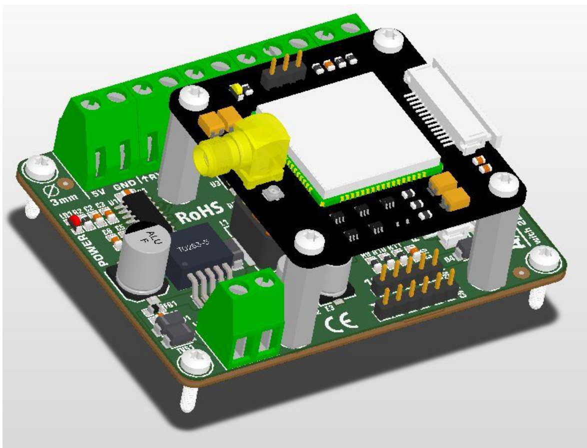

Figure 4. Electronics of SMS Scales of the 2nd generation, registered in the Institute for Intellectual Property of the Republic of Serbia

At the beginning of 2016, the 3rd generation SMS Scale went on sale with completely redesigned electronics, which allowed us to add new functions and constantly improve it. The current third generation version performs over 30 functions available to beekeepers.

Current functions performed by SMS Scale:
1. **WORKING MODE** - the device is either always available or in "sleep" mode
2. **BLUETOOTH** - reading and adjusting the scale for free via Bluetooth
3. **CONF** – reading the configuration of the scale via Bluetooth
4. **LEVER** - provides information on the strength of the swarm and the number of working bees

5. **MULTILINGUALITY** - issuing commands in multiple languages
6. **SCALE** – assigning a name and location to the scale
7. **ADDING USERS by SMS**
8. **ADDING USERS by CALL**
9. **USERS** - listing of all users
10**. CREDIT CHECK** - using the operator's USSD code to check the balance of the account
11. **QUICK CREDIT CHECK** - check account balance without USSD code
12. **NOTIFICATIONS** – the scale responds to the beekeeper's configuration messages
13. **TARE** - taring by SMS message
14. **MEASUREMENT** – by SMS message or free of charge by invitation
15. **MEASUREMENT TIME** - setting the time when the scale measures
16. **TDI** - definition of the start time of the daily measurement
17. **ADDING EXTENSIONS** - automatic transfer of useless cargo to TARA
18. **NET NOTIFICATION** – notification of the reached target weight of honey
19. **PROTECTION AGAINST OVERLOAD** - notification when the total weight approaches the carrying capacity of the measuring part
20. **BATTERY STATUS** – notification about the current state of the battery
21. **SYSTEM TEMPERATURE** – information about the temperature in the electronics box
22. **SUDDEN WEIGHT LOSS** - notification in case of sudden weight loss
23. **GSM position** – gives the relative accuracy of the balance position
24. **GPS position** - gives significant accuracy of the position of the scale
25. **RESET** – turning the scale off and on again
26. **E-MAIL** - sending reports to e-mail
27. **SMS-E-MAIL** - sending reports by SMS and e-mail
28. **FTP** - sending reports to FTP only
29. **PROTECTION AGAINST THEFT** - securing the apiary with various sensors
30. **PROTECTION AGAINST SCALE THEFT** - locating the scale if the device is stolen
31. **ATMOSPHERIC CONDITIONS -** by connecting different types of sensors, information is obtained about the outside temperature, air humidity, temperature inside the hive

For SMS Scale of the third generation, we were awarded at the Archimede fair in Moscow and the agricultural fair in Novi Sad with 5 large gold medals and a cup for the quality of beekeeping equipment and accessories.

6. SMS SCALE 4TH GENERATION

From the beginning of 2024, a prototype of the electronics for the SMS Scale of the fourth generation was made. All previous SMS Scales had 2G modules, while the new scale will be based on a 4G module. 4G module with LTE and NB-IoT standard guarantee long-term stability and sustainability of such a device. The electronics retained the bluetooth module for connection with a mobile phone, and the GPS module became an integral part of the electronics instead of optional, as was the case with earlier generations. The sensor in the basic variant comes with an integrated temperature sensor.

The new electronics also consume less energy, so one of the options is to no longer be powered by a battery but by a battery, which would further enable the creation of a lower construction for the scale.

Regarding the software functions, the gradual implementation of all existing ones from earlier generations is planned. Each function is carefully tested after implementation.

Figure 5: Graphic representation of the components of the circuit board

The new electronics also make it possible to attach up to 5 "platforms" to one central scale, which would measure other hives and send the results to the central unit. It also enables bluetooth protection of beehives, where small and cheap modules would secure other beehives in the apiary. The additional memory is used to update the firmware in the future through the Web server, without the need for the beekeeper to personally bring the scale to be reprogrammed.

7. APPLICATION SOFTWARE AT THE SERVICE OF BETTER HONEY YIELD

Already during the work on the third generation of SMS Scales, we came to the conclusion that just sending data by SMS is not enough. We started work on a portal that would collect that data and classify it. The portal started operating in 2020 and is available free of charge for all our users. After logging in, users have an overview of the data from their scales.
The portal collects readings from the SMS Scale and displays them to the user in the form of graphics with data on NET intake, daily yield, outside temperature and air humidity, temperature inside the hive...
Results are stored for years so that the user can compare and analyze readings over a period of time from a location.

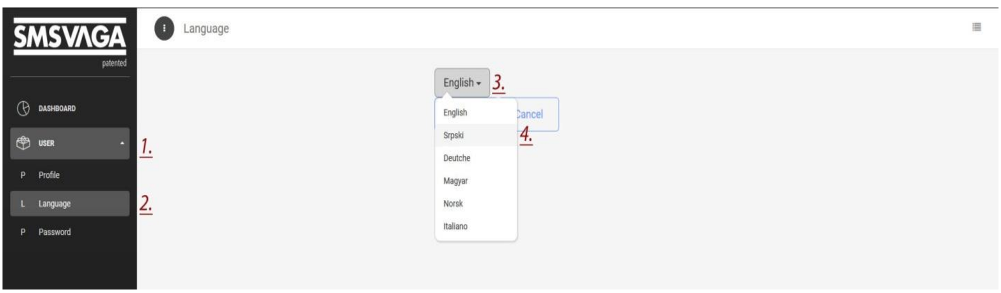

Figure 6: Login to the portal and basic settings

The need to develop a mobile phone application has existed for a long time, we even programmed an application for the second generation SMS Scale and then for the third generation scale. These applications were in use for a short time, and now an application has been created that will be common to the 3rd and 4th generation scales. The application should be available on IOS and Android.

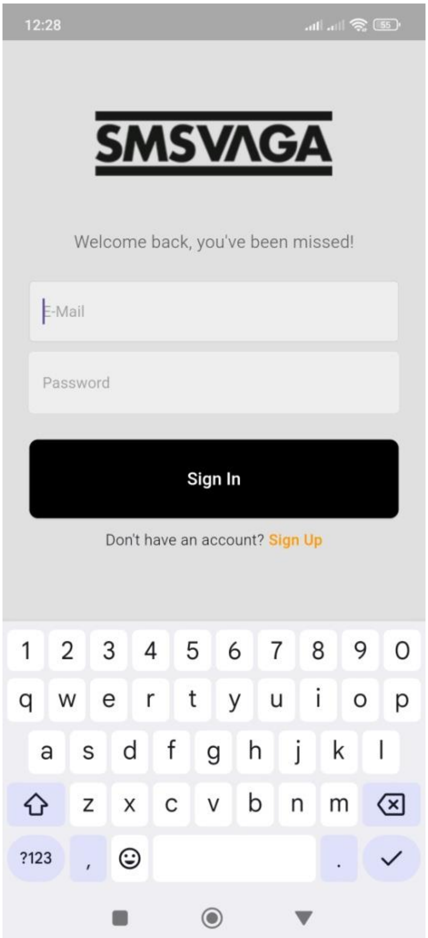

Figure 7: Home screen of the Android application

The application is tasked with receiving measurements from the SMS Scale. These measurements are programmed to take place every hour, resulting in 24 measurements per day instead of the previous two in the 2nd mode of operation. These measurements can also be sent to the portal by e-mail. It is planned that, as with the portal, measurements going back years will be stored in the Cloud, which would allow the beekeeper to have insight into the bee pasture for a longer period of time. All SMS Scales that were purchased after 2017 have the option to use the app with a firmware update.

8. FINAL CONSIDERATIONS

In the difficult conditions of climate change, the disappearance of honey plants and the reduction of areas with bee pasture, only innovations offer a hand of salvation for beekeeping as we know it. Beehives are changing, from wooden to plastic and styrofoam, plastic underlays are increasingly becoming the standard, medicines and preparations for bees are taking on new forms, so it is time to widely accept this sophisticated technology that would help the beekeeper achieve the best possible honey yield.

In terms of hardware, the new scale could become lower compared to the previous generation, which would allow it to fit more easily into beekeeping containers.

The circuit board has been carefully designed to meet our current requirements and leave room for further expansion and modification.

As for the software, we expect the greatest progress there. Apart from possible new functions, the method of data processing through the portal and application gives us the possibility to connect to artificial intelligence (AI) to obtain a hardware-software solution that would have the function of an advisor. Artificial intelligence would collect data, analyze it, and with additional sensors, have insight into what is currently happening in the apiary or in the brood. Then she would inform the beekeeper and even independently propose some solutions. AI is becoming a daily part of our lives and why not incorporate it into beekeeping to help both the bees and the beekeeper for mutual satisfaction..

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CULTURAL HERITAGE AND RURAL AREAS AS A BASIS FOR DEVELOPMENT OF TOURIST DESTINATIONS IN SERBIA AND ALBANIA

КУЛТУРНО НАСЛЕЂЕ И РУРАЛНА ПОДРУЧЈА КАО ОСНОВА ЗА РАЗВОЈ ТУРИСТИЧКИХ ДЕСТИНАЦИЈА У СРБИЈИ И АЛБАНИЈИ

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Abstract: *Development of rural tourism in the Western Europe started in the second half of the last century. In Southern Europe, changes in trends were accepted somewhat later and at the end of the last milenium we can say that this type of tourism is gaining increasing importance. Special forms of cultural tourism are gaining their place withing tourist destination, which enables the deveolpment of local communities through a sustainable approach. New types of tourist appear. They want to experience non-commercialized destinations, customs and culture of the local population. They are willing to pay more to experince something diffrent and unusual. Practical examples show us that the owners of ethno villages are small entrepreneurs, mostly family business. This study show us how rural areas in Serbia and Albania, in synergy with cultural heritage have the potential to attract certain types of tourists and gain economic benefits, while simultanesusly promoting tradition and culture on the global market.*

Key words: *cultural heritage, roural tourism, inovations*

Apstrakt: *Рурални туризам је у другој половини прошлог века почео да се развија на територији западне Европе. На територији југоисточне Европе промене у трендовима се прихватају донекле са закашњењем, па тек крајем прошлог миленијума можемо рећи да овај вид туризма добија све више на значају. Посебни облици културног туризма добијају своје место у оквиру туристичких дестинација што омогућава развој локалних заједница кроз одрживи приступ. Долази до појаве нових типова туриста који желе да упознају некомерцијализоване дестинације, обичаје и културу локалног становништва. Вољни су да плате више како би доживели нешто другачије и необично. Примери из праксе нам показују да су власници етно села мали предузетници, углавном породичне фирме. У раду је приказано на који начин рурална подручја у Србији и Албанији, у синергији са културним наслеђем имају потенцијал да привуку одређене типове туриста и на тај начин стекну економску корист, истовремено промовишући традицију и културу на глобалном тржишту..*

Ključne reči: *културно наслеђе, рурални туризам, иновације*

1. INTRODUCTION

Due to technological, economic, and natural changes in the world, there is also a change in demand in tourism movements. This leads to the creation of new types of tourists who have a developed awareness for the preservation of cultural heritage and the natural environment. Although large hotel chains and urban areas are one of the most important segments in the tourist offer, there is also space for the local population to start providing tourist services and gain

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economic benefits. When developing rural tourist destinations, care must be taken to preserve the local environment and nature. It is also necessary to write strategies that would define the development of such a destination, otherwise the local population could lose more than gain. Development goals must be clearly defined in order to create an adequate tourist offer for a certain number of tourists who are aware of sustainable tourism development.

2. Cultural Heritage – Definition

Cultural heritage occupies an important place in the tourism development. Cultural heritage refers to tangible and intangible assets that have a special value for the local population.
Tangible cultural heritage is divided into movable (library, archival material, etc.) and immovable cultural property (buildings, cultural monuments, churches, monasteries, archaeological sites).
Intangible cultural heritage includes traditional crafts, customs, traditions, beliefs, rituals and holidays. It is transmitted orally and has the role of preserving the history, traditions and culture of a nation.

UNESCO identifies five areas in which intangible cultural heritage is manifested. (https://en.wikipedia.or-en-el/Nematerijalno_kulturno_nasledje):
1. Oral tradition and language
2. Performing arts
3. Social practices, rituals and holidays (customs, beliefs, myths)
4. Knowledge and knowledge related to nature and the universe (practical knowledge about nature, medicinal plants, folk medicine
5.Traditional arts (crafts etc.)

Tangible and intangible heritage are often intertwined, although there are also examples where they are presented independently in a certain territory. Destinations that have tangible and intangible cultural heritage have an excellent basis for the development of cultural heritage tourism and art tourism.
Cultural heritage tourism is a branch focused on exploring and appreciating the cultural, historical and ecological heritage of a region. This form of tourism includes both material elements, such as historically significant sites, monuments and artifacts, as well as intangible aspects such as traditions and customs (http://en.wikipedia.org/wiki/Heritage_tourism).

2.1. Cultural heritage in Serbia

The cultural heritage in Serbia is very rich and is characterized by a large number of landmarks, some of which are on the UNESCO World Heritage List:
1. Intangible cultural heritage (https://rezonmagazin.rs/srpsko-kulturno-nasledje-unesco-lista) :
- Krsna slava (2014)
- Traditional folk dance "Kolo" (2017)
- Singing with the gusle (2018)
- Zlakusko pottery (2020)
- Social practices and knowledge related to the preparation and use of traditional Serbian plum brandy (2024)

Other elements of intagible cultural heritage that have been proposed for inclusion of the UNESCO list are: „Prayer“ (a pracise performed once a year in the village of Vrtovac, on Stara Planina Mountain on St George’s Day), „Pirot carpet making“ (the art of making carpets on a vertical loom, using the kneeling technique), „Bagpipe playing“ (refers to the solo practice of playing two and three bagpipses; fols songs are played), „Knowledge and skills of making kajmak“ (sr.wikipedia.org-sr-el/Nematerijalno_kulturno_nasledje_Srbije).

2. Tangible Cultural Heritage
- Visoki Dečani Monastery (2004), built in the mid-14th century, an endowment of the Serbian king Stefan Dečani
- Peć Patriarchate, Gračanica Monastery and the Church of the Virgin Mary of Ljeviška (2006)
- Medieval tombstones Stećci (2006) which was inscribed together with Bosnia and Herzegovina, Montenegro and Croatia (https://mfa.gov.rs/lat/spoljna-politika/srbija-u-medjunarodnim-organizacijama/unesko/srbija-u-unesko).

A large number of festivals are organized in Serbia, of which the most notable is the trumpet festival "Guča", which was founded in 1961 and which today attracts 200,000 visitors annually. Last year, the event "In Honor of Knitters - Sirogojno" was held at the open-air museum "Staro selo" in Sirogojno, as a combination of tangible and intangible cultural heritage.

2.2. Cultural heritage in Albania

Albania is characterized by a rich history. The territory of present-day Albania has been inhabited since ancient times, and was part of the Roman, later Byzantine Empire. Since 1990, Albania has been oriented towards the West and only in the new millennium has the country gradually developed. In the last twenty years started tourism development.
There are over 2,000 cultural sites in Albania. As of 2021, four sites are on the UNESCO list:

- Butrint – on the UNESCO list since 1992. It was an ancient Greek city and then Roman and the seat of a late Roman bishopric. After a period of abandonment, it was occupied by the Byzantines and Venetians and was abandoned in the Middle Ages. Archaeological sites include a Greek theater, a late antique baptistery, a 9th-century basilica and fortifications from the period of the Greek colony to the Middle Ages.
- Berat and Gjirokastra – on the UNESCO list since 2005
- Primeval forests of the Carpathians and other regions of Europe – on the UNESCO list since 2017
- National and cultural heritage of the Ohrid region

Cultural heritage is also promoted through various festivals during which visitors have the opportunity to learn and get acquainted with the traditions of a people. We will mention only few:

- "Gjirokaster National Folk Festival" is held every five years. In 2025 visitors will have the opportunity to enjoy performances by folklore groups, local cuisine, and old crafts.
- "Rally Albania" is held in June and is one of the largest motorcycle rallies in the country. The races take place through the beautiful and yet challenging nature of Albania, which simultaneously arouses admiration and adrenaline.
- "Summer Day" is a traditional festival celebrating the arrival of spring. It is held in March and people gather to enjoy games, dances, and local specialties.
- "South Outdoor Festival" is held every year in May on the coast. It is promoted as a celebration of all activities that take place outdoors. This festival combines sports, games, concerts, culture, food, entertainment. It offers more than 40 outdoor activities for all ages.
- Music festivals: "Kala" Music Festival, "Unum" Music Festival.

2.3. Rural tourism

According to the definition of the Council of Europe, "Rural tourism is tourism in a rural area with all the activities that are carried out there. The most important characteristics of this type of

tourism are a peaceful environment, the absence of noise, a preserved environment, communication with the hosts, local food and getting to know rural jobs." (Todorović, Štetić, 2009; Geić, 2011). In order to preserve the rural areas in Europe, agriculture and forestry, development of rural tourism started in Europe, primarily in Italy, Austria and France.
Rural tourism integrates all forms of tourist services and activities that take place in rural areas: agritourism or the provision of accommodation, food, drinks and other services on a rural household, small family hotels, campsites, holiday homes in rural areas, ethno villages and ethno houses, wineries, folklore, gastronomic tourism, religious, active, etc.

The main feature of rural tourism is direct contact with the hosts, i.e. direct experience of the local community, culture and way of life in the countryside, as well as participation in rural households. The authenticity and tradition of the specific environment are also important, as well as a relaxing, unique natural environment (Rural Tourism, Handbook for Service Providers). The benefits of rural tourism are numerous: opportunities for additional income, preservation of traditions, development of villages, promotion of rural areas and local customs. At the same time, care should be taken to ensure that the development of tourism in rural areas does not disrupt the way of life of the local population by bringing their habits, as well as environmental protection, as rural areas are becoming a place of arrival for an increasing number of tourists. Based on a survey conducted by UN Tourism in 2003, the following stand out as the biggest challenges for infrastructure in rural areas: lack of transport infrastructure that enables access to rural areas (roads, airports, ports, etc.), deficit in basic living conditions (drinking water, electricity, sanitation systems, etc.), lack of public transport, lack of hospitals, ATMs, shops, etc.

Rural tourism began to develop in Europe. In the mid-20th century in Austria, the Alpine region could not keep up with the trend of industrial agriculture, which resulted in the closure of agricultural households. In order to prevent further decline of agricultural households in rural areas, the government decided to launch the development of agricultural activities, including rural tourism. Thanks to tax breaks and subsidies provided by the state, they managed to launch a new type of tourism that today occupies a significant place in Europe and in other regions of the world. Today, Austria is the European leader in agri-tourism with about 15,000 registered rural households offering about 17,000 beds.

Like many European countries, Italy began to face depopulation and abandonment of farms in the mid-20th century. In Italy, the Agritourism Law was passed in 1985, which is still in force today. Every year, more than 2 million tourists visit Italian villages and farms. Agritourism farms organize painting workshops, wine tasting schools, painting workshops, Italian language lessons, workshops for children, riding schools and other activities.

Rural tourism has gained importance in the era of corona. Due to the restrictions in the city, a large number of people went to rural areas to rest and escape to nature. All categories of visitors (families with children, retirees, young people, etc.) went to natural environments, mainly in the country where they live because movements were limited. This trend of tourist movements has continued to grow today. The motives of visitors are numerous: spending time in the fresh air and walking in nature, getting to know the local culture and way of life, learning new crafts, making local products (brandy, jam, kajmak), collecting herbs, enjoying local gastronomy, visiting cultural and historical landmarks and educational events.

3. SYNERGY OF CULTURAL HERITAGE AND RURAL TOURISM AS A BASIS FOR THE DEVELOPMENT OF TOURISM IN SERBIA

Serbia has a large number of rural areas that have good foundations for the development of rural tourism. The state provides subsidies for the development of tourism. The Ministry of Youth and

Tourism has announced a competition for 2024 for the allocation of incentive funds for the development and improvement of rural tourism and catering. Both physical and legal persons who are owners of rural households or catering facilities could participate in the competition. The state subsidized projects up to 90% of the total value, while the deadline for project implementation was 12 months. When assessing the project, special attention was paid to the contribution to sustainable development, the preservation of natural resources and the engagement of the local population, as well as the contribution to improving the quality of the rural tourism offer (Ministry of Youth and Tourism, public call for the allocation of incentive funds for the development and improvement of rural tourism and hospitality, 2024).

We can single out the following ethno villages in Serbia as examples of good practice:

1. Ethno village "Zlakusa" - until 2005 it was known for its pottery and brass band, and then it was recognized as a tourist potential. The village is known primarily for its pottery, which has been present for more than three centuries. Within the village there is an ethno park "Terzića avlija" which includes apartments, a camp, a museum, a summer stage, and a catering area. The following events are organized in Zlakusa: Zlakusa in song and dance, Autumn in Zlakusa - Pottery Festival, International Colony of Artistic Ceramics, International Ethno Camp.

2. Ethno village "Sirogojno" - since the 1960s, Sirogojno has become a recognizable tourist village. The most significant role in its development was played by the Agricultural Cooperative founded in 1924, which did not stop working during the Second World War. After liberation, it was engaged in the purchase and sale of livestock and agricultural products, and since the 1960s, in improving agriculture, building roads, organizing handicrafts and building trade and catering facilities (https://www.sirogojno.rs/sirogojno). There is a tavern and inns within the village. The hall is equipped for educational content.

3. The ethno village "Drvengrad" was built for the recording of the film "Life is a Miracle". Emir Kusturica built an ethno village on the Mećavnik hill, which primarily had a cultural and educational character. With the construction of accommodation facilities, "Drvengrad" has become a popular tourist destination, which includes: accommodation units, a log church, a cinema, a national restaurant, a folk craft shop, and a congress center. The Kustendorf film festival has been organized in the ethno village since 2019.

4. Ethno village "Gostuša" - an ethno village characterized by stone architecture, which is why it rightfully bears the second name Stone Village. Unlike other ethno villages, Gostuša is a village that has existed for decades and centuries. Thanks to its authenticity, the village is under cultural protection.

4. SYNERGY OF CULTURAL HERITAGE AND RURAL TOURISM AS A BASIS FOR TOURISM DEVELOPMENT IN ALBANIA

As we have mentioned, Albania is a relatively young tourist destination. Given that it borders the Adriatic and Ionian Seas, a lot is being invested in the development of coastal tourism. Rural areas are populated and the Government has recognized the importance of developing this form of tourism, and development is expected in the coming period.

Based on research, we highlight the following tours that are promoted on www.getyourguide.com and www.viator.com:

Tour 1: One-day trip from Tirana "Gjirokastra and Ardennes". The tour includes:

- Visit the 13th century medieval Ardenika Monastery, which is under the administration of the Serbian

Orthodox Church;

- Visit Gjirokaster, a medieval Ottoman city that is a World Heritage Site;
- Visit the Old Bazaar where you can buy souvenirs, traditional pottery and enjoy the local atmosphere;

Tour 2: Black Cave and Erzen Canyon. The tour includes:

- Visit Erzen Canyon and hiking;
- Visit the Black Cave cave;
- Zip line ride;

Tour 3: Kayaking and hiking on Lake Koman, Valboni and a visit to Tet. The trip lasts four days and includes:

- Visit to Lake Koman, kayaking and overnight stay with a local family who is the only one who opened the doors to tourists;
- Visit to households in the village of Kukaj;
- Hiking along the old roads from Valbona to Tet that the local population has used for years. Visit to the village of Tet where you can get acquainted with the customs and way of life of the local population.

Tour 4: Visit to Butrint, the "Blue Eye" spring and Lekuresi Castle. The tour includes:

- Visit to the Butrint National Park and the ancient city of Butrint, which is on the UNESCO World Heritage List.
- Visit to the Lekuresi Castle built by Sultan Suleiman the Magnificent
- Visit to the natural spring "Blue Eye" characterized by turquoise blue water with bubbles gushing out.

Tour 5: Durres – local wine and food tasting. The tour includes:

- Vineyard visit and wine tour
- Local food and Ehtra Olive Oil tasting
- Albanian national drink and brandy tasting

Tour 6: Cooking class and traditional food tasting in Tirana. The tour includes:

- Local market tour and grocery shopping
- National specialty cooking
- Local wine tasting

5. MODERN TRENDS IN TOURIST MOTIVES

Tourist expectations change over time. At the end of the last century, every family aspired to go on a summer vacation once a year. Today, trends have changed and tourists, in addition to vacationing, want to participate in additional activities. Rural tourism, together with cultural heritage, occupies a special place in tourist motives, which we can divide based on the following interests:

1. Gaining new experiences;
2. Experiencing the life of the local population;
3. Learning new skills;
4. Fitness and sports;
5. Wellness holidays.

6. INNOVATIONS IN TOURISM

Artificial intelligence has begun to be applied in all segments of society, including tourism. The goal is to eliminate the human factor based on information that has been collected and sorted for years in order to obtain the requested information in the shortest possible time. Virtual assistants and chat bots are becoming an integral part of service providers, while artificial intelligence provides personalized service, suggesting hotels, flights, excursions and other services.
By communicating with artificial intelligence, tourists can gain new knowledge and travel ideas and can receive offers in a short time.

Automation of the reservation process is also becoming increasingly present in the tourism industry. Algorithmic and artificial intelligence enable faster and more efficient reservations, reducing the need for manual data entry and processing. Online booking platforms offer accommodation, transportation, and excursion reservation services. This change makes travel planning easier for users and helps service providers better understand and meet the needs of their customers (https://www.e-turizam.com/baza-znanja/10-trendova-u-industriji-turizma-za-2024-godinu/).

7. CONCLUSION

The paper presents examples of synergy between rural and cultural heritage tourism. The combination of these two types of tourism provides visitors with an additional experience that can extend the length of stay, which is the economic goal of every destination and every household. Tourists most often decide to stay in nature during the weekend, staying for one or two nights. There are examples where visitors decide to spend five or more days in rural areas. Therefore, it is important to have additional content to make their stay interesting and meet their expectations. The possibilities for creating tourist products are numerous, and with the help of artificial intelligence, creating an offer provides new opportunities.

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NEGATIVE IMPACT OF THE NON-SANITARY LANDFILL ON AGRICULTURE - A CASE STUDY OF THE LANDFILL DUBOKO, SERBIA

НЕГАТИВНО ВЛИЈАНИЕ НА НЕСАНИТАРНАТА ДЕПОНИЈА ВРЗ ЗЕМЈОДЕЛСТВОТО - СТУДИЈА НА СЛУЧАЈ: ДЕПОНИЈА ДУБОКО, СРБИЈА

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Abstract: *Non-sanitary landfills have a solely negative impact on agriculture. The aim of this paper is to warn the population of the municipality of Sveti Nikole in Macedonia about the potential consequences when a sanitary landfill turns into a non-sanitary one due to inadequate and illegal management. This warning is particularly relevant due to the planned construction of the first regional sanitary landfill in Macedonia, located within the municipality of Sveti Nikole. The case study presented in this paper examines the former regional sanitary landfill Duboko, which was eventually transformed into a non-sanitary landfill. The authors aim to provide a comprehensive overview of the negative impact of the Duboko landfill on agriculture in rural areas surrounding the city of Užice in Serbia.*

Key words: *impact, nonsanitary, landfill, agriculture, Macedonia*

Апстракт: *Несанитарните депонии имаат исклучиво негативно влијание врз земјоделството. Целта на овој труд е да ја предупреди популацијата во општина Свети Николе, Македонија, за потенцијалните последици кога санитарна депонија се претвора во несанитарна поради несоодветно и незаконско управување. Ова предупредување е особено важно поради планираната изградба на првата регионална санитарна депонија во Македонија, која ќе биде лоцирана на територијата на општина Свети Николе. Студијата на случај претставена во овој труд го анализира поранешниот регионален санитарен отпад Дубоко, кој со текот на времето се трансформирал во несанитарна депонија. Авторите имаат за цел да дадат сеопфатен преглед на негативното влијание на депонијата Дубоко врз земјоделството во руралните подрачја околу градот Ужице, Србија.*

Клучни зборови: *влијание, несанитарна, депонија, земјоделство, Македонија*

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DIGITALIZATION AND INNOVATIONS IN AGRICULTURE: CHALLENGES AND OPPORTUNITIES FOR SUSTAINABLE PRODUCTION

ДИГИТАЛИЗАЦИЈА И ИНОВАЦИИ ВО ЗЕМЈОДЕЛСТВОТО: ПРЕДИЗВИЦИ И МОЖНОСТИ ЗА ОДРЖЛИВО ПРОИЗВОДСТВО

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Tatjana Blazevska, Associate Professor[102]
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Abstract: *This paper presents modern solutions for applying digitalization and technological innovations to transform agricultural production, highlighting their role in achieving sustainability. The aim is to analyze advanced technologies such as precision agriculture, IoT-based monitoring systems, and AI-driven predictive analytics, which contribute to increased productivity and efficient resource management. The methodology includes a review of digital tools, case studies, and their practical applications in sustainable agriculture. Additionally, it covers the development of use case diagrams, conceptual models, and simulations for detecting atmospheric and soil parameters using drones. The analysis focuses on key system components, including sensor stations and the operations center, emphasizing their functionalities and interconnections. The system processes real-time data and provides decision support to improve measures for timely crop irrigation. The proposed software architecture is scalable and adaptable for future upgrades. The results demonstrate significant benefits such as real-time and accurate monitoring, systematic data collection, reduced resource consumption, improved crop management, and increased yield. The proposed strategies aim to support farmers in adopting digital technologies, contributing to the sustainable development of the agricultural sector.*

Key words: *digitalization, agricultural innovations, IoT, drones*

Апстракт: *Овој труд нуди современи решенија за примена на дигитализацијата и технолошките иновации во трансформацијата на земјоделското производство, нагласувајќи ја нивната улога во постигнувањето одржливост. Целта е да се анализираат современи технологии како што се прецизното земјоделство, IoT-системите за мониторинг и предиктивната аналитика базирана на вештачка интелигенција, кои придонесуваат кон зголемена продуктивност и ефикасно управување со ресурсите. Методологијата опфаќа преглед на дигитални алатки, студии на случај и нивна практична примена во одржливо земјоделство. Дополнително, се опишуваат изработката на use case дијаграми, концептуални модели и симулации за детекција на атмосферски и почвени параметри со помош на дронови. Анализата ги опфаќа главните компоненти на системот, како што се сензорските станици и оперативниот центар, при што се истакнува нивната*

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функционалност и меѓусебна поврзаност. Системот користи обработка на податоци во реално време и обезбедува поддршка за одлучување, со цел да се подобрат мерките за навремено наводнување на земјоделските површини. Предложената софтверска архитектура е прилагодлива за идни унапредувања. Резултатите покажуваат значителни придобивки, како навремено и прецизно мониторирање, систематско собирање на податоци, намалена потрошувачка на ресурси, подобрено управување со посевите и потенцијално зголемен принос. Предложените стратегии имаат за цел да ги поддржат земјоделците во усвојувањето на дигитални технологии, со што се придонесува кон одржлив развој на земјоделскиот сектор.

Клучни зборови: *дигитализација, земјоделски иновации, IoT, дронови*

STATISTICAL ANALYSIS OF THE PRESENCE OF MINERALS IN HONEY SAMPLES FROM MACEDONIA, KOSOVO AND ALBANIA ENRICHED WITH FIVE PLANT EXTRACTS

СТАТИСТИЧКА АНАЛИЗА ЗА ПРИСУСТВО НА МИНЕРАЛИ ВО ПРИМЕРОЦИ МЕД ОД МАКЕДОНИЈА, КОСОВО И АЛБАНИЈА ЗБОГАТЕНИ СО ПЕТ РАСТИТЕЛНИ ЕКСТРАКТИ

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Demokrat Nuha, Asistent Profesor[106]
Arbrie Bytyci,[106]

Apstrakt: *Honey is a complex food and medicine, as well as a healthy alternative to refined sugar. In addition to the complex mixture of carbohydrates, honey contains other minor substances that can threaten human health in excessive concentrations. The objective of the study was to statistically evaluate the impact of herbal extract on the chemical composition of multifloral honey enriched with extracts of five plant species: Rosemary (Rosmarinus officinalis L.), Lavender (Lavandula officinalis), Oregano (Origanum vulgare), Salvia officinalis L. (Sage) and Scots pine oil (Pinus strobus). Honey was enriched with plant extracts at a level of 0.5%, 0.8% and 1% (w/w). Honey samples were taken from three regions such as Kosovo, North Macedonia and Albania and their chemical composition was evaluated in terms of nutritional minerals such as potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), iron (Fe), manganese (Mn) and zinc (Zn) and toxic metals such as lead (Pb), cadmium (Cd), nickel (Ni), aluminum (Al), copper (Cu) chromium (Cr), cobalt (Co) and arsenic (As) before and after the addition of plant extracts. Honey samples were analyzed using the atomic absorption spectrometry (AAS) method. It was found that the content of toxic metals (Al, Cu, Cr, Co, Ni, As, Cd and Pb) in the honey samples studied was below the toxic limit values specified by the World Health Organization and Codex Alimentarius. The mineral content of honey samples varies according to the regions where they were taken and the increasing concentration of plant extracts. The content of nutritional minerals in honey enriched with plant extracts gives hope for new applications of these health-promoting extracts contained in these plants.*

Key words: *Honey, herbal extracts, nutritional minerals, toxic metals*

Apstrakt: *Медот е сложена храна и лек, како и здрава алтернатива на рафинираниот шеќер. Покрај сложената мешавина на јаглени хидрати, медот содржи и други помали супстанции кои можат да го загрозат здравјето на луѓето во прекумерни концентрации. Целта на студијата беше*

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статистички да се оцени влијанието на билниот екстракт врз хемискиот состав на мултифлоралниот мед збогатен со екстракти од пет растителни видови: рузмарин (Rosmarinus officinalis L.), лаванда (Lavandula officinalis), оригано (Origanum vulgare), жалфија Salvia officinalis L.) и масло од бел бор (Pinus strobus). Медот беше збогатен со растителни екстракти на ниво од 0,5%, 0,8% и 1% (w/w). Беа земени примероци од мед од три региони како што се Косово, Северна Македонија и Албанија и нивниот хемиски состав беше оценет во однос на хранливи минерали како што се калиум (K), калциум (Ca), магнезиум (Mg), натриум (Na), железо (Fe), манган (Mn) и цинк (Zn) и токсични метали како што се олово (KelminicumN) (Al), бакар (Cu) хром (Cr), кобалт (Co) и арсен (As) пред и по додавањето на растителни екстракти. Примероците од мед беа анализирани со методот на атомска апсорпциона спектрометрија (AAS). Утврдено е дека содржината на токсични метали (Al, Cu, Cr, Co, Ni, As, Cd и Pb) во испитуваните примероци на мед е под токсичните гранични вредности специфицирани од Светската здравствена организација и Codex Alimentarius. Минералната содржина на примероците од мед варира во зависност од регионите каде што се земени и зголемената концентрација на растителни екстракти. Содржината на хранливите минерали во медот збогатен со билни екстракти дава надеж за нови примени на овие екстракти кои ги има во овие растенија, а го подобруваат здравјето.

Клучни зборови: *Мед, билни екстракти, хранливи минерали, токсични метали*

APPENDIX

Appendix A: Authors - co-authors in alphabetical order
(Прилог А: Автори - коавтори по азбучен ред)

No. R. Br.	AUTOR - KOAUTOR	No. R. Br.	AUTOR - KOAUTOR
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1.	Aleksandrovna Maxim Ekaterina	**34.**	Kalevska Tatjana
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3.	Andrei Vasile Jean	**36.**	Knežević Biljana
4.	Anatolyevich Denis Yurin	**37.**	Knights Vesna
	B	**38.**	Kočoska Karolina
5.	Bajraktarova Nadica	**39.**	Kojić Jovana
6.	Bajagić Marija	**40.**	Kresović Siniša
7.	Benković Maja	**41.**	Krstić Boro
8.	Blazevska Tatjana	**42.**	Kuzelov Aco
9.	Bytyci Arbrie		**L**
	V	**43.**	Lučanović Paun
10.	Valinger Davor		**M**
11.	Viorel Mihalcea Mihai	**44.**	Matejić Biljana
12.	Vujko Aleksandra	**45.**	Magerovska Milena
	G	**46.**	Marčić Milijašević Svetlana
13.	Gorčev Jordan	**47.**	Mihajlov Ljupčo
14.	Gruevska Nevena	**48.**	Milošević Milica
15.	Gevorgyan Lilya	**49.**	Mikhailovich Lugovoy Mikhail
	D	**50.**	Mladićević Ivana
16.	Dameska Pelivanoska Daniela		**N**
17.	Delinikolova Eleonora	**51.**	Nakov Dimitar
18.	Despotović Aleksandra	**52.**	Nešić Bratimir
19.	Dimov Zoran	**53.**	Nistoroiu Bianca Florentina
20.	Duduk Bojan	**54.**	Nikolić Malenović Jelena
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22.	Evgeny Yakovlev		**P**
	Ž	**57.**	Pandurević Juliana
23.	Živanović Ivan	**58.**	Pashovska Silvana
	Z	**59.**	Papadopol Paula Irene
24.	Zdraveska Nataša	**60.**	Pavllova Valentina
	I	**61.**	Pavlovska Gorica
25.	Ivanović Ivan	**62.**	Petković Todor
26.	Ivanović Miroljub	**63.**	Petković Mirko
27.	Ion Raluca Andreea	**64.**	Pejanović Tamara
	J	**65.**	Petrović Jelena
28.	Jankuloska Vezirka	**66.**	Petrovska Olivera
29.	Jovanović Stanić Sara	**67.**	Petrović Dana
30.	Joksimović Miljan	**68.**	Popović Tatjana
31.	Jovanović Miomir	**69.**	Popa Ovidia Ramona
32.	Jurina Tamara	**70.**	Potočnik Ivana
33.	Jovanović Nikola	**71.**	Prčkovska Marija

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72.	Raičević Danijela	**96.**	Ćosić Milivoje
73.	Radenković Sonja	**97.**	Ćosić Irina
74.	Ramadani Nimetula		**F**
75.	Rekanović Emil	**98.**	Feruh Bešlin Marija
76.	Rizani Smajl		**C**
77.	Ruzdik Markova Natalija	**99.**	Cvetkoviќ Dragan
	S	**100.**	Cvetkovik Gavrilovska Blagica
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81.	Srbinoski Stojan	**104.**	Cvijanović Dušica
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83.	Stepanov Nemanja		**Č**
84.	Stepanović Miloš	**106.**	Čabilovski Đorđe
85.	Stepanović Jelena		**Š**
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90.	Sterie Cristina Maria	**110.**	Wachon Stan
91.	Subin Radovan		
92.	Sokolovski Boyko		
	T		
93.	Tasić Jelena		
94.	Tomska Kristina		
95.	Tušek Jurinjak Ana		

Appendix B: Authors – Participating Countries
(Прилог Б: Автори – земји учеснички)

No. (Р. Бр.)	Countri (Земја)	Number of authors (Број на автори)
1.	**North Macedonia**	**11**
2.	**Serbia**	**16**
3.	**Russia**	**2**
4.	**Montenegro**	**2**
5.	**Bosnia and Herzegovina**	**2**
6.	**Romania**	**2**
7	**Canada**	**1**
8.	**Croatia**	**1**
9.	**Kosovo**	**1**
10.	**Armenia**	**1**
11.	**Bulgaria**	**1**
	Totally (Целосно)	**40**

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