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The journal's structure covers all aspects of the fields approached, the focus being on original and current researches with applications in agriculture, food industry and rural tourism. Collaborators may feel free to undertake biological and technical aspects as well as aspects with social, cultural and environmental impact. Information of general interest is also welcome for the agriecology-food-tourism axis

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**RESEARCH CENTER
BIODIVERSITY OF FOOD SYSTEMS - BIOSAL
FROM THE TRANSILVANIA UNIVERSITY OF BRAȘOV**

(coordinated by Prof. Dr. Romulus GRUIA, PhD supervisor PhD, and
Scientific Secretary Prof. Dr. habil. Liviu GACEU)

✚ It is important to mention that the research conducted at the **BIOSAL Research Center** aligns with global and European trends, being part of broader biodiversity protection strategies, such as those promoted through the European Union's Common Agricultural Policy or under the Convention on Biological Diversity.

The Biodiversity of Food Systems (BIOSAL) Research Center at the Transilvania University of Brașov (center founded on March 1, 2012) is a research unit dedicated to studying biological and ecological diversity within food systems. It functions as a branch of the CSCBAS “David Davidescu” Center – INCE / Romanian Academy. This center focuses on integrating aspects related to biodiversity conservation and food sustainability, aiming to contribute to developing viable solutions for current challenges in agriculture and food sectors.

The *BIOSAL Research Center* is involved in interdisciplinary research, targeting, among others:

1. **Conservation of plant and animal biodiversity in agriculture:** BIOSAL studies the genetic diversity of agricultural crops, livestock, and associated ecosystems, considering the importance of these elements for food security and adaptability to climate change.
 - For example:
 - Research projects in international consortia and local networks / Brașov Municipality – e.g., the FoodCLIC Project;
 - Studies on *Genetics of Biocoenoses*.
2. **Agroecology and sustainable practices:** Research within the center focuses on promoting agricultural production methods that protect natural biodiversity while reducing negative environmental impacts.
 - For example:
 - Publications (studies and research) in prestigious books, journals, conferences, and seminars.
3. **Sustainable food systems:** BIOSAL explores ways to create sustainable food systems that combine food production with biodiversity protection, having a positive impact on ecosystem health and local communities.
 - For example:
 - Studies on the valorization of local genetic resources through agritourism.

4. **Education and community awareness:** Another important goal of the center is to educate students, researchers, and the general public about the importance of biodiversity in food systems and support biodiversity conservation initiatives in agriculture.

➤ For example:

- The foundation (2005) and continuous publication of the BDI Journal of EcoAgriTourism;
- The foundation (1998-2006 as BIOTASAS, then 2007-present) and periodic organization of the International Conference on Food and Tourism - BIOATLAS;
- Education through the establishment (2007) of the Faculty of Food and Tourism at the Transilvania University of Braşov: university courses, bachelor's, master's, and doctoral theses.

Under the coordination of Prof. Dr. Eng. Romulus Gruia, BIOSAL has become a reference point in research on **the link between biological biodiversity and food sustainability**, actively contributing to the development of innovative solutions for current agricultural and food challenges.

Additionally, BIOSAL promotes collaborations with other academic institutions, research organizations, and government agencies, being part of a larger network of researchers and experts in agriculture and environmental protection.

➤ For example:

- ♦ **Institutional cooperation** through studies and research with the CSCBAS "David Davidescu" from INCE - Romanian Academy;
- ♦ **Research collaboration** with the Montanological Research Institute (CE-MONT) Vatra Dornei - Institute of the Romanian Academy;
- ♦ **Integration into academic activities** at The Academy of Romanian Scientists (AOŞR) – Section VII - Agriculture, Forestry, and Veterinary Medicine and at Academy of Agricultural and Forest 'Gheorghe Ionescu-Şişeşti' (ASAS) - Section of Agrarian Economics and Rural Development.

Short presentation
Prof. Romulus Gruia, PhD
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PRIVATE LABEL DAIRY PRODUCTS – CASE STUDY FOR THE MOUNTAINOUS AREA OF ROMANIA

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Abstract: This paper addresses a topical issue in the field of marketing and food quality management, namely the evolution of the quality of dairy products sold under private labels, in the context of the accelerated development of modern trade and changes in consumer behavior. Private labels have become a central element of the commercial strategies of retailers in Romania and around the world, and dairy products occupy a significant place in the shopping cart of the Romanian consumer, which is why the analysis of their quality becomes essential. The main purpose of the paper is to analyze how the quality of private label dairy products has improved in recent years, what are the factors that contributed to this evolution, and how this quality is perceived by consumers. The objectives of the paper include: exploring the concept of private label and quality in the food industry, identifying and analyzing the methods by which the quality of dairy products is kept under control, especially in the case of private label products through applied research, formulating conclusions and recommendations for the continuous improvement of the quality of these products.

Keywords: private label, dairy, marketing, retailers.

1. Introduction

1.1. The evolution and history of the own brands

In recent decades, private label products have become a significant component of the retail market worldwide. These products, which are sold under the brand name of a retailer or merchant, but are usually manufactured by another supplier, have gained great popularity due to affordable prices and improved quality. While these products were initially associated with lower quality, today private label products have come to compete with branded products in terms of quality and performance. The evolution of private label is linked to the transformations in global trade and changes in consumer behavior. Many of these changes have been fueled by economic trends and increasing awareness of costs and quality. Technological changes and marketing innovations have also had a significant impact on the success of private label.

1.2. Consumer Perception of Private Label

In the early years of private label development, consumers had a rather negative perception of

these products, associating them with low quality and low prices. However, in the 1980s and 1990s, this perception began to change. Retailers invested in improving production processes and quality control, and private label products began to improve significantly in terms of quality and diversity.

During this period, private label products were influenced by economic trends and developments in global trade. Globally, retailers began to draw attention to competitive prices and high-quality standards, and consumers began to be more willing to buy private label products, especially when their price was lower than that of traditional brands.

1.3. Involving Technology and Innovation in Brand Development

Since the 2000s, technology has played an important role in the development and success of private label products. Technological progress in manufacturing and processing has contributed to significantly improving the quality of private label products, and this has had a positive impact on consumer perception. Retailers have also started to apply new marketing and promotional

technologies to attract customers. Advertising and digital marketing campaigns have helped build a positive image for private label products. The growth of online commerce and sales through digital platforms has allowed retailers to reach a wider audience, thus expanding their success in the global market.

1.4. Quality Evolution and Innovations in Private Label Products

Another significant aspect of the evolution of private label has been the constant improvement of product quality. While these products were initially associated with lower quality, many private label products are now considered to be of higher quality. For example, in the food sector, private label products are often comparable to those of traditional brands.

In addition, many private label products are now certified as ecological or organic, thus responding to the growing consumer demand for sustainable and environmentally friendly products. These innovations have contributed to the increasing popularity and acceptability of private label products in the global market.

1.5. The Challenges and Risks Associated with Private Labeling

Even though private label products have gained ground in recent times, there are still significant challenges that retailers need to take into account. One of the biggest challenges is maintaining a balance between price and quality. While private

label products are often appreciated for their competitive price, there are risks related to the perception of quality, especially if manufacturing standards are not consistently maintained.

2. Current Status of Private Brands for Dairy Products in Romania

The current state of private label dairy products in Romania reflects a constant evolution of the market, characterized by a diversification of the offer and a growing demand from consumers for affordable and quality products. In recent years, private label products have gained a significant share of the dairy market, largely due to their competitive price and, in many cases, quality that rivals traditional brands.

Local and international retailers have understood the importance of this category and have started to invest more and more in diversifying the range of private label dairy products. Thus, from milk, cheese and yogurt, the private label offer now also includes more special products, such as organic dairy or dairy alternatives.

When it comes to consumer preferences, there is a clear trend towards more affordable products, but also a growing concern for health. At the same time, interest in organic dairy products has increased significantly, and the demand for dairy from local sources continues to be an important factor.

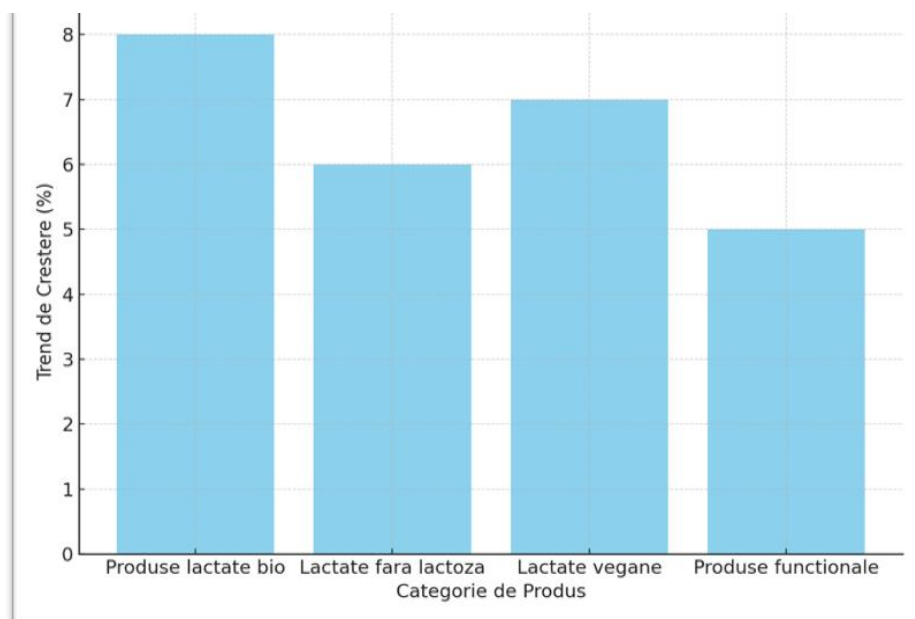


Fig. 1. Growth trend in the dairy market in Romania

In parallel, the Romanian dairy sector is facing certain challenges, such as the decline in dairy cattle numbers and fluctuations in raw material prices. Nevertheless, industry investors remain focused on modernizing production facilities and improving quality standards to meet market requirements.

There is also a noticeable rise in interest in product innovation, with many producers concentrating on developing new products aligned with current consumer trends, such as lactose-free dairy or products with natural additives. Looking ahead, the private-label dairy market in Romania is expected to continue growing, as consumers are increasingly willing to choose these products, considering both their economic advantages and the diversity of the offering. The Romanian dairy sector holds considerable growth potential, and rapid adaptation to new market demands will be essential to meet consumer needs.

2.1. Diversifying the offer of private label products in the dairy sector

In recent years, the Romanian dairy market has witnessed a significant diversification of private label products. This change has been driven by the adaptation of local retailers and producers to the ever-changing consumer preferences and global trends in the food industry. Private label dairy products are no longer limited to traditional milk, cheese and yogurt, but now include a wide range of options that meet diverse health requirements, tastes and dietary needs. As Romanian consumers become more informed and selective in their food choices, retailers have understood that they need to diversify their offer to meet these demands. Thus, in addition to traditional products (milk, cheese, yogurt), a series of innovative products are now available, including variants for different types of diets and lifestyles. Among the new private label dairy categories are:

2.1.1. Organic dairy products

A growing segment in the Romanian market is organic dairy products. Consumers are increasingly concerned about their health and the impact that food products have on the environment. Organic dairy products, obtained from milk from animals fed with organic feed

and raised in conditions closer to natural ones, have started to be a popular choice. Large retailers in Romania have started to include a wide range of organic dairy products under their own brands in their portfolios.

2.1.2. Lactose-free dairy products

Another important trend is the demand for lactose-free dairy products. With lactose intolerance affecting a significant percentage of the population, more consumers are choosing to avoid milk and dairy products containing lactose. As such, retailers have introduced lactose-free private label products such as milk, yogurts and cheeses into their dairy portfolios to address this need.

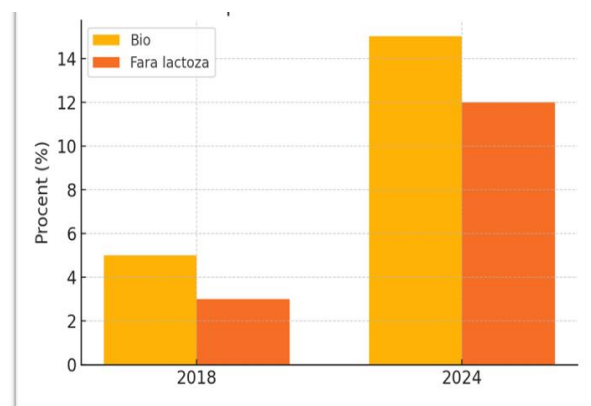


Fig. 2. Growing Organic and Lactose-Free Products

2.1.3. Vegan dairy and plant-based alternatives

Amidst the growing interest in vegan and vegetarian diets, plant-based dairy products (such as almond, soy, and oat milk) have gained traction. Retailers in Romania have begun to expand their offerings, and private label products have begun to include plant-based alternatives to dairy, providing an affordable option for those who prefer to avoid animal products.

2.1.4. Functional products

As more consumers become concerned about gut health and overall immunity, dairy products with probiotics or functional additives (vitamins, minerals) have become more popular. Probiotic yogurts or vitamin D-fortified milk are examples of products that have begun to be included in private label dairy portfolios.

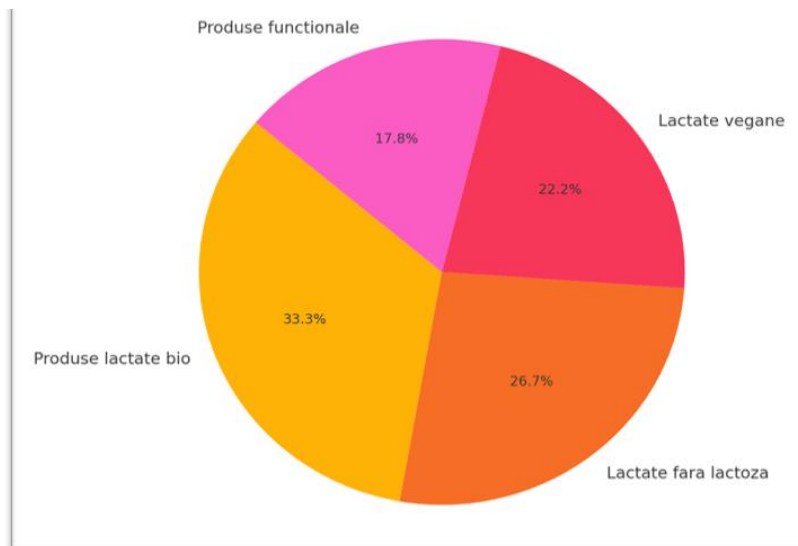


Fig. 3. Market shares of dairy products in Romania

2.2. Reason for diversification and response to market demands

The diversification of the private label dairy offer is not simply a response to global trends, but also a reaction to changes in the behavior of Romanian consumers. Over the years, their food preferences have changed significantly, and consumers have become increasingly interested in healthy and sustainable nutrition. At the same time, the prices of private label products remain an important factor, and private label dairy products continue to be an affordable option for a large segment of the population. These changes have led manufacturers and retailers to seek innovative solutions to meet the diversity of consumer demands.

2.3. Benefits of diversification for consumers and the Romanian market

For consumers, the diversification of private label dairy offers has brought several benefits. They now have access to quality products at more affordable prices, especially in the context of rising prices on the branded products market. In addition, product diversity allows consumers to choose options that better suit their dietary and health needs, thus contributing to a more balanced diet. On the other hand, for the Romanian market, the diversification offered by private label products has contributed to increased competition and improved the overall quality of dairy products available on the market. Local producers have been stimulated to improve their production standards and invest in more modern technologies, in order to be able to meet

market demands. This has led to increased competitiveness of the Romanian dairy industry.

2.4 Challenges and prospects for private label product diversification

Although the diversification of private label dairy products is a positive step for the Romanian market, it comes with some challenges. First, producers need to ensure that they comply with quality and food safety standards, which requires significant investments in technology and process control. Also, the increase in demand for organic or vegan products requires significant adjustments to the supply and production chains, which can be costly. In addition, as consumers become more demanding, it will be necessary for retailers to focus not only on diversifying the offer, but also on improving the shopping experience, by developing marketing campaigns that draw attention to the quality and benefits of these products.

3. Factors that Influence the Growth of Demand for Own Brand Dairy in Romania

The growing demand for private label dairy products in Romania is a phenomenon that can be attributed to several economic, social and cultural factors. In the context of a constantly changing market, where consumers are becoming increasingly informed and selective, retailers and dairy producers have had to respond to their increasingly diversified demands. The factors contributing to this trend are multiple and

interdependent, including economic, behavioral and cultural aspects.

3.1. Affordable price and value for money

One of the most important factors influencing the growth of private label dairy demand is its affordable price. In a period of economic uncertainty and income fluctuations, Romanian consumers are increasingly mindful of their budget. Private label dairy products, which are usually cheaper than traditional brands, offer an attractive alternative for people who want to save money but without making major compromises in terms of quality. Over time, consumer perception of private label products has changed, and today many of these products are considered as good, if not better, than branded ones. In addition, retailers have understood the importance of offering a favorable quality-price ratio. Thus, private label dairy products are perceived not only as affordable, but also as having good quality, especially due to the higher production standards imposed by European Union regulations.

3.2. Lifestyle changes and healthy eating

In recent years, Romanian consumers have become increasingly concerned with healthy eating. As awareness of the effects of diet on health has grown, Romanians have started to rethink their eating habits, with more and more people choosing products that are better for their health. Private-label dairy products not only meet this demand for healthier food, but have also been diversified to satisfy consumer preferences. At the same time, as interest in special diets has increased in Romania (for example, vegan or lactose-free diets), private-label dairy has diversified and begun to include alternatives to traditional cow's milk products. These alternatives are usually more affordable than branded products, making them an attractive option for a growing number of consumers.

3.3. Marketing strategies and promotional campaigns

Another important factor contributing to the growth in demand for private-label dairy is the marketing strategy of retailers. Promotional campaigns and periodic discounts play an essential role in attracting consumers and encouraging them to choose private-label products. Many consumers are influenced by discounts and special offers, which are frequently

applied to private-label dairy, making them an attractive choice for dairy purchases.

Through effective marketing strategies, retailers have also managed to strengthen the image of private-label products, promoting them not only as affordable, but also as reliable and high quality. Advertising campaigns that emphasize freshness and quality have been essential in changing public perception of private-label dairy.

3.4. Growing consumer trust in private-label products

With the increasing number of private-label dairy products available on the market, consumer trust in these products has grown significantly. In the past, many consumers were skeptical about the quality of private-label goods, perceiving them as inferior to traditional brands. However, today this perception has shifted, largely due to the continuous improvement of quality and greater transparency in the production process. Moreover, private-label dairy products are often subject to strict quality standards and are inspected by competent authorities, which further increases consumer confidence. Quality certifications and origin labels play an important role in strengthening trust, and this has contributed to rising demand for private-label dairy.

4. Sustainability in the Private Brand Lock Industry

In recent decades, sustainability concerns have evolved considerably and have begun to influence more and more economic sectors. The food industry, especially the dairy sector, is no exception. Private label dairy products are increasingly associated with a strong commitment to environmental protection, social responsibility and the saving of natural resources. In a world where the impact of economic activities on the environment is increasingly visible, sustainability is becoming a necessity for the development of a sustainable and responsible food industry.



Fig. 4. *Sustainability. From organic farming to recyclable packaging*

4.1. Sustainability in the dairy sector

Sustainability in the dairy sector does not refer only to environmental protection but also to farming practices that guarantee decent working conditions and ethical treatment of animals. In the context of private-label dairy, sustainability can be approached from several perspectives: reducing environmental impact, using renewable resources, and promoting responsible agricultural practices.

4.1.1. Reducing the carbon footprint

In the dairy sector, reducing the carbon footprint is a major priority. Private-label dairy producers are increasingly aware of the significant impact that production processes have on the environment and are beginning to adopt greener technologies to minimize greenhouse gas emissions. On dairy farms, technologies are being implemented to reduce energy consumption, and many have started to use renewable energy sources such as solar panels or wind turbines to power production processes. In addition, some milk processing plants are using energy recovery systems, which allow the reuse of heat generated during industrial processes.

4.1.2. Management of natural resources and water

Another essential aspect of sustainability is the efficient management of natural resources, especially water. The dairy industry consumes significant amounts of water, both in production processes and for animal care. For this reason,

many private-label dairy producers are implementing modern technologies to reduce water consumption. These include water recycling systems and technologies that allow more efficient use of water, such as recirculating it in washing or irrigation processes. Some farms have also introduced rainwater harvesting systems to use for various on-farm activities.

4.1.3. Organic farms and sustainable production methods

Another important step toward sustainability in the private-label dairy industry is the growing number of organic farms. These are farms that follow the principles of organic farming, meaning the use of natural fertilizers and the avoidance of pesticides and other harmful chemicals. Dairy products from these farms are often marketed as “organic” or “bio,” and producers who adopt such practices must comply with strict regulations to ensure that the products are safe and beneficial for consumers’ health. Organic production is also associated with improved animal welfare, as animals enjoy more space to move and are fed more natural feed. These farms provide an example of sustainability where animals live more naturally, while environmental impact and the use of harmful chemicals are reduced.

4.1.4. Eco-friendly packaging and recyclability

Another important factor in sustainability within the private-label dairy industry is the use of sustainable packaging. Packaging accounts for a large share of the waste generated by food products, and the dairy industry is no exception. Retailers and private-label dairy producers have started adopting more eco-friendly packaging solutions to reduce environmental impact. For example, cardboard and plastic packaging are increasingly made from recycled and recyclable materials. In addition, many brands have begun to phase out single-use plastic packaging, opting instead for biodegradable or reusable packaging. Private-label dairy products that use recyclable materials or recycled plastic are becoming increasingly popular on the market, helping to reduce the amount of plastic that ends up in landfills or oceans. In some cases, private-label dairy producers have also implemented packaging return systems, where consumers can bring back empty packaging for recycling or

reuse. These practices contribute to more responsible consumption and reduce the waste of natural resources.

4.2. The importance of quality certifications for private-label products

Quality certifications are an essential tool for ensuring high standards in food production, especially in the case of private-label dairy products. In a dynamic and highly competitive market, certifications are seen as a symbol of trust and transparency, and in the case of dairy products, they have a direct impact on food safety, consumer health, and environmental protection.

4.2.1. What do quality certifications mean for private-label dairy products?

Quality certifications for private-label dairy products are granted by independent organizations and competent authorities that verify compliance of products and production processes with national and international standards. These standards may include:

- Food safety (e.g., ISO 22000, HACCP);
- Organic certification (e.g., BIO, Global G.A.P.);
- Animal welfare (e.g., Animal Welfare Approved);
- Fair trade certification (e.g., Fair Trade);
- Sustainability certifications (e.g., Rainforest Alliance, UTZ).

For private-label dairy products, obtaining these certifications is not just a formality but an ongoing commitment to transparency, safety, and sustainability. Certifications also provide retailers with a way to differentiate their products in the market, helping consumers choose products that meet their expectations for quality, safety, and ethics.

4.2.2. The role of quality certifications in ensuring food safety

One of the most important reasons why quality certifications are necessary is food safety. In the dairy industry, this is even more crucial since dairy products are perishable and can easily become a breeding ground for harmful bacteria if not handled properly.

Certifications such as ISO 22000 and HACCP (Hazard Analysis and Critical Control Points) are examples of standards that guarantee dairy products are processed and handled in accordance with the highest food safety requirements. By implementing a HACCP system, private-label dairy producers can identify and control potential contamination risks at various stages of production – from the farm to processing and packaging of the final product. For example, on dairy farms, strict measures are taken to prevent milk contamination with harmful bacteria (such as *E. coli* or *Salmonella*) through constant monitoring of animal hygiene and processing equipment. Another example is ISO 22000 certification, which ensures that every part of the food chain – including transportation and storage – complies with food safety regulations to prevent any contamination risks. A further significant benefit of food safety certifications is product traceability. Certifications such as ISO 22000 or HACCP require producers to maintain detailed records and monitor every step of the production process. This means that any product batch can be traced along its entire journey. In the event of an issue (for example, contamination), this traceability allows for rapid and effective product recalls, thereby protecting consumer health.

5. Conclusions

The analysis of private-label dairy products highlights several important findings regarding their evolution, perception, and future prospects in Romania and beyond:

Improved Quality and Consumer Trust

Private-label dairy products have evolved from being perceived as low-cost, lower-quality alternatives to becoming strong competitors of traditional brands. Continuous investments in production processes, quality control, and marketing strategies have significantly enhanced consumer trust and acceptance.

Diversification Driven by Consumer Preferences

The Romanian market demonstrates clear evidence of diversification, with private labels now offering organic, lactose-free, vegan, and functional dairy products. This diversification responds to the growing consumer interest in health, sustainability, and personalized nutrition, while maintaining affordability.

Price-Value Advantage

Affordability remains one of the strongest drivers of demand. Romanian consumers increasingly perceive private-label dairy products as providing not only economic benefits but also acceptable, and often high, quality standards comparable to branded products.

Role of Innovation and Technology

Technological advancements and innovation in production, packaging, and marketing have strengthened the competitive position of private labels. Retailers and producers leverage these tools to improve quality, ensure food safety, and engage consumers more effectively.

Sustainability and Responsibility

Sustainability has become a central element in the development of private-label dairy products. From eco-friendly packaging and organic farming to reduced carbon footprints and water management, producers are aligning with global sustainability trends, responding both to consumer expectations and regulatory pressures.

Importance of Certifications

Quality certifications play a vital role in ensuring safety, transparency, and credibility. They not only guarantee compliance with national and international standards but also strengthen consumer confidence and market differentiation.

Challenges and Future Prospects

Despite strong growth, challenges remain. Retailers and producers must balance affordability with consistent quality, address supply chain adjustments for organic and vegan products, and manage rising consumer expectations. Rapid adaptation and ongoing innovation will be essential for sustaining competitiveness. Overall, the study demonstrates that private-label dairy products in Romania hold considerable growth potential, fueled by affordability, diversification, consumer trust, and sustainability initiatives. The ability of retailers and producers to anticipate and respond quickly to evolving consumer needs will determine the long-term success and development of this sector.

References

1. Luntraru, C. M., Apostol, L., Oprea, O. B., Neagu, M., Popescu, A. F., Tomescu, J. A., Gaceu, L. (2022). Reclaim and valorization of sea buckthorn (*Hippophae rhamnoides*) by-product: antioxidant activity and chemical characterization. *Foods*, 11(3), 462.
2. Apostol, L., Belc, N., Gaceu, L., Vladut, V., Oprea, O.B. (2019). Chemical composition and rheological parameters of *Helianthus Tuberosus* flour used as a source of bioactive compounds in bakery. *Rev. Chim*, 70(6), 2048-2053.
3. Mnerie, D., Gaceu, L., Gubenia, O., Shamtsyan, M., Birca, A., & Mnerie, G. V. (2016). Comparative study on the evolution of the food labeling quality in some countries from the Black Sea region. *J. of Hygienic Engineering and Design*, (14), 60-65.
4. Apostol, L., Belc, N., Gaceu, L., Oprea, O.B., Popa, M.E. (2020). Sorghum flour: A valuable ingredient for bakery industry?. *Applied Sciences*, 10(23), 8597.
5. Gaceu, L., Gadei, G., Oprea, O.B. (2014). Methodology for analyzing EU-conform label information content of meat products in Romania. *J. of Agricultural Informatics*, 5(1), 18-26.
6. Oprea, O.B., Gaceu, L. (2016). Application of multiple criteria decision making (mcdm) in bakery industry. Study case: wastes and by-products. *Bulletin of the Transilvania University of Brasov. Series II: Forestry• Wood Industry• Agricultural Food Engineering*, 89-94.
7. Oprea, O. B., Gaceu, L., & Gadei, G. (2013). Investigation methodology about labels information content of the meat products from Romania, in accordance with European Legislation. In *Proceeding of the international conference Agri. Informatics*, (pp. 7-12).
8. Oprea, O. B., & Gaceu, L. (2020). Consumer acceptance and sensorial analysis of bread with grape seed flour. In *E3S Web of Conferences* (Vol. 215, p. 01005). EDP Sciences.
9. European Food Safety Authority. (2024). (EFSA) | SAFE – Safe Food Advocacy Europe www.efsa.europa.eu [Accessed on 18th March 2025].
10. Gaceu, L. (2018). Comparative study on European legislation about hygienic engineering and design. *Journal of EcoAgriTourism*, 14(2), 42-47;
11. Gaceu, L. (2020a). Design principles for assuring food safety in Romanian mountain dairy farms. *Journal of EcoAgriTourism*, 16(2), 21-25;
12. Gaceu, L. (2020b). Food safety in pasteurization of liquid food-basic elements for mountain farmers. *Journal of EcoAgriTourism*, 16(2), 51-55.

STUDY ON GEO-CLIMATIC FACTORS IN RELATION TO THE MOUNTAIN GRADIENT AND PHOTOSYNTHESIS MECHANISMS

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Abstract: The study analyzes a highly relevant topic concerning the mechanisms of photosynthesis, which are influenced by a multitude of factors. Among these, the geo-climatic factors differentiated along altitudinal gradients are highlighted. The aim is to determine their influence on the photosynthesis of plants within the studied area. The paper emphasizes the evolution of temperature over the past 150 years in correlation with the vegetation period of plants, in order to identify the optimal bioactive period. The bioactive period with thermal inhibition is underlined according to altitude, for both herbaceous vegetation and trees in the area. Differences based on the slope's sun exposure and precipitation intensity are determined. The study provides information on the integrated geo-climatic influence on the photosynthesis mechanism, in order to assess the oxygen source level along altitude gradients, in relation to the photosynthetic process, which directly influences the productivity of the herbaceous cover as well as its quality, specific to the mountain area.

Keywords: altitude, climate, photosynthesis, mountain

1. Introduction

In the early stages of human society, when natural ecosystems covered most of the land surface, vegetation was considered a producer of resources. Primitive humans, in the gatherer–hunter phase, could not have existed without knowledge of the surrounding ecosystems, from which they obtained everything necessary for life and which offered them shelter and protection.

It is considered [21] that the ecosystem is the basic unit of nature, characterized by the integration of the biocoenosis with the biotope into a unified whole. It is mentioned that the main terrestrial ecosystems are forests, shrublands, and grasslands. Among these, the primary natural grassland established itself spontaneously on the parent rock in parallel with the pedogenesis process [28]. All these ecosystems, so different in substrate, specific composition, or size, nevertheless share common structural plans [20].

Individuals, populations, and different species never associate randomly, and this applies to all categories of living beings: lower plants, higher plants, animals, and microorganisms. This

community of individuals forms the biocoenosis, which together with the biotope constitutes the ecosystem [18].

As is well known, the two elements of the ecosystem are:

Biotope – representing the physical environment of existence for a community, the abiotic environment.

Biocoenosis – the biological subsystem of the ecosystem. The biocoenosis includes all living beings (microorganisms, plants, animals) whose living space is the respective biotope.

It is known [3] that all the components of the biocoenosis are determined by a series of factors whose importance makes it impossible to rank them, namely the species composition, the proportions between species, the spatial distribution of species, and their dynamics over time. Among the living beings in the ecosystem, the essential differences are linked to the functions these living beings perform within this system (Figure 1). As parts of nature, ecosystems are structural and functional units generated by the integrality of the biocoenoses and biotopes (habitats) and are the locus of the actions and reactions of the living world [11].

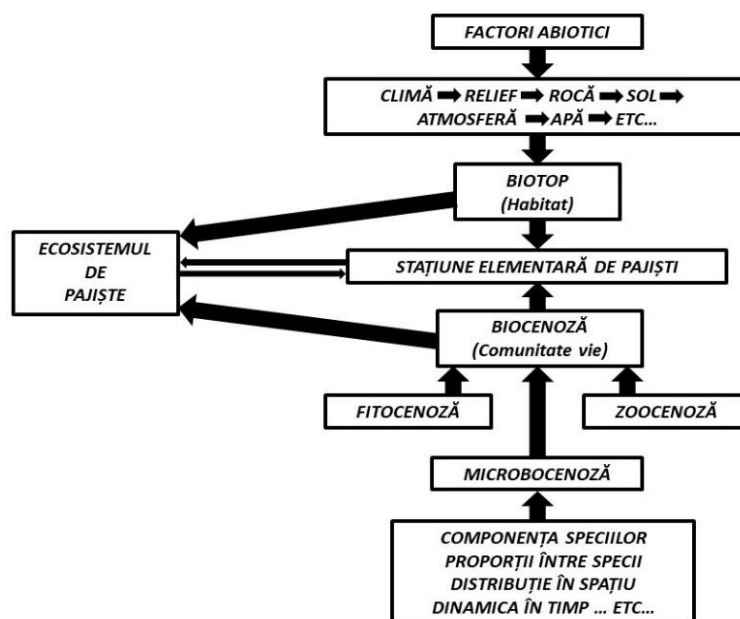


Fig. 1. Relationships between abiotic factors and biocenosis populations [26]

As general and specific objectives of the study, we specify that the time evolution of temperature over the last 150 years was analyzed in correlation with the vegetation period of plants in order to determine the optimal bioactive period. The bioactive period with thermal inhibition depending on altitude is emphasized, both for the herbaceous vegetation and for the trees in the respective area. The differences depending on the sun exposure of the slope and precipitation are determined. A series of aspects regarding the integrated geo-climatic influence on the development of the photosynthesis mechanism are concluded, in order to see the productivity of the herbaceous carpet and the level of the oxygen source on altitude gradients in relation to the photosynthesis process.

2. Study Results

2.1. Climatic, Pedochemical and Orographic Gradients in the Mountain Area

In Romania, the analysis of historical air temperature data shows that the multiannual average has increased in the last 33 years by 0.5°C (1981-2013/ 10.2°C), compared to the period 1901-1980 (9.6°C), this value being below the global average warming of 0.85°C recorded in the last 100 years (1850-2012). In the last 33 years, in our country the warmest year was 2007 (11.5°C), and the coldest year was 1985 (8.4°C) [12]. The data on air temperature in our country, presented in various specialized works for the periods 1896-1955 [2,23,25] were used to outline new types of gradients of the thermal factor in the

altitude range of 600–1800 m, for mountain forest ecosystems [16].

It is stated [14] that the most used gradients so far have been the thermal one, which indicates the average decrease in the vertical temperature of the atmosphere for every 100 m difference in level by 0.6°C , and the geothermal one, which indicates the average increase in the temperature towards the interior of the earth for every 100 m depth, by about 3°C in Europe and about 2.5°C in America.

In parallel, the term geothermal step is also used, which is the distance expressed in meters, by which one must descend vertically into the depths of the earth to observe an increase in temperature by 1°C , a distance that varies between 5-150 m depending on the thickness of the earth's crust [14].

Due to the heating of the air by the heat given off by the earth's crust, as one move away from the crust towards height, the temperature of the atmospheric air decreases.

The standard temperature gradient is equal to $0.65^{\circ}\text{C}/100\text{ m}$ height; in reality, it differs according to the air layer in the troposphere, being extremely high up to a height of 2 m of only $0.3\text{--}0.4^{\circ}\text{C}$, up to 1500 m altitude, $0.5\text{--}0.6^{\circ}\text{C}$ between 1500-6000 m and $0.65\text{--}0.75^{\circ}\text{C}$ between 6000-9000 m [6].

For the conditions of our country, the vertical thermal gradient in the troposphere was established, which is $0.5^{\circ}\text{C} \dots 0.6^{\circ}\text{C}/100\text{ m}$ altitude [23] and the water gradient, which is $40\text{--}50\text{ mm}/100\text{ m}$ [13].

The main characteristic of the troposphere is the decrease in temperature in direct proportion to height, the vertical thermal gradient being 6.5 °C/km [6].

After interpreting the climatic data, several mountain ecological gradients resulted, which

reconfirm the decrease by approximately 0.50°C in the average annual air temperature with every 100 m altitude, in the range of 600-1800 m, the decrease by -0.30°C in the average temperature of the coldest month (January) and by -0.70°C in the warmest month (July) (Figure 2).

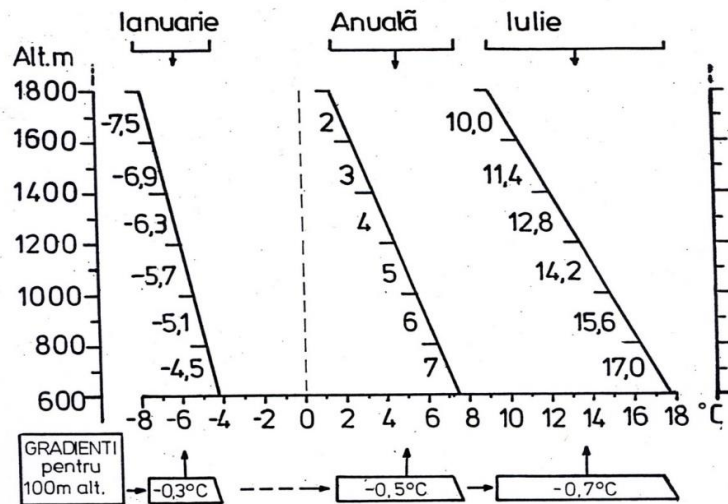


Fig. 2. Altitude evolution of average air temperatures in the mountain forest area of Romania [14]

According to these data, the upper limit of the extension of the closed forests in the Romanian Carpathians is located between 1600-1800 m altitude, a limit determined mainly by the average air temperature, which is approximately 2°C annual average, -7.5°C average in January and 10°C average in July.

Moreover, on the globe, the northern limit of the forest closely follows the 10°C isotherm in July and oscillates around the Arctic Circle (66°30') [7]. The ecological gradients for the duration of the intervals with average daily temperatures equal to or greater than 0°C, 5°C and 10°C are the same -7.5 days for every 100 m altitude, respectively 4.0 days at the beginning of the period and 3.5 days at its end (Figure 3).

It can be appreciated that trees are established up to the limit where the interval with average daily temperatures, above 0°C, exceeds 50% of the year, those above 5°C (limit period of vegetation) exceed 33% of the year and those above 10°C (optimal bioactive period) reach at least 20% of a year (about 75-90 days). For intervals with average temperatures, equal to or above 15°C, (bio-active period with thermal inhibition), which are maintained up to 1000 m altitude, the gradient of duration with this interval decreases by 15 days/100 m altitude.

Soil temperature at altitude closely follows that of the air. Systematic research on the topoclimate and microclimate of plant communities in the air and soil was initiated for the first time in Europe, at the Botanical Garden of Cluj-Napoca [4]. With the help of thermal micro-gradients it was possible to outline the evolution of temperature from 10 to 10 cm height in the air and depth in the soil [15].

The expansion of boreal forests (spruces) at higher altitudes, namely above 1600-1800 m altitude in the Romanian Carpathians, is also limited by the wind intensity, which exceeds 7 m/s per year on average, and at even stronger winds in the subalpine layer, the woody vegetation is made up of shrubs and subshrubs, and in the alpine layer almost exclusively of herbaceous vegetation [16].

It is stated [14] that the exposure of the slopes influences the climate and implicitly the herbaceous and woody vegetation, at the same altitudinal level on the southern slope the same climatic conditions are encountered as on the northern one 200 m higher.

Due to the fact that the average annual air temperatures on the southern slope are 0.9°C higher and the annual precipitation is 381 mm higher, the duration of the optimal grazing season

is 15 days longer than the conditions on the northern slope.

It is worth mentioning that the average temperature of the months of May-September is also higher on the southern slope by 0.5°C and precipitation is higher by 82 mm compared to the northern one, which will obviously have a positive influence on the productivity of the

grassy carpet and the grazing animals. A special role in the distribution of vegetation is played by the exposure and inclination of the terrain, respectively its orography. Pedogenetic factors (climatic, orographic, biotic) in turn influence the chemistry of the soil, with which, together, they have a predominant role in the biogeochemical cycle of matter in ecosystems (Figure 3).

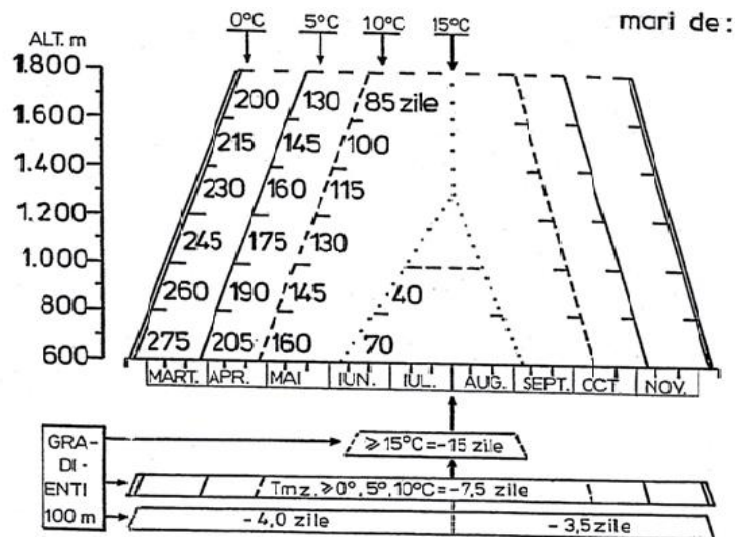


Fig. 3. Altitude evolution of the duration of intervals with some average daily temperatures in the Romanian Carpathians [14]

3. The Influence of Climate Factors on Vegetation and Photosynthesis Mechanisms

Within physical-geographic regions, vegetation zones or at the level of the entire country, meadow phytocenoses present great diversity, with differences or similarities in floristic composition, requirements towards environmental factors, biological, agronomic and zootechnical value, evolutionary dynamics, etc. [17,27]. As stated [17], over the fundamental morpho-structural units of the country's relief: plains, hills, medium and high mountains (alpine), climate and soil factors also overlap, which together with natural vegetation constitute latitudinal and altitudinal natural zonal complexes (on levels) to which pasture and hayfield formations are closely linked, whether of primary or secondary origin.

The stratification of climate determined the stratification of vegetation, which in turn influenced soil conditions on different lithological substrates (limestone, crystalline schists, volcanic rocks).

As a general characteristic of altitude, the thickness of these soils decreases, as does the degree of base saturation (V%) and the soil reaction (pH) as a result of increasing precipitation and decreasing temperature. With increasing altitude, soils are increasingly poor in fertilizing elements, increasingly acidic and unfavorable for plant growth and development. Reduced air humidity causes plant transpiration to intensify, increasing water consumption from the soil. If the soil cannot fully cover the evaporated water, plant cells dehydrate and plants wither. Under these conditions, plant production decreases, hence lower amounts of feed. Increased air humidity prevents transpiration, chlorophyll assimilation, flowering, pollination and fruiting, all of which lead to low yields both in terms of plant mass and in terms of seeds, which constitute the basis of concentrated animal feed.

The temperature of the atmospheric air exerts multiple indirect influences on animals, through the environment in which they live. The quantity and quality of feed, as well as the quality of the soil necessary for the preservation or multiplication of microbial germs and parasites,

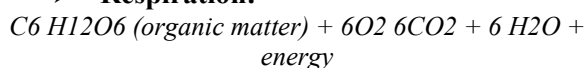
to a certain extent, depend on the quality and temperature of the atmospheric air.

Given the need for continuous increase in food resources, it is all the more necessary to have a detailed knowledge of photosynthesis, a particularly important and complex process that ensures the existence of the vast majority of living things and of life on Earth as a whole [19]. The process in nature by which green plants synthesize the first organic compounds from carbon dioxide and water with the help of energy from solar radiation and in the presence of chlorophyll is known as photosynthesis or chlorophyll assimilation.

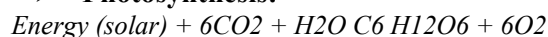
Through photosynthesis, green plants in grasslands are able to convert atmospheric carbon dioxide into carbohydrates (sugars). Plants and animals then use these carbohydrate compounds in the process of respiration (the reverse of photosynthesis) [24]. The energy contained in carbohydrates used in various metabolic processes is released through respiration, which results in carbon dioxide, which returns to the atmosphere. Animals consume oxygen and release carbon dioxide into the atmosphere, while plants consume carbon dioxide and produce oxygen [22].

The metabolism of carbon dioxide from the atmosphere takes place through the following chemical reactions, thus ensuring a cycle of matter and energy in nature.

➤ **Respiration:**



➤ **Photosynthesis:**



Plants form, as "primary producers", the first link in the food chain, the energy problem from an ecological point of view constitutes the starting point of all substance production in both the plant and animal kingdoms, dependent on the former

both nutritionally and energetically, and this starting point is formed by photosynthesis [1].

The mechanisms of photosynthesis carried out by plants represent the main source of oxygen for the biosphere and the atmosphere, being considered the most important natural process, because it represents the very essence of life on Earth [22]. Through photosynthesis, plants have the ability to transform the electromagnetic energy of light into chemical energy (ATP, NADP), creating bonds and organic compounds using as raw materials water, CO₂ and some nutrients taken from the soil solution [5].

The oxygen content of the soil decreases with depth, which creates unfavorable conditions for plant nutrition [9].

Carbon dioxide (CO₂) in nature is a limiting factor for photosynthesis, its concentration of 0.03% being suboptimal compared to the possibility of plants to use it in photosynthesis, with optimal efficiency.

The importance of photosynthesis in nature is given by: the concentration of a certain amount of potential energy, the fixation of carbon with the release of oxygen and the accumulation of organic substances in plant mass (Figure 4). These represent the sources of food and energy for all living things on Earth.

The primary source of formation of the entire quantity of organic substances, accumulated in various forms (carbohydrates, lipids, proteins, vitamins, hormones, enzymes, glucosides, tannins) is photosynthesis. These organic substances, synthesized by plants for their own needs, subsequently become absolutely necessary food products for human and animal nutrition.

The organic biomass accumulated by such plants provides the energy necessary for the growth and development of all animal and human organisms, which are not able to directly capture energy from the sun and are totally dependent on the plant kingdom.

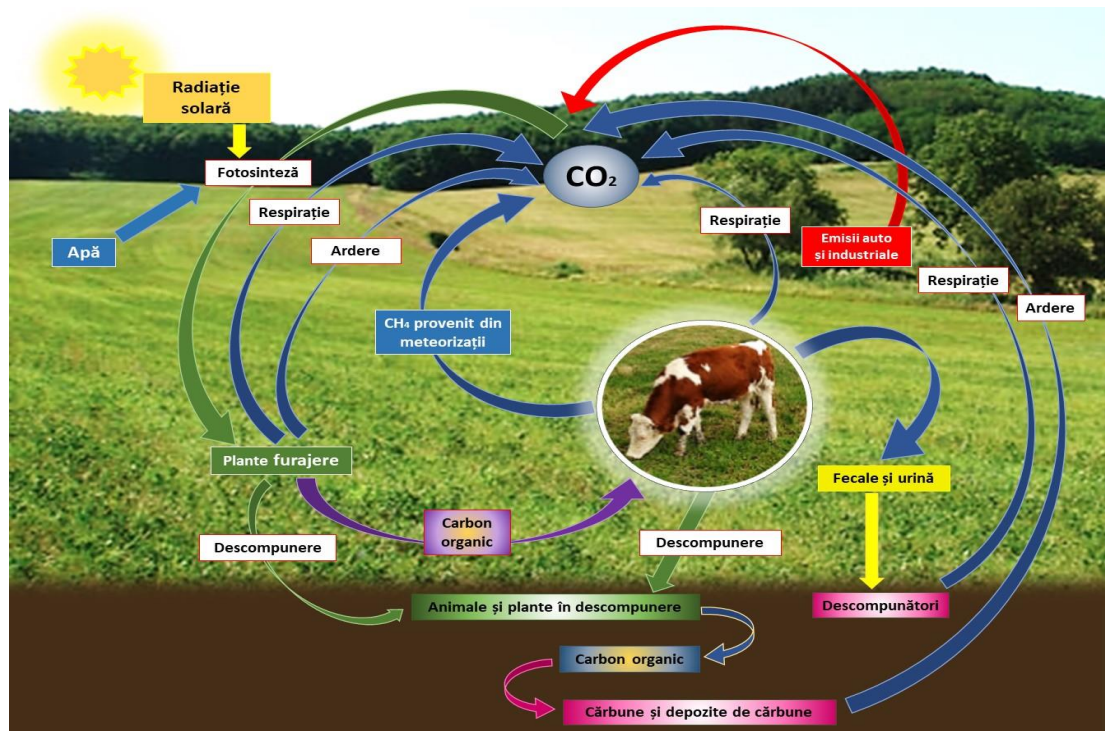


Fig. 4. Carbon cycling in the vegetative ecosystem [29]

Like animals, plants have temperature limits, between which physiological processes can occur, called biological thresholds. Chlorophyll assimilation is very weak at 1-3°C, increases in intensity with temperature, up to 30-35°C and ceases above 50-55°C. The magnitude of chlorophyll assimilation means intense metabolism, plant mass and therefore greater amounts of feed.

The distribution of plant species is based on the air temperature in the area, which can provide the sum of the temperature degrees needed by each species, by the type of soil, the thickness of the soil, the level of precipitation. These are in turn influenced by altitude.

According to the latest predictions of global climate change, the phenomenon of general warming due to human activities (deforestation, industrialization, transport) with increased carbon dioxide emissions, melting of ice caps and mountain glaciers, rising oceans, floods, aridification and desertification will have a major impact on all of humanity with unpredictable consequences, some of the most negative [10].

4. Conclusions

1. The multiannual average has increased in the last 33 years by 0.5°C (1981-2013/10.2°C), compared to the period 1901-1980 (9.6°C), this value being below

the global average warming of 0.85°C recorded in the last 100 years (1850-2012).

2. Trees are installed up to the limit where the range of average daily temperatures, above 0°C, exceeds 50% of the year, those above 5°C (limit period of vegetation) exceed 33% of the year and those above 10°C (optimal bioactive period) reach at least 20% of a year (about 75-90 days).
3. For intervals with average temperatures equal to or above 15°C (bio-active period with thermal inhibition), which are maintained up to 1000 m altitude, the duration gradient with this interval decreases by 15 days/100 m altitude.
4. The exposure of the slopes influences the climate and implicitly the grassy and woody vegetation, at the same altitudinal level on the southern slope the same climatic conditions are encountered as on the northern one 200 m higher.
5. The average temperature of the months of May-September is higher on the southern slope by 0.5°C and precipitation is higher by 82 mm compared to the northern one, which will obviously have a positive influence on the productivity of the grassy carpet and the grazing animals.
6. With increasing altitude, the soils are increasingly poorer in fertilizing elements,

increasingly acidic and unfavorable for plant growth and development.

7. The photosynthesis mechanisms carried out by plants represent the main source of oxygen for the biosphere and atmosphere, being considered the most important natural processes, because they represent the very essence of life on Earth.
8. The distribution of plant species is made according to the air temperature in the area, which can provide the sum of the degrees of temperature necessary for each species, according to the type of soil, the thickness of the soil, the level of precipitation.

References

1. Atanasiu, L. (1984): *Ecofiziologia plantelor*, Ed. științifică și enciclopedică, București.
2. Bacinschi D., Neacșa, O. (1985): *Principalele caracteristici climatice ale Carpaților românești*, Lucr. Șt. ale ICPCP Măgurele-Brașov, vol. X, pag. 33-74, Red. prop. tehn. agr. București.
3. Botnariuc, N., Vădineanu, V. (1982): *Ecologie*, Ed. Didactică și Pedagogică, București.
4. Bujorean, G., (1930): *Contribuții la cunoașterea succesiunii și întovăririi plantelor*, Bul. Grădinii și Muzeului Botanic, vol. X, Cluj – Napoca.
5. Davidescu, V., Davidescu, V. (1992): *Agrochimie horticola*, Ed. Academiei Române, București, ISBN 973-27-0306-7.
6. Drăghici, C., (1982): *Influența factorilor atmosferici asupra animalelor domestice*, Ed. Ceres, București, pag. 17, 9.
7. Florescu, I.I., Nicolescu, N.V. (1996): *Silvicultura, vol. I, Studiul pădurii*, Ed. Lux Libris-Brașov.
8. Gaceu, L., Tzortzios, S., & Gruia, R. (2006). *Continuing education in agriculture-a challenge for Information Technology, in the Proceedinds of international Conference Information Systems in Sustainable Agriculture*. Agroenvironment and Food Technology-HAICTA, 20-23.
9. Gaceu, L. (2017). Assessment method for hygienic design in food industry. Water drainage and water saving study case. Journal of EcoAgriTourism, 13(2), 53-56;
10. Gaceu, L. (2018). Comparative study on European legislation about hygienic engineering and design. Journal of EcoAgriTourism, 14(2), 42-47;
11. Gaceu, L. (2020a). Design principles for assuring food safety in Romanian mountain dairy farms. Journal of EcoAgriTourism, 16(2), 21-25;
12. Gaceu, L. (2020b). Food safety in pasteurization of liquid food-basic elements for mountain farmers. Journal of EcoAgriTourism, 16(2), 51-55;
13. Gaceu, L., Oprea, O.B. (2024). *The Short Food Chain and its Importance for Sustainable Development In Mountain Areas*. Journal of EcoAgriTourism, 20 (1).
14. Giurcăreanu C., (1988): *Populația și așezările din Carpații românești*, Ed. științifică și enciclopedică, București.
15. Goian, M. (2000): *Agrochimie*, Ed. Marineasa, Timișoara.
16. Gore, Al. (2007): *Un adevăr incomod-pericolul planetar reprezentat de încălzirea globală și posibilele măsuri care pot fi luate*, Ed. Rao International Publishing Company.
17. Gruia, R. (1998): *Managementul eco-farmelor*, Ed. Ceres, Brașov.
18. Hera, C., (editor), 2015: *Schimbări climatice globale, grija pentru resurse naturale*, Ed. Academiei Române, București.
19. Marcu M., (1983): *Meteorologie și climatologie forestieră*, Ed. Ceres, București.
20. Marușca, T. (2017): *Elemente de gradientică și ecologie montană*, Ed. Univ. Transilvania din Brașov, ISBN 978-606-19-0892-9.
21. Marușca, T., Filip, F.N. (1995): *Studii de microgradientică termică în ecosisteme forestiere și practice din Munții Apuseni*, Sesiunea ICAS-Stațiunea Brașov.
22. Marușca, T., Doniță, N. (1994b): *Aspecte de gradientică ecologică montană din Carpații României, Meteorologie, Studii și cercetări, nr. 9 (I)*, pag.75-83, INMH București.
23. Mihai, A.L.; Muțescu, M.; Negoită, M.; Horneț, G.A.; Surdu, I.; Nicula, A.S. (2022). *Nutritional Characterization of Some Romanian Mountain Products*. Ann. Univ. Dunarea Jos Galati, Fascicle VI Food Technol., 46, 104–124, DOI10.35219/foodtechnology.2022.2.08.
24. Mocanu, V., Dragomir, N., Blaj, V.A., Ene, T.A., Tod, M.A., Mocanu, V., (2021): *Pajiștile României-Resurse, strategii de îmbunătățire și valorificare*, Ed. Univ. Transilvania din Brașov, ISBN 978-606-19-1414-2.
25. Moisuc, A., Samfira, I., Carrere, P. (2001): *Pajiști naturale și exploatații ecologice*, Ed. Agroprint, Timișoara.
26. Oprea, O.B., Popovici, C., & Gaceu, L. (2015). *Aspect regarding the use of renewable energy into vegetable farms of agritouristic pensions. J. of Agricultural Informatics*, 6(1). <https://doi.org/10.17700/jai.2015.6.1.156>
27. Oprea, O.B., (2024). *Sustainable Vegetable Farming in Mountain Regions: Challenges, Innovations, and Economic Opportunities*, J.

- of EcoAgriTourism, <http://dx.doi.org/10.2139/ssrn.5106932>
28. Pencheva, M., Petkova, Z., Dincheva, I., Kostova, I., Damyanova, S., Stoyanova, A., Gaceu, L. (2022). *Phytochemical and biological profiles of fennel fruits (Foeniculum vulgare Mill. var. dulce Mill.)*. Carpathian Journal of Food Science and Technology.
29. Pop A. (2004): *Fiziologie vegetală*, Ed. Walddpres, Timișoara.
30. Puia, I., și colab. (1980): *Pajiștea ca ecosistem, Stațiunea centrală de cercetări pentru cultura pajiștilor Măgurele- Brașov – 10 ani de activitate*; Casa Agronomului, Brașov.
31. Samfira, I., Moisuc, A. (2007): *Ecopratotehnica*, Ed. Eurobit, Timișoara.
32. Stevenson, F. J., Cole, M. A. (1999): *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Micronutrients, Second edition*, John Wiley & Sons, Inc. New York.
33. Stoenescu, M.Ș., Țișteea, D. (1962): *Clima României, vol. I*, Institutul Meteorologic București.
34. Șumălan, R. (2006): *Fiziologie vegetală*, Ed. Eurobit, Timișoara, ISBN 973-620-199-6.
35. Țișteea D., și colab. (1974): *Variația altitudinală a principalilor parametri climatici din zona Bilea-Capra din masivul Făgăraș*, *Studii de climatologie, vol. I*, IMH București.
36. Țucra, I., Neacșu, Marcela, (1985): *Aspecte privind caracterizarea, cartarea și bonitarea pajiștilor permanente (naturale)*, L. Șt. ale Institutului de Cercetare și Producție pentru Cultura Pajiștilor Măgurele-Brașov, Vol. X, București.
37. Țucra, I., și colab. (1987): *Principalele tipuri de pajiști din RS România*, Redacția de propagandă tehnică agricolă, București.
38. Voina, V. (2005): *Valoarea pastorală a pajiștilor permanente și pajiștilor împădurite din zona Caransebeș*, Teză de Doctorat, Timișoara.
39. *** <https://www.usab-tm.ro/rezumat/REZUMAT%20TEZA%20HARMANESCU.pdf> / Hărmănescu, M. (2009): *Influența fluxului de substanță asupra calității furajelor din pajiști*, Teză de doctorat, Facultatea de Agricultură - Univ. de Științe Agricole și Medicină Veterinară a Banatului din Timișoara.

SEARCH DATA ANALYSIS IN TOURIST WEBSITE VISITATIONS FOR TOURIST TRANSPORT SERVICES

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Abstract: The article presents the online tool used for enhancing a website visibility in search engines that provide tourist transport services. Achieving favorable positions in search engines results is called search engine optimization. The Google Analytics reports are used in the paper to provide the relevant information regarding the interest of visitors relative to the information presented on the car rental website. The article presents the data analyzed for a car rental website from Romania.

Keywords: Google analysis, car rental, search results, tourist visitation, SEO.

1. Introduction

Tourism is based on transport possibilities and varieties of traveling which consists as one of the fundamental part of the tourism system. [1] Therefore, tourists travel by different means to various destinations and the mean of transportation is the foundation for the touristic service. The invisible link between transport and tourism can be presented by two major categories: the tourism and the transport.

The “act of tourism” happens when tourists depart from their residential place, known as the “place of origin” or “origin” to take a trip to another destination, outside of their usual environment (work, school, etc.), also called a “tourism destination”, or simply “destination”. [2]

Transport is essential in tourism because it connects the residence of the tourist to the tourist service destination. Transport has also a service side as it can offer tourists a variety of services that can make easier the connection between airport and the hotel, from the hotel to the site seeing or in the case of multiple destinations, transports the burden of luggage to the next accommodation arrangement. [3]

Road transport is the main route of carrying out tourist traffic, both domestically and internationally. [8] It is carried out using coaches, minibuses and cars. Coaches and minibuses are used in organized forms of tourism for collective transport and are managed by tourism organizers. A successful vacation depends on a successful transport service. An important step to achieve

this goal is the tourist's choice of an appropriate road transport service, and this is achieved by accessing a website. [5]

The main purpose for which a website is built as an e-tourism tool is to transform website visitors into beneficiaries of tourist services and thus generate profit. In fact, a very good website, that is unknown, it practically does not exist. It is like an excellent "bait" but completely unknown to the fish. Initially, tourists who access the website are just visitors, but if their expectations are satisfied by the website's offer, they can turn into customers. [3] Search engines help users to find the things they are looking for online. The user enters a word or phrase, called a query, and the search engine displays a set of results relevant to that query. It is important to know that 99% of visitors who arrive at a website DO NOT look further than the second or third page of results. These details speak for themselves. If the website is not on the first, second or maximum third page of search results, the site is practically unreachable for potential customers.[5]

2. SEO Methods for Favorable Website Positioning in Search Engines

Search Engine Optimization, also known as SEO (Search Engine Optimization), is the method of updating the content of a website so that search engines can find it in relation to the search words used by the human user. [7] SEO not only increases the likelihood that the website will be found when someone searches for it directly, but also makes it easier to investigate

what are visitors searching for when looking for travel services such as geographic destinations and desired touristic experiences. [4]

SEO is a tool used in marketing, that can bridge the gap between search engines and their search algorithms and on the other side the Internet visitor that is doing the search. This tool can improve greatly the contents of websites to be tailored to the information sought by human visitor. Some SEO techniques may involve optimizing the source code of a website, without making these changes visible to visitors. These could be as: hierarchizing the structure of the site, enhancing the capabilities of the search engines to fully index the site. Other more visible efforts would be the inclusion of unique content, which is easily indexed and extracted from websites by search engines. The optimization process of indexing websites begins from the source code of the site, and is the foundation for the future development and the way the website will present the information. [6]

There are many ways to increase a website's position in search engines. There are mainly two major types of possible optimizations: content-level optimizations and optimizations by including it in directories and obtaining links to its own site. An evolved web interface must emphasize the keywords it wants to exploit.

Proper SEO means continuously refreshing the HTML code (the code hidden behind the text) and using targeted phrases or keywords throughout the site. Careful placement, formulation and analysis of keywords that are directly relevant to the words a visitor uses in the search engine can lead to optimal search engine ranking. For proper SEO, quality content on the site is vital. It must meet the following conditions:

- there must be no duplicates (it attracts a drastic penalty in the ranking a search engine algorithm creates);
- it must be written as naturally and simply as possible (if a child understands the text, search engines will certainly understand it);
- the frequency of "keywords" within the content must be natural, their excessive use may lead to the activation of a "spam" filter and as a result, to downgrade the rank of the website in the results list generated by the search engine.

The use of reciprocal links increases the number of visitors who reach websites. These links are addresses, destinations, links to any "corner" of the Internet and represent the easiest technology to use and understand. Posting links on external websites is extremely important. Currently, the Google search engine places great emphasis on posting links that lead to the main website.

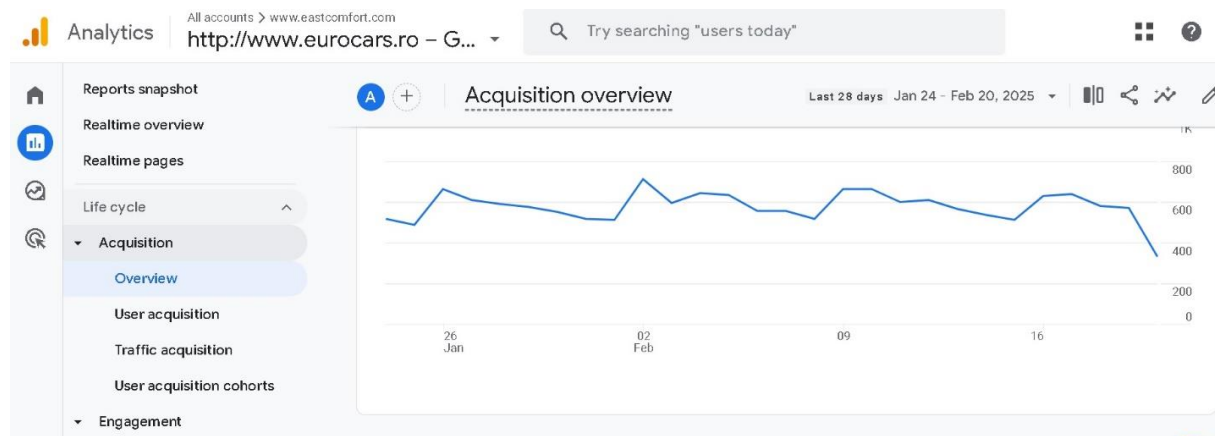


Fig. 1. Example of Google Analytics reports

Links are of two types: external links, those added on websites other than the one we own, and internal links, which are those to the internal pages of the website we own. The more known a person is to many other people, the easier it is for them to enter the "celebrity" category. The same applies to the website we want to promote: the more websites our website link appears on, and especially on quality websites in the same field,

the more it will be a "star" in search engines results list. It is very important on which websites the link is posted. If they are spam websites, inciting violence, pornographic websites, then they will be known in the bad world and therefore will be penalized and removed from the search results.

3. Getting proper SEO by using the Google Analytics graphical interface

One of the best services for monitoring traffic and performing deep analysis of data is the Google Analytics software. Through this tool, is possible to analyze complex reports about visitor activity on a website or in the search engine. For all the data provided, one can perform "Cross Segment" analyses, by isolating reports on certain segments: traffic sources, keywords, visitor, country, city, new visitors and many others. Both Google Analytics and other similar tools use a suite of specific terms, some of which are explained below.

Google Analytics can answer the following questions: Where do visitors come from and what activities do they undertake on a website? How could a websites convert more visitors into customers? What keywords have an effect on potential customers, leading to conversions? Which online ads or advertisements are the most

effective? What is the reason why visitors leave the website without taking the desired action? Are the website design elements turning visitors away? What is the website content that visitors are most interested in? Google Analytics generates various detailed reports on topics chosen by the website developer.

Figure 1 shows an example of a report dashboard for a leading Romanian website. Analyzing trends is a way to determine the difference between an increase in visits and an increase in webpage views for a visitor.

4. Results obtained with Google Analytics and their relevance for SEO

It is important for the SEO optimization of the website to know as much information as possible about the behavior of visitors. For the website to be analyzed, an off-season reference period was established (between January 24, 2025 and February 28, 2025).

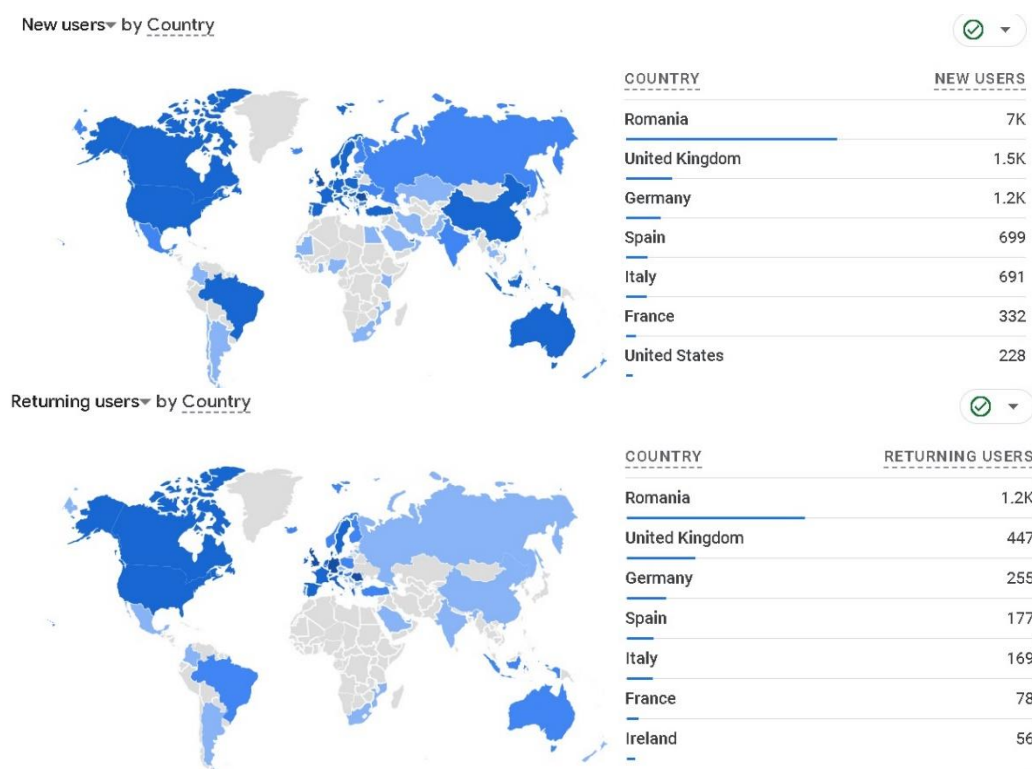


Fig. 2. *New visitors and returning visitors*

An important aspect for SEO is the ratio between new visitors and returning visitors. In figure 2 it is represented the new visitors in the upper part, and the recurring (returning) visitors in the second image. A high number of new visitors suggest that traffic is being successfully generated to the site, and a large number of

recurring visitors suggests that the site has enough exciting content to make visitors return. The increase in visitor traffic shows the success of the SEO measures carried out on the website. It is also an advantage to know the countries from which visitors come because SEO measures can be taken to increase traffic from areas with fewer

visitors. For example, in figure 2 we can see that the number of visitors from France is lower. One measure for increasing the number of visitors from this country is to increase the density of French keywords. Another series of important reports for SEO optimization are those grouped in the traffic sources window. These are information about different types of sources that provide traffic to the site to be analyzed. Direct

traffic represents visits from users who clicked on a bookmark to access the site or who typed the site's URL directly into their browser.

Referral sites show visits from users who, to access the site, clicked within another site. The search engines section shows visits from users who, to access the site, clicked on one of the search results provided by a search engine.

Table 1. Reports on Internet visitor searches for travel website

Session primary...Channel Group) ▾ +		↓ Sessions	Engaged sessions	Engagement rate	Average engagement time per session
☒	Total	20,673 100% of total	13,706 100% of total	66.3% Avg 0%	1m 36s Avg 0%
☒	1 Organic Search	13,707	9,796	71.47%	1m 48s
☒	2 Direct	3,292	1,704	51.76%	1m 17s
☒	3 Paid Search	3,105	1,892	60.93%	1m 12s
☒	4 Unassigned	294	23	7.82%	2m 23s
☒	5 Referral	250	160	64%	2m 11s

Several reports on visitor searches are presented in table 1, and the same information can be represented in graphical form, as seen in figure 3. For example, we also find the paid search report which shows the number of visitors who arrive on the website as a result of paid ads. But the most important report for SEO optimization is

the Organic Search report. In fact, this is the goal of SEO, to raise the website to higher position in organic searches that are unpaid ones. The values obtained and the possibility of comparing them over certain periods of time show again the success SEO actions.

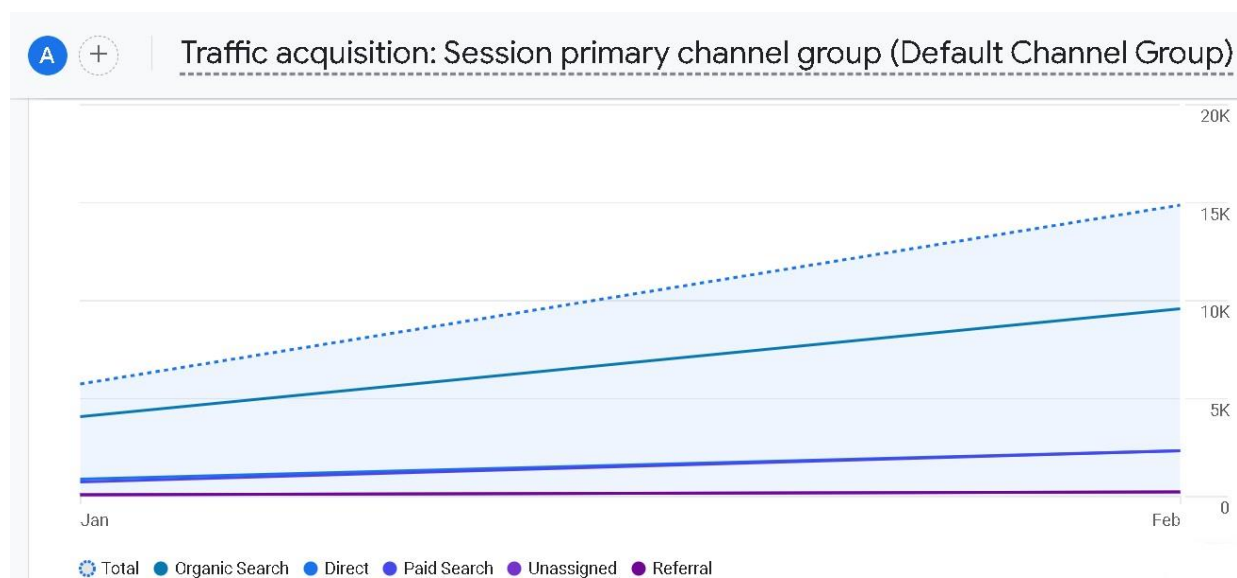


Fig. 3. Sources of visitor traffic for the travel website

5. Conclusions

Monitoring the actions the visitors make on a website is a key parameter in achieving a proper SEO in order to increase the number of visitors for a website. The Google Analytics reports are used in the paper to provide the relevant information regarding the interest of visitors relative to the information presented on the car rental website. Key information presented is related to the countries from which visitors come, the time visitors spend on the website, the traffic sources, how many new visitors arrive on the website and how many are returning visitors. This crucial information is used in specific SEO methods for website development and new measurements can be made to see the impact of changes made and their effectiveness.

References

1. Boian, N., Diagnosis of Tourism Enterprises. In: Journal of EcoAgriTourism, vol. 10(2), pp. 66-70.
2. Bucsa, S., Gaceu, L., Travel and tourism terminology and document databases, essential tools for handling specialized knowledge and professional communication. In: Journal of EcoAgriTourism, 2009, Vol. 5, No. 1, 36-42 ref. 6.
3. Cismaru, L., Ispas, A., Improving the Profile of the European Tourist Destinations through the European Tourism Indicators System. In: Bulletin of the Transilvania University of Braşov, Series V, vol. 8(57), no. 1, pp. 87-94 – 2015 2014.
4. Danila, D. M., & Gaceu, L. (2010). Online Evaluation Method for Assessing the Variation of the Number of Tourists Interested In Car Rental. Bulletin of the Transilvania University of Brasov. Series II: Forestry• Wood Industry• Agricultural Food Engineering, 75-78.
5. Fang, W: Using Google Analytics for Improving Library Website Content and Design. In : J. Library Philosophy and Practice (2007) No. 9(3), p.1–17.
6. Foris, D.; Crihalmean, N.; Foris, T. Exploring the Environmental Practices in Hospitality through Booking Websites and Online Tourist Reviews. Sustainability 2020, 12, 10282.
7. Phippen, A., Sheppard, L., Furnell, S. (2004): A Practical Evaluation of Web Analytics. In: Internet Research (2004), No.14(4), p. 284-293.
8. Tejaswi Dubashi, Adwords Learning, Google Adword Learning Center, Published on February 2017.
9. THIERHEIMER, W. et al. Risk Arising from Transport Activities. Environmental Engineering & Management Journal (EEMJ), [s. l.], v. 9, n. 12, p. 1667–1670, 2010.

RESEARCH ON THE PRODUCTION AND PROMOTION OF A LACTIC ACID PRODUCT: AYRAN WITH LIME AND PEPPERMINT ESSENTIAL OIL

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Abstract: Acidic dairy products are considered dietary products, a trustworthy "source of health", having an essential curative role, being recommended in the nutritional treatment of various conditions, such as gastrointestinal, liver, and kidney diseases, obesity, etc. Thus, the present study resulted in the development of a dairy product, Ayran with lime and mint, as a healthy alternative to soft drinks. A questionnaire was applied to identify consumers' perception of the product. Also, the physicochemical and sensory analysis of the product was carried out to determine the effect that lime juice and mint oil have on the product. The results showed that consumers are interested in this type of product, and when choosing a product, consumers generally take into account the ingredients it contains. The addition of lime juice and mint oil led to an increase in the acidity of the product and a decrease in the water activity of the product.

Keywords: Ayran with lime and mint; dairy drink; consumer acceptance.

1. Introduction

Long-term economic development is based on sustainability, innovation, and circularity. Economic agents must constantly keep up with the latest trends in the field. At the same time, they must focus on the well-being of all partners: employees, customers, community, shareholders, etc. [2, 3]. Consumers are looking for minimally processed food products, which have a clean label and ingredients that bring health benefits. Moreover, in recent years, there has been an emphasis on the development of sustainable food products, which minimize the impact on the environment and implicitly on human health. In the context of sustainable development, the development of circular products is also aimed at achieving sustainable development goals such as "Development of a circular economy, with an emphasis on waste reduction and efficient recycling." "Sustainable economic growth, based on innovation and energy efficiency" [4, 5].

Ayran is the name of a Turkish drink made from yogurt, water, salt, and other ingredients. This drink is very refreshing and can successfully replace juices consumed during meals, especially with meat or spicy dishes. The quality of the yogurt used in the production of Ayran dictates the quality of the finished product. A bacterial culture of *Lactobacillus bulgaricus* and

Streptococcus thermophilus is usually used to prepare the yogurt; the amount of culture used and the dominant microorganism can influence the quality of the product. Furthermore, bacterial cultures can be added to fermented milk products to enhance product functionality or to improve some sensory characteristics, such as flavor [11, 13]. Even so, the choice of the percentage of water for dilution and the salt concentration was chosen to achieve optimal consistency and to prevent serum separation during storage, since increasing the levels of water and salt added led to greater serum separation [10]. The development of Ayran-type drinks with functional ingredients may spark the interest of consumers who are increasingly looking for innovative products that bring health benefits and meet sensory demands. Lime juice contains glucose, fructose, sucrose, organic acids such as citric acid and malic acid, in the highest proportions, amino acids and flavonoids, coumarins and characteristic psoralens. It is about as rich as lemon in organic acids and much higher than orange and grapefruit, poorer in sugars than they are. Although the taste is more acidic and less sweet than orange or grapefruit, lime juice has about the same acidity as lemon juice, but it is different in terms of phenolic compounds [9, 12]. Mint is an aromatic, medicinal plant widely used in industries such as

the food industry, the perfume industry, and the pharmaceutical industry, due to the phenolic compounds that this plant contains and which confer antioxidant, antifungal, antibacterial, antiviral, and other biological properties [7].

Essential oils are concentrated extracts from various plants that retain their original aroma and flavor. They can be extracted using a variety of methods, including mechanical or distillation processes [8]. The concept of new product design starts from the needs and requirements of consumers, based on the requirements of daily life. This concept includes not only the design of a new product, but also its functionality [1]. An important aspect that must be taken into account when a product is to be designed is the association and match between the flavors of several ingredients that are to be mixed and the association that the product is to have, depending on its final destination (when the final purpose of the product is to be consumed with other foods) [6]. Consumer perception of a new product must be studied before introducing this product to the market, and the questionnaire can be an effective method to investigate this [15, 16]. The objective of this work was to develop a recipe for lime and mint ayran as an alternative soft drink. To this end, the perception and acceptability of the product by consumers were monitored through a questionnaire, as well as the analysis of the product from a physicochemical point of view to identify the effects that lime juice and mint oil have on the product during storage.

2. Materials and Methods

2.1. Preparation of the ayran sample

Cow's milk was purchased from a farm near the city of Sibiu, Romania. The milk was processed according to the technology of obtaining yogurt, being pasteurized at a temperature of 90°C for 20 min, followed by cooling the pasteurized milk at a temperature of 46°C, being seeded with a culture of Hansen-type lactic acid bacteria containing two thermophilic microorganisms, namely *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. The seeded milk was divided into two equal parts and placed in plastic vessels and subjected to the thermostating operation, which was carried out at a temperature of 42°C, for 2 hours and 45 min, after which it was subjected to a cooling operation to obtain a coagulum as firm as possible and of a sure consistency. After 12

hours, a 700 g yogurt sample was mixed with 300 ml water, 25 g salt, 30 ml lime juice, and two drops of peppermint oil purchased from a pharmacy. The products were stored at a temperature of 60°C. The samples were scored as follows:

- Ayran ;
- Ayran LM (lime and mint ayran sample).

2.2. Analysis methods

Applying a questionnaire to identify consumer expectations

A questionnaire is a research instrument consisting of a series of questions and other requests to gather information from people. They are often designed to analyze the statistical responses. We conducted a questionnaire to observe the desires and preferences of consumers regarding the innovative dairy product Ayran with lime and peppermint essential oil. Fifty-five people responded to this questionnaire. The questionnaire was launched on social media.

Sensory analysis

The evaluation of each organoleptic characteristic was carried out by comparing it with a 1...5 point scoring scale and obtaining the average score given by the group of 5 tasters. For each organoleptic characteristic (appearance, color, taste, smell, consistency) that is analyzed and is noted in the analysis sheet, ratings are given from 5 (excellent) to 1 (unsatisfactory).

Titrateable acidity

In a 100 ml Erlenmeyer flask, 10 ml of the lactic acid product is introduced. 20 ml of warm distilled water is passed through the pipette used for dosing the sample, and 3 drops of phenolphthalein are added [14]. The sample is thoroughly mixed and then titrated with sodium hydroxide, 0.1 n solution, under continuous stirring, until the appearance of a pink color, which must persist for 30 seconds. The acidity expressed in Thörner degrees (°T) is calculated using the following formula:

$$\text{Titrateable acidity } ^{\circ}T = V \times 10 \quad (1)$$

Where: V – Volume of sodium hydroxide, 0.1 n solution used in the titration, in ml; 10 – Volume of the product taken into work.

Determination of lactose content by the polarimetric method

75 ml of dairy product is treated in a 100 ml flask with 7.5 ml of 20% sulfuric acid. Then 7.5 ml of

mercuric iodide solution is added, made up to 100 ml, shaken, and filtered on a pleated filter [14]. Polarimetry is done in a 20 mm tube at 200 in the penumbra apparatus, divided into degrees of a circle. The lactose content is calculated with the relationship:

$$\text{Lactose content, \%} = \frac{\alpha \cdot 100}{[\alpha]_D^{20} \cdot 2} \quad (2)$$

Where: α – angle read at the polarimeter

$[\alpha]_D^{20}$ – specific rotation of lactose equal to +52.53; 2 – length of the polarimeter tube, dm

Determination of water activity

The water activity was determined using the "Novasina" apparatus. The homogeneous sample was placed in special plastic vials, after which the vials were placed one by one in the apparatus, where the water activity in the product was determined [14].

Statistical Analysis

The Ayran samples were stored for 18 days, and analyses were performed on days 1, 9, and 18. Each determination was performed separately, and the results were plotted as mean $\pm$ standard deviation using Minitab software. Analysis of variance was applied to determine whether there were significant differences over the storage period and whether the sample was significantly affected by the passage of time.

4. Results and discussion

Results of applying a questionnaire to identify consumer expectations

The following questions were applied to the participants. The answers provided by the respondents were graphically represented and analyzed.

1. What is your occupation?

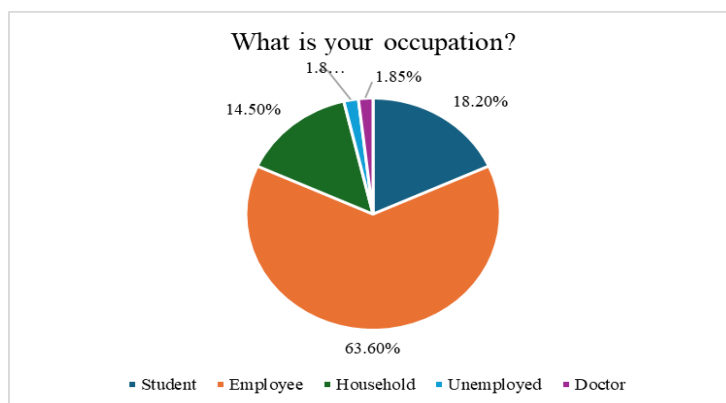


Fig. 1. The ratio between occupations

55 people with different occupations answered the questions. As can be seen in Figure 1, 63.6% (35 people) were employees, 18.2% (10 people) were students/master's students, 14.5% (8 people)

were housewives, and the rest had other occupations (1 doctor, one person unemployed).

2. How old are you?

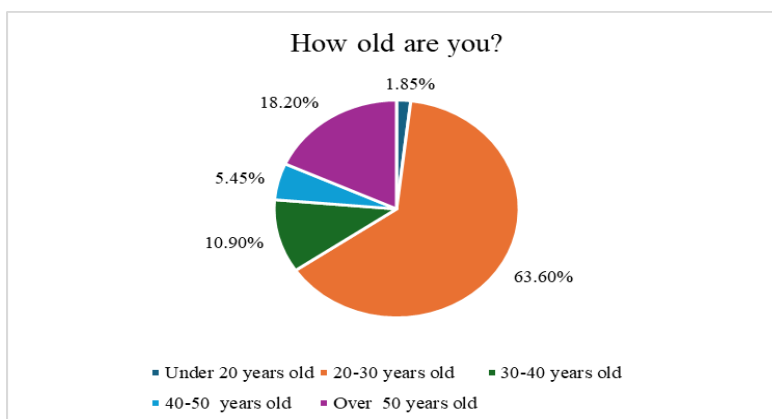


Fig. 2. The ratio between ages

Of the total number of people who responded to the questionnaire, according to the Figure 2, the majority are between 20-30 years old (63.6%, i.e. 35 people), over 50 years old (18.2%, i.e. 10 people), between 30-40 years old (10.9%, i.e. six

people), and the rest are between 40-50 years old (3 people) and under 20 years old (1 person).

3. Do you come from a rural or urban area?

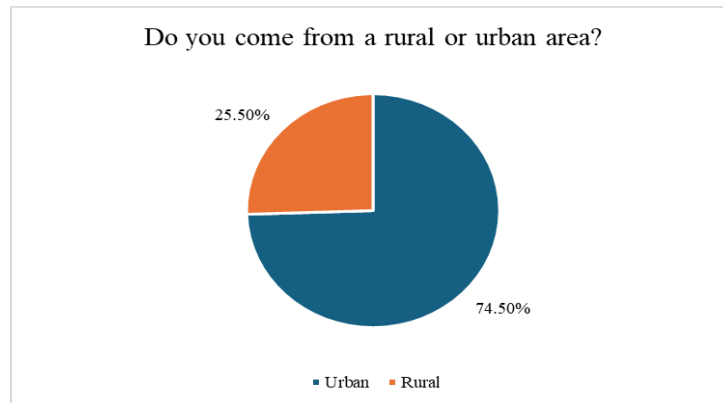


Fig. 3. *The relationship between urban and rural areas*

According to Figure 3, 74.5% (41 people) of the respondents live in urban areas, and the remaining 25.5% (14 people) live in rural areas.

4. What is your average monthly income?

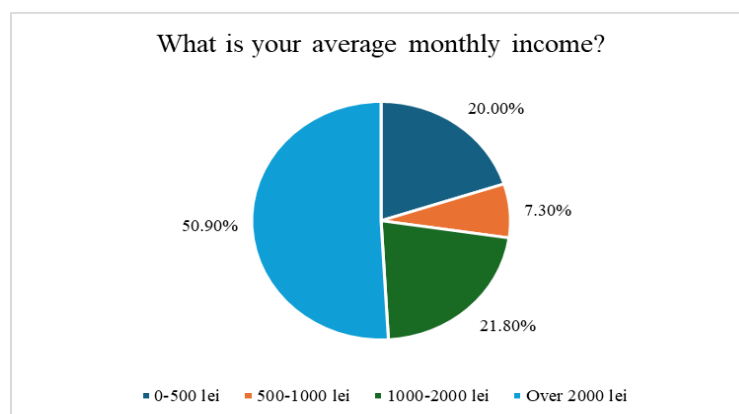


Fig. 4. *Monthly income ratio*

According to Figure 4, 50.9% of people have incomes over 2000 lei, 21.8% have incomes between 1000 and 2000 lei, 20% have incomes

between 0 and 500 lei, and 7.3% have incomes between 500 and 1000 lei.

5. How often do you consume dairy products?

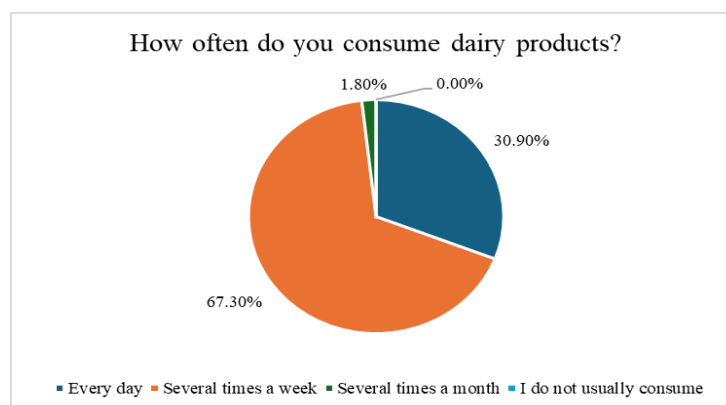


Fig. 5. *Frequency ratio of dairy product consumption*

From Figure 5, it can be seen that the majority consume dairy products several times a week (63.7%), others every day (30.9%), and one person consumes several times a month.

6. What are the reasons why you consume dairy drinks?

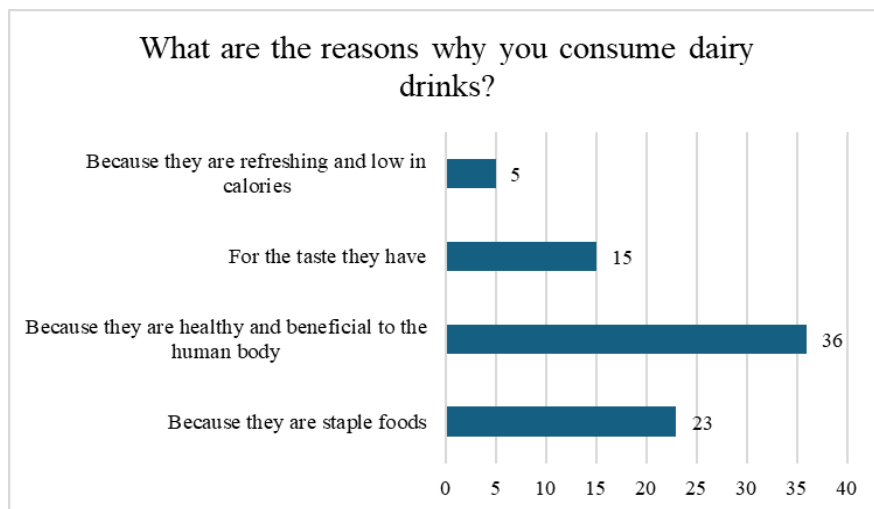


Fig. 6. Dairy beverage consumption motivation report

According to the graphic Figure 6, 41.8% of consumers consume dairy drinks because they are a staple in their diet; 65.5% consume them because they are healthy and beneficial to the body; 27.3% consume them because of their

taste, and 9.1% because they consider them refreshing and help with weight loss.

7. As a dairy consumer, would you be willing to try an innovative dairy product?

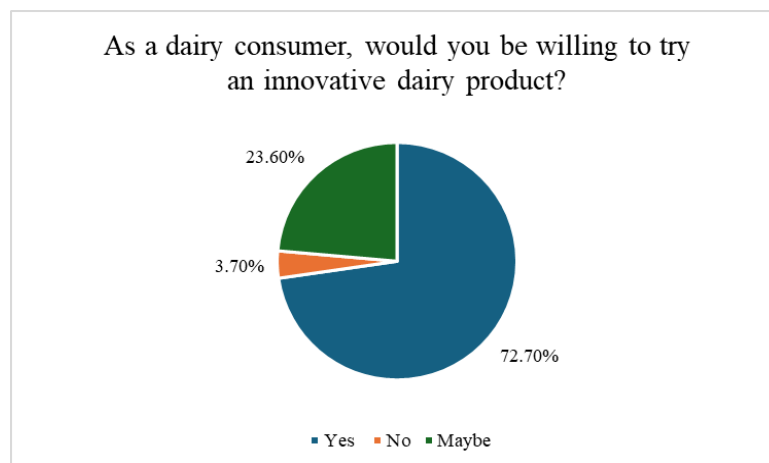


Fig. 7. Product purchase report

To the question above, illustrated in Figure 7, the answers were mostly positive; 40 people voted that they would purchase such a product, two people would not purchase it, and 13 people answered that it would be possible to buy it.

8. On a scale from 1-5, how would you rate the Ayran dairy product with lime and peppermint essential oil (1=lowest, 5=highest)?

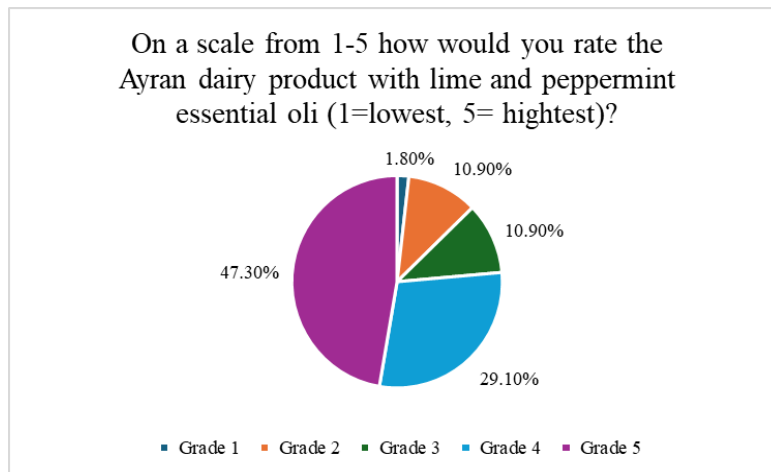


Fig. 8. *The ratio of the ratings*

Figure 8 shows that most consumers rated the product with the maximum score of 5 (26 people) out of a total of 55. The others voted as follows: 16 people rated it with a score of 4, 6 people rated it with a score of 3, 6 people rated it

with a score of 2, and one person rated it with a score of 1.

9. How much would you be willing to pay for this product?

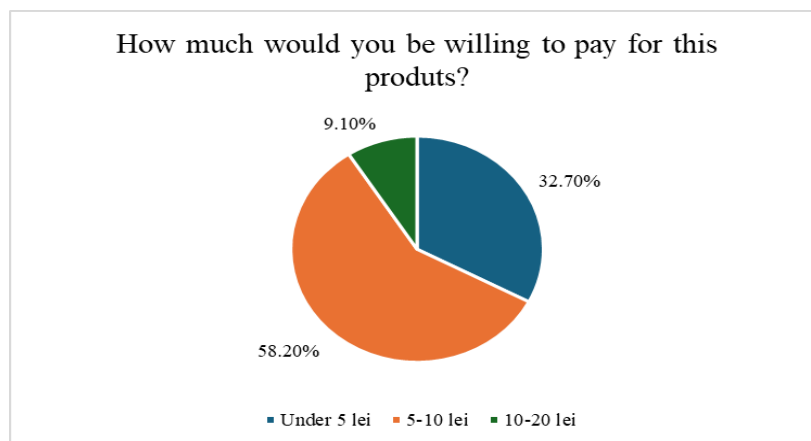


Fig. 9. *Price ratio for this product*

According to Figure 9, 18 people (32.7%) would prefer a price below 5 lei for such a product, while 32 people (58.2%) would be willing to pay between 5 and 10 lei, and the

remaining 5 people (9.1%) would be willing to buy for 10-20 RON

10. What do you keep in mind when buying such products?

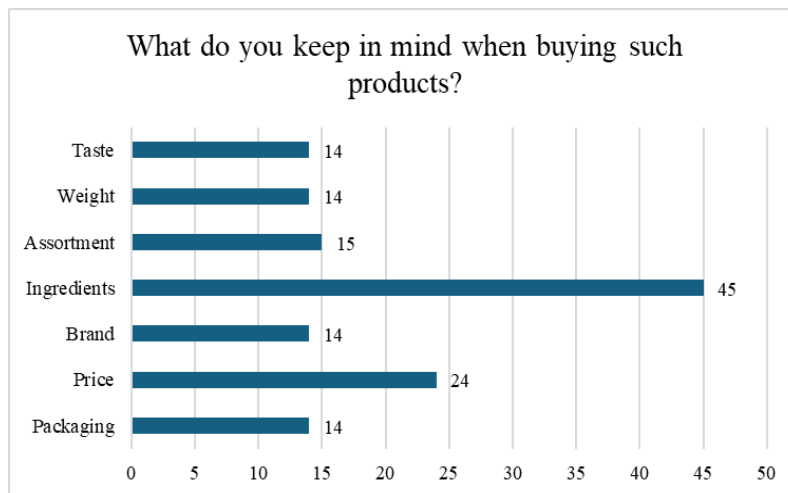


Fig. 10. *The ratio of reasons for purchasing such products*

From the graphic Figure 10 above, it can be seen that ingredients are the most important to 81.8% of people. Also, price influences consumers' purchasing decisions to the extent of 43.6%, while packaging, brand, and weight influence 25.5% of consumers. The type of

assortment is essential for 27.3%, and taste for 3.6% of consumers.

11. What do you consider to be the appropriate weight for this type of product?

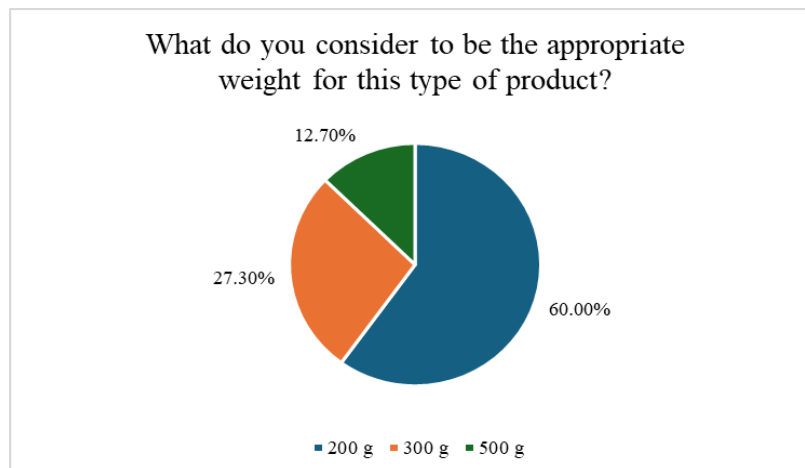


Fig. 11. *The ratio between the weights*

As can be seen in Figure 11, 33 people (60%) considered that the appropriate weight for this product is 200 g, 15 people (27.3%) would prefer

the product to be 300 g, and 7 people (12.7%) would choose the weight of 500 g.

12. Where would you be willing to buy this product?

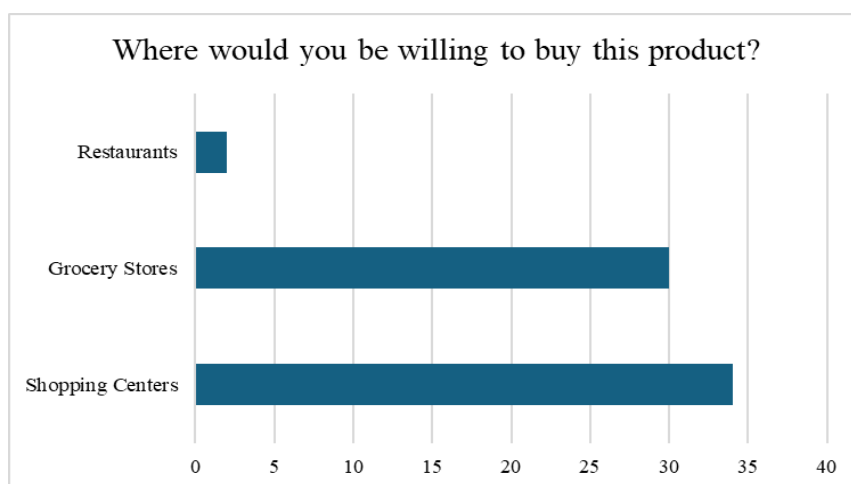


Fig. 12. Place of purchase report for this product

According to Figure 12, 34 people (61.8%) preferred to buy the product from shopping centers, while 30 people (54.5%) preferred to buy from grocery stores. The remaining 2 people (3.6%) would like to buy from a restaurant.

Sensory analysis

As can be seen in the Figure 13, after sensory examination in terms of appearance of the control

sample (Ayrar) and the Ayrar sample with the addition of lime and volatile peppermint oil (Ayrar LM), over a storage period of 18 days, the following observations were made: the ayrar with lime and mint obtained the highest marks during the analyzed period compared to the control sample, and also on the last analyzed day, the products change their appearance, due to the appearance of a larger amount of whey.

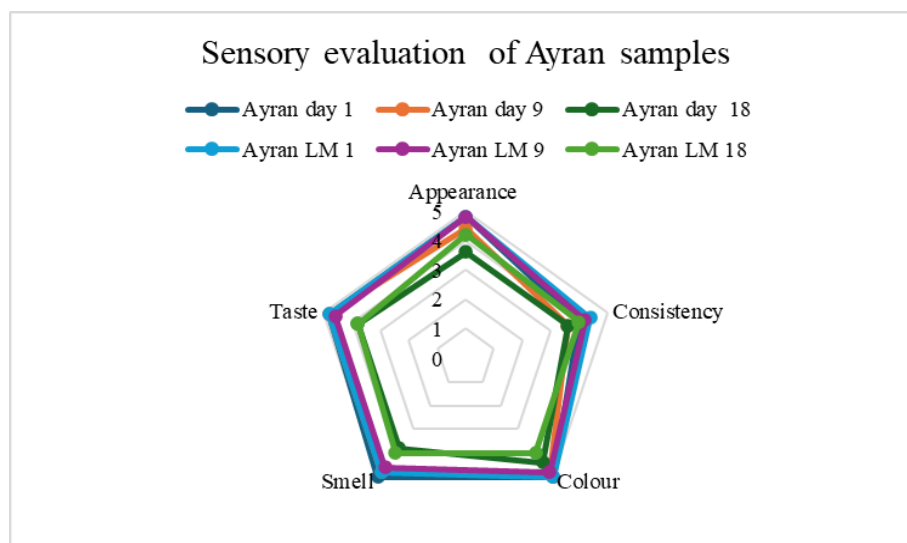


Fig. 13. Sensory evaluation of the Ayrar samples

The consistency of the two types of yogurt changed from the first day, when they received high scores from the tasters. On day 18, the products begin to show defects in the consistency characteristic due to the increased syneresis process, especially for ayrar with lime and mint.

Analysing the presented data, it can be noticed that the colour of the ayrar with lime and mint oil was not to the liking of the tasters during the analysed period; for this reason, it obtained a lower score than the control sample. Regarding

the evolution of the smell of the analyzed products, we can observe that the ayrar with lime and peppermint oil has a pleasant smell on the first day of analysis. Also, with the passage of storage time, there is a decrease in grades, especially on the last day, because they feel a more pungent smell of lactic acid, due to the increase in the larger amount of lactic acid. The score for the sample's taste also decreased over time. In the first analysis periods (day 1 and day 9), both products received high scores. The

control sample had a pleasant sour taste of lactic fermentation, and the ayran had a refreshing taste due to lime and peppermint oil. At the end of the analyzed period, the scores decreased because the

increase in lactic acid levels influenced their taste.

Analysis of physical-chemical parameters
Titratable acidity

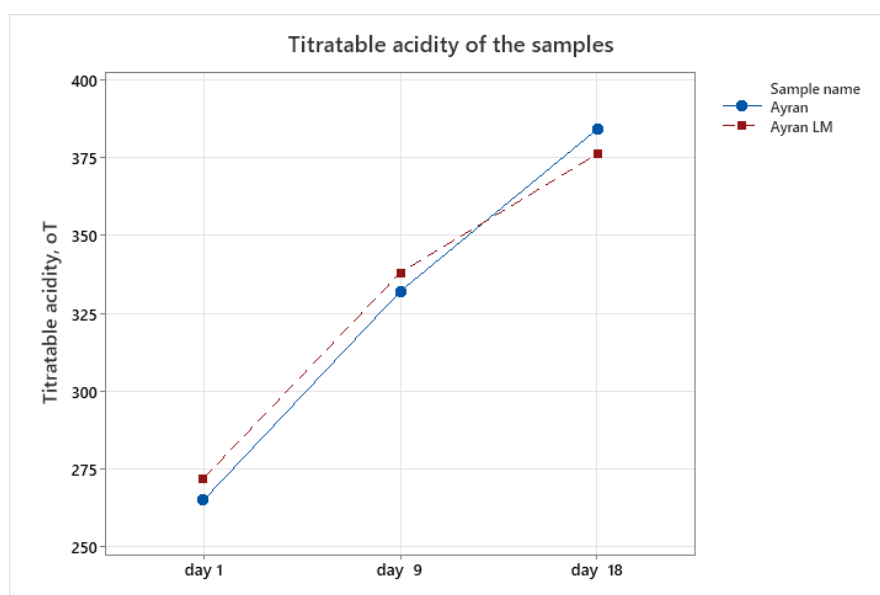


Fig. 14. Evolution of Titratable acidity of the Ayran samples

During the 18 days of storage, we observed an increase in acidity (Figure 14) for both samples because the lactic acid resulting from lactic fermentation produced by lactic bacteria that act

on lactose participates in the formation of the taste/aroma of acidic dairy products.

Determination of lactose content

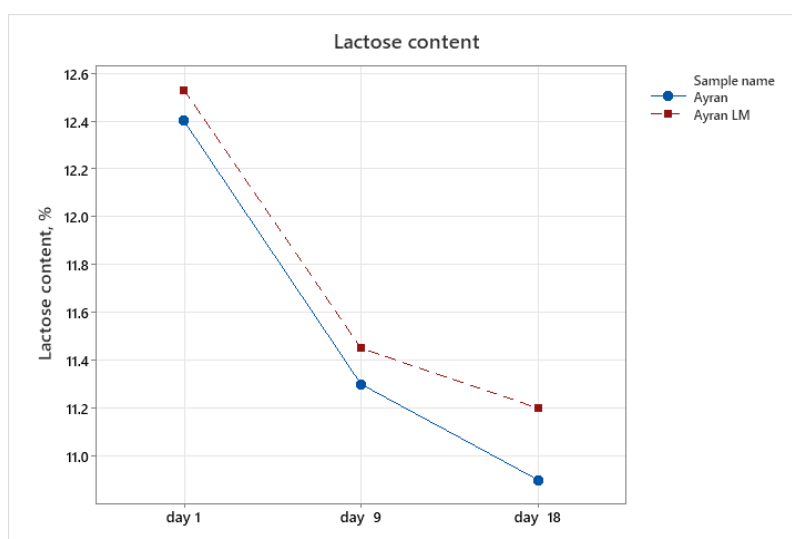


Fig. 15. Evolution of lactose content of the Ayran samples

It is observed from Figure 15 that for the analysed period, the lactose content decreases for both analysed samples, due to the fermentation process that takes place, specific to the fermented dairy products.

Determination of water activity

From Figure 16, it has been observed that over time, a more intense activity of microorganisms takes place. This leads to the appearance of syneresis (removal of whey), which also leads to an increase in water activity for both products analyzed, more intense for yogurt than for ayran.

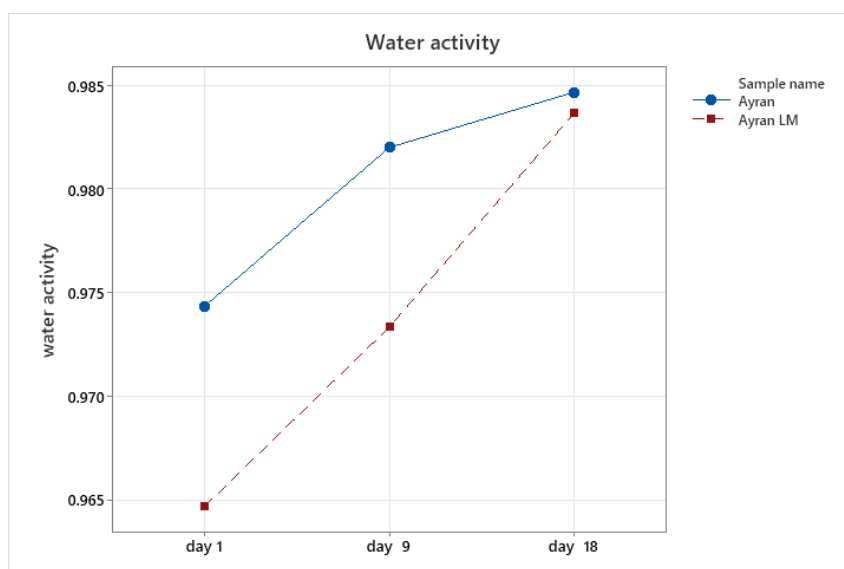


Fig. 16. Evolution of water activity for the Ayran samples

ANOVA statistical analysis results

From Table 1, it can be seen that there are significant effects ($p < 0.05$) of the addition of peppermint and lime volatile oil on yogurt, and that the samples are affected by the passage of time during the storage period. As can be seen in

Table 2, Tukey post-hoc analysis shows that, statistically, the results expressed as mean and standard deviation for the entire storage period for the two samples were classified as belonging to the same group for acidity and to different groups for lactose and water activity.

Table 1. ANOVA results

Coefficients		Titrateable acidity, oT	Lactose content, %	Water activity, a_x
Sample type	F -value	0.560	6.980	15.320
	p-value	0.467	0.019	0.002
Day of analysis	F -value	844.450	136.800	26.570
	p-value	0.000	0.000	0.000

The lactose content was higher overall for the Ayran LM sample; this may indicate that the activity of microorganisms to decompose lactose into lactic acid was slowed down during the storage period by the lime essence and

peppermint volatile oil. Also, this sample presented a lower water activity compared to the untreated sample, resulting in a slower degradation of this sample during the storage period.

Table 2. ANOVA post-hoc test Tukey

	Titrateable acidity, °T	Lactose content, %	Water activity, a_x
Ayran	109.56±17.24 ^a	3.84±0.22 ^b	0.98±2.99 ^a
Ayran LM	109±15.21 ^a	3.91±0.20 ^a	0.97±0.008 ^b

4. Conclusion

According to the questionnaire, most people decided to buy the Ayran product with lime and volatile peppermint oil. They also voted where they would buy such a product, from malls or grocery stores. The final opinions on the questionnaire were positive, stating that the innovative product would be a good and superb choice for the summer, an interesting idea, and would be curious to try.

The sensory characteristics were influenced by the storage period, so at the beginning the tasters scored high scores for both samples, but towards the end of the periods the grades decreased, mainly due to the fermentation process. As a result of the fermentation processes that take place, the acidity increases, the lactose decreases, and the water activity increases, along with the storage

period, negatively influencing the quality of the analyzed products.

References

1. Altay, F. (2017). Rheology and Functionality of Ayran—A Yogurt Drink. *Yogurt in Health and Disease Prevention*, 295–305.
2. Bătușaru, C. (2019). Sustainability of the Small Business Environment In Romania In The Context of Increasing Economic Competitiveness. *Manag. Sustain. Dev*, 11(2), 1-5.
3. Bătușaru, C., & Rădoi, A. (2022). Sustainable value of companies. *Manag. Sustain. Dev*, 14(1), 10-15.
4. Bătușaru, C., & Sbârcea, I. (2023). Harmonizing Circularity: Romania's Progressive Efforts Towards Circular Economy Integration In Europe. *Manag. Sustain. Dev*, 15(1), 62-74.
5. Celac Sergiu, & Vădineanu Angheluță. (2018). Strategia națională pentru dezvoltarea durabilă a României 2030.
6. Eschevins, A., Giboreau, A., & Dacremont, C. (2018). Effect of aromatic similarity on food-beverage pairing perception when consumers' attention is focused on aromas of interest. *Appetite*, 130, 303.
7. Hedayati, S., Tarahi, M., Azizi, R., et al. (2023). Encapsulation of mint essential oil: Techniques and applications. *Adv. Colloid Interface Sci.*, 321, 103023.
8. Inanoglu, S., Goksen, G., Nayik, G.A., et al. (2023). Essential oils from Lamiaceae family (rosemary, thyme, mint, basil). *Essential Oils: Extraction, Characterization and Applications*, 309–324.
9. Jungen, M., Gilcher, C., Patz, C., et al. (2025). Phenolic compounds and quantitative ¹H-NMR spectroscopy for authentication of lemon, lime, orange, and grapefruit juices. *Food Chem.*, 485, 144379.
10. Köksoy, A., & Kiliç, M. (2003). Effects of water and salt level on rheological properties of ayran, a Turkish yoghurt drink. *Int. Dairy J.*, 13(10), 835–839.
11. Ramzan, M., Nuzhat, H., Tita, M., & Tita, O. (2010). Relative Changes in pH and Acidity during ripening of Cheddar Cheese, manufactured by using *Lactobacillus Rhamnosus* as an adjunct culture. *Food Technol.*, XIV(1), 27–36.
12. Stringaro, A., Colone, M., & Angiolella, L. (2018). Antioxidant, Antifungal, Antibiofilm, and Cytotoxic Activities of *Mentha* spp. *Essential Oils. Medicines*, 5(4), 112.
13. Tamime, A., & Robinson, R. (2007). *Tamime and Robinson's Yoghurt*. Woodhead Publishing Limited.
14. Tița, M. (2002). *Handbook of Quality Analysis and Control in the Dairy Industry* („Manual de analiză și control calității în industria laptelui”). Sibiu, Romania: "Lucian Blaga" University Publishing House.
15. Tița, M., & Shamtsyan, M. (2018). Research on the Development and Implementation of an Innovative Dairy Product. *Management of Sustainable Development*, 9(2), 59–61.
16. Oprea, O.B., Tița, O., Georgescu, C. (2015). Romanian consumers behavior regarding food labeling-short analyse in the frame of Irse 318946 Project. *Journal of EcoAgri Tourism*, 11(1), 70-79.
17. Oprea, O.B., Gaceu, L. (2020). Consumer acceptance and sensorial analysis of bread with grape seed flour. In *E3S Web of Conferences* (Vol. 215, p. 01005). EDP Sciences.

STUDY ON THE PRINCIPLES OF THE NEW FOOD CULTURE SPECIFIC TO THE 21ST CENTURY

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Abstract: *The paper highlights the principles underlying food culture, as they influence not only the way we eat, but also our health, cultural identity, social cohesion and our relationship with the environment. An attempt is made to elucidate the complexity of food culture as well as its conceptual evolution in order to analyze the dynamics of food security and adaptation to the specific situations of modernity. The aspects related to definition, opportunity and strategy are addressed by analyzing the necessary steps for implementation in the current reality and in the coming decades. The factors of transition towards the new food culture are described, as well as the strategic steps or stages to be followed for the implementation of the new paradigm regarding the way and security of food in the contemporary era.*

Keywords: *food, nutrition, sanogenesis, food system.*

1. Paper sections and font styles

The new benchmarks of the development typology reflect a growing interest in sustainable, rational, balanced and resilient nutrition from an economic and social point of view, with an emphasis on ecological and sanogenic direction. These aspects are also found in the way of eating and in nutrition in general. Food culture is constantly evolving, and today we are witnessing a significant change, with increasing diversity in food choices and with concerns related to health, the environment and ethics.

Thus, in relation to the overlapping contemporary demands and crises, with repercussions on the food security of the population and the deterioration of the environment, innovative technologies are being developed that can solve and even revolutionize agro-zootechnical production, food processing and culinary production in the gastro-industry. Moreover, there is a trend of culinary diversification and a renewed interest in local products and related traditions, with the idea of developing gastronomic combinations and interferences at a global level [2, 3, 6, 15].

Therefore, studies on the new food culture become timely, both from a practical and theoretical perspective. Practically, the new food culture occupies a central place in the existential

concerns of the contemporary world, being directly linked to fundamental themes such as holistic health, environmental sustainability, food equity and human rights, being de facto a global problem that intersects both economic and social and ecological aspects, becoming essentially a pillar of the future of humanity, supported by a rich and diverse research activity [9, 11, 17, 25, 29, 34, 37, 38]. Theoretically, the conceptual dynamics and the potential for adaptation are analyzed.

Therefore, the new societal food culture is approached as a multidimensional system based on a series of concepts that reflect not only technological and economic progress, but also fundamental changes in the social, economic and ecological values of contemporary society. The idea is marked by the bioharmonization of PARADOXICAL CONTRASTS between tradition and innovation, between ensuring quantitative needs and health, between individual and collective, or local and global consumption, as well as between traditional food habits and the fast and technological lifestyle specific to the 21st century.

International research supports, directly or indirectly, the principled analysis of the new food culture of the 21st century. They are essential for understanding the fundamental transformations taking place in global food systems. As

ecological, economic and social challenges become increasingly urgent, the new food culture is seen as a “group of solutions” that can respond to the challenges of ensuring the quantity and quality of food at local, regional and global levels. The study has theoretical and practical objectives. From the first category, the definition of the concept and the opportunity of the approach are fixed, and from the second, the pragmatic one, the objectives become punctual, being expressed by establishing the necessary steps for the transition to the new contemporary food culture.

Essentially, the proposed objectives are:

- DEFINING THE CONCEPT of a new food culture of societal bioharmony linked to the processes of today's reality, of biological and ecological sustainability and resilience, of climate change and public health;
- HIGHLIGHTING THE OPPORTUNITY, directions and factors in correlation with the historical moments of the evolution towards a new food culture and
- ESTABLISHING THE STEPS of the new food culture in the direction of sanogenic nutrition, as structural elements that reflect the balance and dynamics of a transdisciplinary nature specific to the way of eating in the 21st century, based on health, sustainability and social responsibility.

2. State of knowledge of the problem

The dynamics of food security and adaptation to the specific situations of the 21st century is one of the preoccupying themes of researchers. The various approaches, nuances and solutions found are found in entire lists of publications and authors. For the present study, all of these have been grouped into main subthemes necessary to outline a coherent vision for the new contemporary food culture. First, studies and research related to the definition and integrated analysis of the food system were analyzed [2, 9, 11, 17, 33, 35]. One of the major themes related to the new food culture is the adaptation to the requirements of ecological sustainability and climate change, approaches that highlight a multitude of directions and impact factors [5, 8, 10, 20, 21, 22, 24, 28, 31]. Of major interest in the food culture of the 21st century is public health and related nutrition [13, 18, 19, 23, 36]. Regarding innovation in food production and processing, there are concerns that target processing techniques and their importance in the eating style of consumers in this period [1, 12,

14, 27]. Last but not least, social aspects represent a concern of maximum interest at a global level, as an important part of global accessibility, combating hunger and avoiding food waste [4, 7, 16, 26, 30, 32].

3. Working Methodology

The working method in the principle analysis of the new food culture involves a set of steps aimed at understanding and evaluating an innovative food system, which may include new approaches to products, processing, consumption and impacts on health and the environment. This working method can be applied in academic studies, research, food product development or even public policies.

As a methodological benchmark, we mention the key elements that can be part of a working method in the analysis of the new food culture, namely the steps related to:

- (a) documentary aspects regarding the Identification of the main characteristics of the new food culture,
- (b) indicators of impact on health and nutrition,
- (c) statistical and interpretative analysis of sustainability and environmental impact,
- (d) taking into account economic, commercial, social and legal indicators.

Therefore, the principle analysis of the new food culture involves a multidisciplinary approach that combines methodological aspects from food science, public health, economics, culture, technology and politics, with the aim of assessing their potential to solve current and future challenges of global food systems.

4. Results and Discussion

In the analysis of the study, it is appropriate to have as a starting point the known approach regarding CONVENTIONAL FOOD CULTURE. Thus, within the food act we refer conceptually to a culinary system formed by rules, rites and codes that define the TOTALITY of customs, traditions, knowledge and practices related to the production, preparation, consumption and distribution of food in society or in a certain community, reflecting the values, cultural identity of a population and the history of a people, being able to vary significantly from one region to another, being transmitted from one generation to another through education and daily practice. Compared to the above, the present study defines from the beginning the NEW

FOOD CULTURE that expresses the requirements and challenges of the 21st century. Therefore, we specify that practice is a trend in food culture in recent decades that emphasizes sustainability, health and ethics within a continuously changing multidimensional conceptual system, which is influenced by a series of factors and interactions between tradition, economy, technology and cultural identity, SEARCHING SOLUTIONS for

problems related to nutritional disorders, diseases of modernity and the negative impact of industrial agri-food production on the environment, all with the aim of understanding how food approaches and habits develop and adapt to contemporary society. Their principle analysis helps not only to their theoretical understanding, but also to their practical integration into current societies (table 1).

Table 1. Directions and opportunities of the new food culture in the 21st century

No. crt.	DIRECTIONS OF ANALYSIS	RESEARCH AXES	OBS. - components exemplary
1.	Ecological sustainability and climate change	- Reducing the carbon footprint: New food crops, such as plant-based proteins and alternatives to traditional meat (e.g. lab-grown meat, insects, algae), offer significant opportunities to reduce greenhouse gas emissions. This is a key opportunity, given the significant impact of the food industry on climate change.	As an example, the production of cultured meat can reduce land and water consumption and reduce methane emissions.
		- Efficient use of natural resources: Sustainable food alternatives reduce pressure on natural resources, such as water and land, which are essential for conventional food production.	For example, vertical farming and hydroponics allow food to be grown in a smaller space and with much less water consumption.
2.	Public health and nutrition	- Healthier food products: New food crops have the potential to support public health by reducing the consumption of saturated fats and red meat, and plant-based products or alternative proteins can address diet-related health issues	For example, such as cardiovascular disease, type 2 diabetes, and obesity.
		- Functional and bioactive foods: New food crops allow the development of functional foods that bring additional health benefits, especially improving the gut microbiome and increasing resistance to disease.	As an example, fermented foods are already being studied for their impact on digestion and immunity.
3.	Innovation in food production and processing	- Emerging technologies: enable the development of innovative food products, which can completely revolutionize the way food is produced and consumed.	We see progress in biotechnology, 3D food, food printing and advanced fermentation are just a few examples of technologies that
		- Automation and efficiency: Automated technologies can reduce production costs and make food more widely accessible.	The use of robots for harvesting or processing food is becoming increasingly common.
4.	Global accessibility and the fight against hunger	- Affordable and sustainable food for all regions: New food crops offer solutions for areas with limited resources, helping to combat hunger and malnutrition	For example, using ingredients that can be produced more efficiently and with fewer resources.
		- Global distribution and integration of emerging markets: Emerging markets can benefit from innovative food solutions that are easy to distribute and less expensive than traditional food production models	These markets can help reduce food inequalities.

As is known, food culture in its broadest sense represents the set of customs, traditions, values, and practices related to the production,

preparation, and consumption of food in a given society or community. As societies and technology have evolved, concepts related to

food culture have also changed. There are several conceptual types regarding food culture, which can be divided according to historical periods and future developments. As a finding, food culture is in a state of continuous change, from traditionalism based on regions and local techniques, to the industrialization and

globalization of food. The future promises innovations that will make food more accessible, sustainable and customizable, as societies become increasingly health, ethical and environmentally conscious (fig. 1).

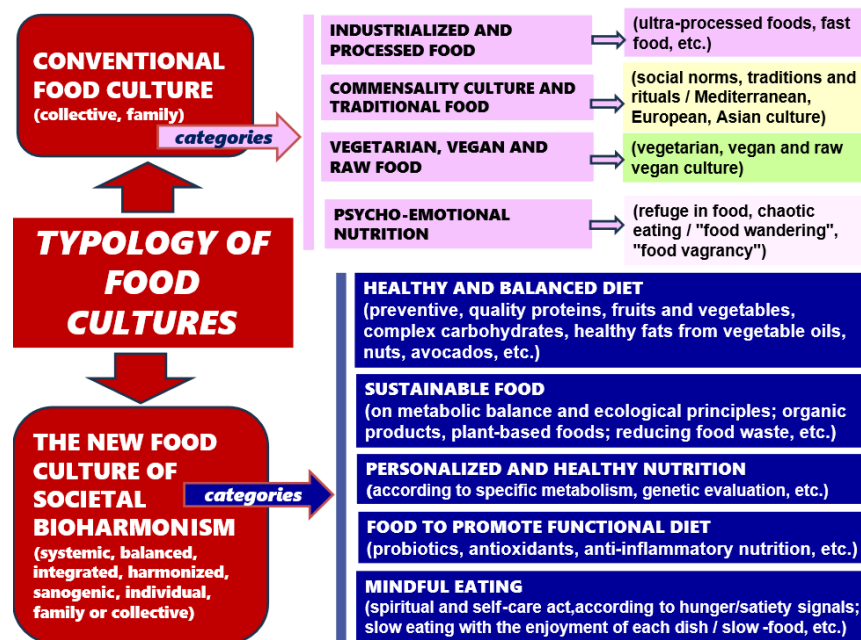


Fig. 1. Conceptual typology regarding food culture, analyzed according to historical periods and future developments

Regarding the conceptual and educational development related to modern nutrition, we observe that a process of transition from classical culture to a new 21st century food culture is currently underway, a process that is supported

and directed by a multitude of factors. We can analyze them by grouping them into two large categories: socio-cultural factors and technical-biological factors (fig.2).

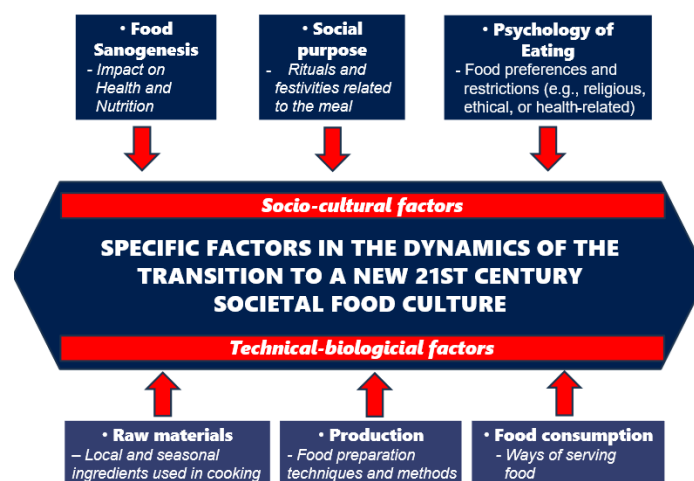


Fig. 2. The main groups of factors supporting the transition to the new food culture adapted to contemporary requirements

A defining aspect for the new food culture is the holistic understanding of nutrition from a structural and, especially, functional perspective, respectively as a balanced, healthy and resilient

dynamic supported by a series of mechanisms that aim at systemic bioharmony (fig.3).



Fig. 3. The process of sanogenesis in the population's diet in the decade of steps towards the new food culture based on the principles of social bioharmony

The conceptual dynamics involve a series of evolutionary stages regarding the transition and shaping of the new societal food culture, that is, from the classical approach to the modern one, as we see in the synthesis below:

- Classical food culture: In the past, access to certain types of food was limited by geography and resources. People mainly consumed local products, and food was linked to regional traditions and customs.

- Modern food culture: Globalization has led to a democratization of food, and food products from various corners of the world are now accessible almost everywhere. For example, exotic dishes or rare ingredients that were once inaccessible to many consumers have become part of the daily diet. The stages themselves are characterized by several main aspects that we have summarized in Table 2.

Table 2. Stages of the transition to the new food culture

No. crt.	ASPECTS OF EVOLUTION	CONVENTIONAL FOOD CULTURE	THE NEW 21ST CENTURY SOCIETAL FOOD CULTURE
1.	From manual preparation to food industrialization	In the past, food was characterized by traditional cooking, with local ingredients and prepared in households, usually by women, within family rituals. The dishes had a personalized character, and the foods were often seasonal and locally sourced.	In the 21st century, with the development of the food industry, many of the foods consumed are processed and available in supermarkets, being mass-produced and distributed on a global scale. Fast food and ready-made foods (e.g. pizza, hamburgers, frozen products) have become extremely popular. Technology has allowed for the rapid and efficient production of food, but also increased its availability regardless of the season.
2.	From family meals to	Traditional meals were often community or family events,	There is currently a growing trend towards individualizing food consumption, with more

	individual consumption	where people gathered together to eat. Cooking and eating food were collective activities, and meals reflected social and family values.	people eating in different ways and at different times. For example, due to busy work schedules, many people prefer to eat quickly, usually alone, at the office or in front of the TV. Food preferences have also become more personalized, such as vegan, gluten-free or keto diets.
3.	Global food diversification	Food was often specific to a particular region or culture. Traditional dishes were preserved over decades or even centuries and reflected local natural resources.	Globalization has led to an explosion of food diversity, with products from different corners of the world now accessible everywhere. Foods like sushi, curry, pizza, and tacos are widely consumed in many countries, and the internet and social media have made it possible for cultural food influences to spread rapidly. International labels and restaurants are also now more accessible.
4.	Food technologies and mass production	Food was largely obtained from traditional agriculture, and its preparation involved several manual steps, from cultivation to cooking.	In the 21st century, advanced technologies have allowed for increased food production on a large scale. Preservation, pasteurization, freezing and processing technologies have made possible long-life foods and ultra-processed products, as well as the development of innovative foods such as lab-grown meat and plant-based alternatives.
5.	Growing concerns about health and nutrition	Traditional diets were often based on natural, whole foods, such as vegetables, fruits, meat, and dairy products, and people had a closer connection to the process of obtaining food.	In the 21st century, there is an increased awareness of the impact of food on health. However, there is a polarization between fast, often unhealthy diets (fast food, ultra-processed foods) and trends in the consumption of healthy and sustainable foods (organic, vegan, gluten-free). At the same time, many people are concerned about the number of calories, the sugar or fat content and the impact on body weight.
6.	Food ethics and sustainability	Most food was consumed without significant concern for the sustainability or ethics of food production. In the past, the consumption of meat or animal products was much more dependent on local resources.	With the rise of awareness of environmental and ethical issues (e.g. animal rights, carbon emissions), movements for more sustainable eating have emerged. Organic food, vegetarianism and veganism, reducing food waste, and consuming local foods have become central themes of modern food culture. Large food companies are also now under pressure to adopt more environmentally responsible practices.
7.	Lifestyle transformation and food preparation time	In the past, cooking at home was a daily practice, and the process of preparing food was part of everyday life, playing a central role in the family and community.	The fast-paced lifestyle of the 21st century has led to a decrease in time spent in the kitchen, and many people are opting for quick meal solutions. Instant meals, food deliveries, and pre-packaged or frozen foods are now preferred by a growing number of people.
8.	Relationship with technology and the influence of social networks	Culinary traditions were passed down through direct education and experience, from one generation to the next, through face-to-face interactions in the community.	Technology and social media have transformed the way people learn about food and recipes. Platforms like Instagram, YouTube, and TikTok have helped new food trends and diets spread rapidly. Recipes and cooking demonstrations go viral, and influencers and celebrity chefs have a significant impact on consumers' food choices.
9.	Globalization and democratization of food	In the past, access to certain types of food was limited by geography and resources. People mainly consumed local produce, and their diet was tied to regional traditions and customs.	Globalization has led to a democratization of food, and food products from various corners of the world are now accessible almost everywhere. For example, exotic dishes or rare ingredients that were once inaccessible to many consumers have become part of the daily diet.

From what has been presented, it follows that the transition to a new food culture is a complex and strategic process, which involves profound changes at the individual, societal, economic and political levels. This transition is not only about what we put on our plates, but also reflects a paradigm shift in our relationship with food, the environment and public health.

6. Conclusions

1. The new food culture of societal bioharmony can be defined as a multidimensional concept that encompasses interactions between tradition, economy, technology, cultural identity, health and ecological aspects, being practically a unitary model that promotes an integrated and balanced approach to nutrition, based on the principles of bioharmony between body, mind and environment, developing a culinary system that focuses on the relationship with food and its impact on health, as well as the natural balance of the individual organism and integration with the environment and contemporary societal challenges.

2. The conceptual basis of the new food culture becomes timely and necessary because it is supported by the integrative principles specific to contemporary society, with reference to the theory of bioharmony and emerging transdisciplinary knowledge, these having the potential to avoid food crises and solve food security, overcoming adverse historical moments, and through the numerous nuances of applying the way of eating, to lead towards a new food culture adapted to the requirements of contemporary society.

3. Among the directions towards a new food approach, the step of elucidating the food impact given by the group of transition factors of a technical-biological and socio-cultural nature is highlighted, which de facto influences the evolution of the individual and collective mentality necessary for adapting to the difficult requirements of the 21st century.

References

1. Apostol, L., Belc, N., Gaceu, L., Vladut, V., & Oprea, O. B. (2019). Chemical composition and rheological parametrs of *Helianthus Tuberosus* flour used as a sources of bioactive compounds in bakery. *Rev. Chim*, 70(6), 2048-2053.
2. Baker, P., Machado, P., Santos, T., et al. (2020). *Ultra-processed foods and the nutrition transition: global, regional and national trends, food systems transformations and political economy drivers*. *Obes Rev.*, 21 (12): e13126.
3. Baker, L., Castilleja, G., De Groot Ruiz, A., Jones, A. (2020). *Prospects for the true cost accounting of food systems*. *Nature Food*. 1 (12): 765–7.
4. Barrett, C.B., Benton, T.G., Cooper, K.A., et al. (2020). *Bundling innovations to transform agri-food systems*. *Nature Sustainability*. 3 (12): 974–6.
5. Bell, W., Lividini, K., Masters, W.A. (2021). *Global dietary convergence from 1970 to 2010 altered inequality in agriculture, nutrition and health*. *Nature Food*. 2 (3): 156–65.
6. Brown, M. (2014). *Food security, food prices and climate variability*. Abingdon, United Kingdom: Routledge.
7. Constantinides, S.V., Turner, C., Frongillo, E.A., et al. (2021). *Using a global food environment framework to understand relationships with food choice in diverse low- and middle-income countries*. *Glob. Food. Sec.* 29: 100511.
8. Crenshaw, K.W. (2017). *On intersectionality: essential writings*. NY: The New Press.
9. Crippa, M., Solazzo, E., Guizzardi, D., Monforti-Ferrario, F., Tubiello, F.N., Leip, A. (2021). *Food systems are responsible for a third of global anthropogenic GHG emissions*. *Nature Food*. 2 (3): 198–209.
10. Fanzo, J., Davis, C. (2021). *Global food systems, diets, and nutrition: linking science, economics, and policy*. Cham, Switzerland: Springer Nature.
11. Fanzo, J., Bellows, A.L., Spiker, M.L., Thorne-Lyman, A.L., Bloem, M.W. (2021). *The importance of food systems and the environment for nutrition*. *J. Clin. Nutr.* 113 (1): 7–16.
12. Fanzo, J., Haddad, L., McLaren, R., et al. (2020). *The Food Systems Dashboard is a new tool to inform better food policy*. *Nature Food*. 1 (5): 243–6.
13. Franco-Martínez, L., Martínez-Subiela, S., Cerón, J.J., Bernal, L.J., Tecles, F., Tvarijonaviciute, A. (2020). *Teaching the basics of the One Health concept to undergraduate veterinary students*. *Res. Vet. Sci.* 133: 219–25.
14. Frioui, M., Shamtsyan, M., Gaceu, L., Oprea, O.B., & Mnerie, D. (2017). Rheological influence of (1-3)(1-6) mushrooms β -Glucan, used as flour

- substitution in bakery industry. Proceedings of the 45th International Symposium on Agricultural Engineering, Actual Tasks on Agricultural Engineering, 21-24 February 2017, Opatija, Croatia, 2017, 377-384.
15. Gaceu, L., Gadei, G., Oprea, O. B. (2014). Methodology for analyzing EU-conform label information content of meat products in Romania. *Agrárinformatika/Journal of Agricultural Informatics*, 5(1), 18-26.
 16. Gaceu, L., Gruia, R., & Thierheimer, W. (2009, October). Applications of a model simulation referring to the energetic flow transformities in agroecosystems. In *Proceedings of the 8th WSEAS International Conference on System Science and Simulation in Engineering (ICOSSSE '09)* (pp. 41-46).
 17. Gruia, R., (2003). *Bazele științei managementului în ingineria alimentară*, Ed. Univ. Transilvania Brasov ISBN 973-635-154-8, 187 p.
 18. Gruia, R., 2018a. *Evoluția științifică a gastronomiei în cadrul actului alimentar*, Ed. Clarion Brașov ISBN 978-606-94470-3-1, 163 p.
 19. Gruia, R., 2018b. *Gastronomia și principiile biologiei alimentației*, Ed. Clarion Brașov, ISBN 978-606-94470-4-8, 187 p.
 20. Gruia, R. et al., (2021). *Reducing Environmental Risk by Applying a Polyvalent Model of Waste Management in the Restaurant Industry*, Sustainability, 13 (11).
 21. Gruia, R., Gaceu, L., (2022). *The Concept of Integrated Food Policy*, Annals of the Academy of Romanian Scientists Series Agriculture, Silviculture and Veterinary Medicine Sciences, online ISSN 2344-2085, Vol.11, nr.2, 105-119.
 22. Gruia, R., Țuluca, E., Munteanu, I. (2018). *Study on interface environment-food, with change of paradigm towards health generating gastronomy*, Envir. Eng. and Manag. J., Gheorghe Asachi Technical Univ. Iasi, ISSN 1582-9596, 17 (11): 2703-2709.
 23. Gruia, R., Gaceu, L., Oprea, O. B. (2025). The Pillars of Societal Bioharmony: a Conceptualist Contribution to the Evolution of the Contemporary Society. *Challenges*, 16(1), 16.
 24. Harris, J., Tan, W., Mitchell, B., Zayed, D. (2021). *Equity in agriculture-nutrition-health research: a scoping review*. Nutr Rev.
 25. Koo, J., Mamun, A., Martin, W. (2021). *From bad to worse: poverty impacts of food availability responses to weather shocks*. Agric Econ. 52 (5): 833-47.
 26. Kim, B.F., Santo, R.E., Scatterday, A.P., et al. (2020). *Country-specific dietary shifts to mitigate climate and water crises*. Global Environ Change. 62: 101926.
 27. Luntraru, C. M., Apostol, L., Oprea, O. B., Neagu, M., Popescu, A. F., Tomescu, J. A., & Gaceu, L. (2022). Reclaim and valorization of sea buckthorn (*Hippophae rhamnoides*) by-product: antioxidant activity and chemical characterization. *Foods*, 11(3), 462.
 28. Mbow, C., Rosenzweig, C., Barioni, L.G., et al. (2019). *Food security*. In: Climate change and land: an IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. Geneva, Switzerland: IPCC.
 29. Micha, R., Mannar, V., Afshin, A., et al. (2020). *Global nutrition report: action on equity to end malnutrition*. Behrman, N., editor. Bristol, UK: Development Initiatives.
 30. Mnerie, D., Gaceu, L., Gubenia, O., Shamtsyan, M., & Birca, A. (2015). Critical analysis of the reflection by the resources quality agro-livestock in the labeling of generated foodstuff.
 31. Mnerie, D., Gaceu, L., Gubenia, O., Shamtsyan, M., Birca, A., & Mnerie, G. V. (2016). Comparative study on the evolution of the food labeling quality in some countries from the Black Sea region. *Journal of Hygienic Engineering and Design*, (14), 60-65.
 32. Myers, S.S., Smith, M.R., Guth, S., et al. (2017). *Climate change and global food systems: potential impacts on food security and undernutrition*. Annu Rev Public Health. 38: 259-77.
 33. Nisbett, N., Harris, J., Backholer, K., et al. (2022). *Holding no-one back: the nutrition equity framework in theory and practice*. Glob Food Sec. In press.
 34. Oprea, O. B., & Gaceu, L. (2011). Preliminary researches on using spices in traditional bakery product recipes. *Journal of EcoAgri Tourism*, 7(2), 15-18.
 35. Oprea, O. B., Gaceu, L., & Gadei, G. (2013). Investigation methodology about labels information content of the meat products from Romania, in accordance with European Legislation. In *Proceeding of the international conference Agriculture Informatics*, pg (pp. 7-12).
 36. Oprea, O. B., & Gaceu, L. (2016). Application of multiple criteria decision making (mcdm) in bakery industry. Study case: wastes and by-products. *Bulletin of the Transilvania University of Brasov. Series II: Forestry• Wood Industry• Agricultural Food Engineering*, 89-94.
 37. Oprea, O. B., Sannan, S., Tolstorebrov, I., Claussen, I. C., & Gaceu, L. (2024). Effects of fish protein hydrolysate on the nutritional,

- rheological, sensorial, and textural characteristics of bread. *Foods*, 13(5), 698.
38. Ospanov, A. A., Popescu, C. V., Muslimov, N. Z., Gaceu, L., Timurbekova, A. K., Stefan, M., ... & Jumabekova, G. B. (2018). Study of the food safety and nutritional value of the buckwheat grains of Kazakhstani selection.
 39. Perry, B.D., Grace, D.C. (2015). *How growing complexity of consumer choices and drivers of consumption behaviour affect demand for animal source foods*. *Ecohealth*. 12 (4): 703–12.
 40. Popkin, B.M., Corvalan, C., Grummer-Strawn, L.M. (2020). *Dynamics of the double burden of malnutrition and the changing nutrition reality*. *Lancet*. 395 (10217): 65–74.
 41. Ray, D.K., West, P.C., Clark, M., Gerber, J.S., Prishchepov, A.V., Chatterjee, S. (2019). *Climate change has likely already affected global food production*. *PLoS One*. 14 (5): e0217148.
 42. Searchinger, T., Waite, R., Hanson, C., et al. (2019). *Creating a sustainable food future: a menu of solutions to feed nearly 10 billion people by 2050*. Washington (DC): World Resources Institute. <https://www.wri.org/research/creating-sustainable-food-future> (Accessed March 2025).
 43. Schneider, F., Eriksson, M. (2020). *Food waste (and loss) at the retail level*. In: Reynolds, C., Soma, T., Spring, C., Lazell, J., editors. *Routledge handbook of food waste*. Abingdon, UK: Routledge. p. 114–28.
 44. Springmann, M., Clark, M., Mason-D'Croz, D., et al. (2018). *Options for keeping the food system within environmental limits*. *Nature*. 562 (7728): 519–25.
 45. Tadesse, G., Algieri, B., Kalkuhl, M., Von Braun, J. (2014). *Drivers and triggers of international food price spikes and volatility*. *Food Policy*. 47: 117–28.
 46. Thow, A.M., Nisbett, N. (2019). Trade, nutrition, and sustainable food systems. *Lancet*. 394 (10200): 716–18.
 47. Valin, H., Sands, R.D., Van der Mensbrugghe, D., et al. (2014). *The future of food demand: understanding differences in global economic models*. *Agric Econ*. 45 (1): 51–67.
 48. Von Braun, J., Afsana, K., Fresco, L., Hassan, M., Torero, M. (2020). *Food systems – definition, concept and application for the UN Food Systems Summit*. Scientific Group for the UN Food Systems Summit.
 49. Walls, H., Baker, P., Chirwa, E., Hawkins, B. (2019). *Food security, food safety & healthy nutrition: are they compatible?* *Glob. Food Sec*. 21: 69–71.
 50. Wegner, L., Zwart, G. (2011). *Who will feed the world? The production challenge*. *Food Chain*. 1 (2): 187–205.
 51. Wood, S.A., Smith, M.R., Fanzo, J., et al. (2018). *Trade and the equitability of global food nutrient distribution*. *Nature Sustainability*. 1 (1): 34–7.

CONSUMER PERCEPTIONS OF PLANT-BASED FOOD IN THE REPUBLIC OF MOLDOVA

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Abstract: Plant-based food (PBF) has developed rapidly in recent years as a response to growing interest in sustainable options, with challenges in consumer beliefs/perceptions. In this study, opinion surveys were carried out to identify Moldavian consumers' perceived benefits/barriers regarding PBF. This study was conducted according to the Regulation (EU) 2016/679, the Declaration of Helsinki, and approved by the Ethics Committee of the Technical University of Moldova (TUM). An online survey was conducted using the Google Forms platform. Recruitment was carried out by sending email invitations and disseminating the survey on social networks, using the snowball sampling method. The sample size was 186 valid cases, the confidence level was 95% ($k=2$), $p=q=50$, and the sampling error was 4.9%. The survey was composed of closed questions and divided into four sections: (1) participants' demographics, economic, and diet factors; (2) perceived PBF health consciousness; (3) perceived PBF knowledge, attitudes & purchase intention; and (4) perceived PBF subjective norm, restaurants visits & environmental concern. Of the participants, 69.7% were women and 63.5% had completed university studies. Consumers (88.9%) had intermediate knowledge about PBF and 79.6 % expressed a desire to consume PBF. An important factor in PBF purchase decision was its positive effect on health and the environment. Participants (45.3%) experienced barriers with PBF's high price, its low availability and difficulties in changing eating habits. Popular PBFs were meat substitutes, dairy alternatives and beverages. The results showed that interest towards PBF did not differ between genders but did between participants' age, education and diet. Future studies for specific PBF groups may offer new outcomes in consumer perception studies.

Keywords: plant-based food (PBF), consumer perceptions, survey.

1. Introduction

Interest in plant-based alternatives (PBAs) has grown due to their potential benefits as healthier, animal-friendly, and more environmentally sustainable options [1, 2]. The motivation behind the development of PBAs is to provide options that taste like conventional animal products, with the assumption that greater similarity to animal products will improve acceptance [3, 4].

Previous attempts to reveal how consumers perceive PBA relative to animal-derived products have largely focused either on meat alternatives broadly [5, 6]. Person-related factors are also associated with perceptions, attitudes, and consumption of PBAs. For example, concern for animal welfare, health, and the environment are associated with interest and motivation to consume PBA [7, 8].

Considering the growing concern among consumers regarding the fear of food processing and mistrust for food products, including PBA [9], it is important to identify how consumers perceive the category. Therefore, primary objectives of current study are to (1) assess how Moldavian consumers perceive PBAs relative to animal-based foods, and (2) identify person-related factors that predict PBA acceptance.

2. Material and methods

2.1. The design of the survey

The questionnaire was divided into four sections (Table 1). The section 1 was designed to collect the basic data of the consumers (i.e., gender, age, education, occupation and geographic location).

Table 1. *The design of the survey*

Constructs & Attributes	Number of items	Summary	References
1. Demographics			
• Gender	2	<i>Demographic</i> factors of gender, education, occupation and geographic location had small effect on consumer perceptions towards food products.	[10], [11]
• Age	5		
• Education	4		
• Occupation	5		
• Geografic location in Moldova	5		
2. Health consciousness			
• What impact does diet has on health?	4	Consumers’ attitudes toward products perceived as beneficial to personal health are significantly influenced by <i>health consciousness</i> .	[12], [13]
• Are you concerned about healthy diet?	4		
• Are you ready to make changes to your regular diet to improve your health?	3		
3. PBFs knowledge, attitudes & purchase intention			
• Are you conscious about the specifics of plant-based foods?	3	A consumer with a higher <i>product knowledge</i> is more familiar with a particular product that they select are more likely to use intrinsic cues to judge the <i>product attributes</i> and the quality. Product knowledge has a significant positive impact on <i>purchase intention</i> for PBFs, being highly consumed by well-educated people.	[14], [15]
• Would you prefer to consume plant-based foods?	2		
• What do you think might prevent people from including plant-based foods in their diet?	7		
• Do you think there are enough plant-based food options on the domestic market?	3		
• How important do you place the following attributes when purchasing plant-based foods?	5		
• What factors led you to try these products?	4		
4. PBFs subjective norm, restaurants visits & environmental concern			
• Would you like to learn more about plant-based foods and their health benefits?	2	<i>Subjective norm</i> is significantly contributing to the consumers’ positive attitudes for PBFs. Consumers’ attitudes toward PBFs may result in positive PBFs <i>restaurant visits</i> . <i>Environmental concern</i> helps consumer to acknowledge the environmental consequences that associated with the PBFs.	[16], [17]
• Do you or someone close to you know people who have implemented a plant-based diet?	4		
• Do you think that a plant-based diet can positively contribute to the health of people who use it?	4		
• Do you think it is necessary to extand plant-based food options?	3		
• What plant-based foods would you like to see more often in a supermarket?	7		
• Would you like to visit a PBFs reasturants?	3		
• Do you think that plant-based food is environmentally friendly?	3		

Within the 1st section demographic information had 5 questions. The 2nd section included the information regarding the health consciousness of the sample, which had three questions. The 3rd section measured the plant-based foods knowledge, attitudes and purchase intention of the consumers and it had six questions in total.

The 4th section comprised the information regarding the plant-based foods attitudes, restaurants visits intentions & environmental

consciousness, which had seven questions in total.

2.2. Data collection

All the questions presented in the survey were formulated mainly in a short form, without difficult turns, for a clearer understanding by all survey participants.

The questions were also grouped into separate categories and analyzed. Table 2 shows demographic data of the participants.

Table 2. Demographic data of the participants (n=186)

Demographic Attributes & Characteristics	n	%	Demographic Attributes & Characteristics	n	%
Gender			Occupation		
• Male	38	20.3	• Student	76	40.6
• Female	149	79.7	• Employed	57	30.5
Age			• Entrepreneur	21	11.2
• < 18	55	29.4	• Unemployed	21	11.2
• 8-25	54	28.9	• Retired	12	6.4
• 26-35	28	15.0	Geographic location in Moldova		
• 36-50	29	15.5	• North	78	41.4
• > 50	21	11.2	• South	21	11.3
Education			• Center	70	37.6
• High school graduate	59	31.6	• East	10	5.4
• Secondary school graduate	46	24.6	• West	8	4.3
• University graduate	48	25.7			
• Post graduate	34	18.2			

When compiling the questionnaire, it was important to preserve the logical relationship between questions and answers, to prevent their ambiguity. To conduct the study, it was expected to determine the level of interest of Moldavian consumers in the plant-based food and diet, and to understand their beliefs and barriers regarding PBF purchasing intention and consumption.

3. Results and discussions

The data analysis allowed to find out more about the level of knowledge about plant-based food and diet and the awareness of PBF on health by Moldavian consumers. The results in this regard are presented in Table 3.

Table 3. Data regarding the health consciousness (n=186)

Constructs	n	%
What impact does diet has on health?		
• Has an important role	149	79.7
• Has an insignificant role	17	9.1
• Does not influence	9	4.8
• Do not know	12	6.4
Are you concerned about healthy diet?		
• Yes, I am concerned about this aspect	85	45.5
• I try, but I do not always succeed	71	38.0
• Sometimes	15	8.0
• No, I do not pay attention to this concern	16	8.6
Are you ready to make changes to your regular diet to improve your health?		
• Yes, I am ready	128	68.4
• Not yet	34	18.2
• No, I am not sure	25	13.4

Respondents (79.7%) see a relationship between the food consumed and its impact on the quality of health. However, their understanding

of the importance of nutrition slightly does not correspond to the products they use in a daily diet (Fig. 1, 2).

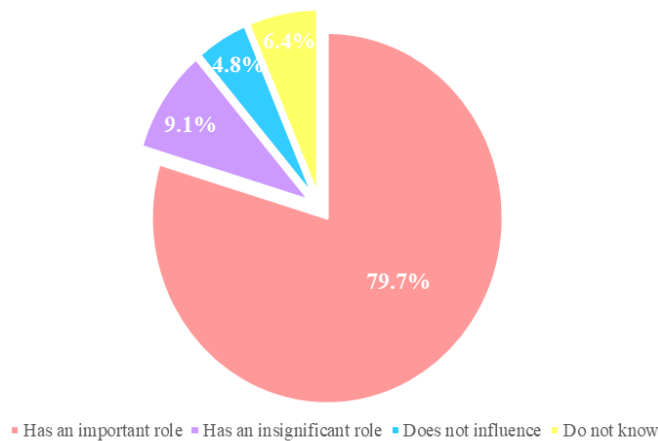


Fig. 1. Distribution of consumers' perceptions on the significance of healthy diet on health

In general, from the respondents' answers, it was concluded that Moldavian consumers are aware of their diet. Within the framework of the survey, this value may not seem so impressive, since it is only 20% of all participants. If these percentage is correlated with the entire population of the Republic of Moldova (2,597,107 people, according to statistics), then, presumably, 519,422 people include plant-based food in their diet every day. There is an extremely small number of autochthonous plant-

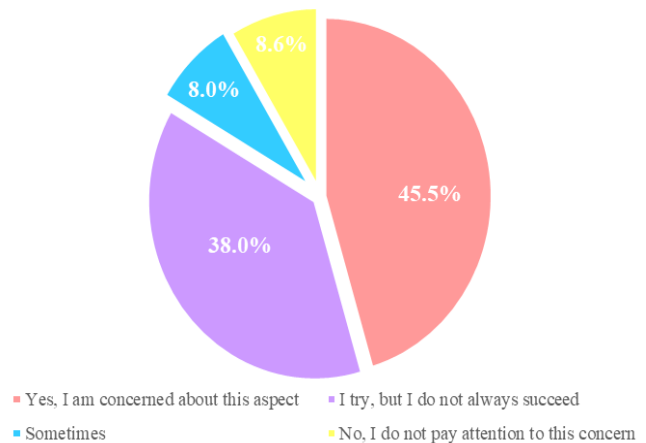


Fig. 2. Distribution of consumers' concerns on healthy diet

based food on the RM market, but their demand is growing [18-21]. One of the reasons of the lack of variety of plant-based food products is low consumer awareness (Fig. 3, 4). It is important to note that 39.0 % of respondents are conscious regarding the PBF. Respondents (51.9%) consider that the PBF is not available enough on the domestic market, but 28.9% of respondents perceive that PBF is presented enough on the Moldavian market.

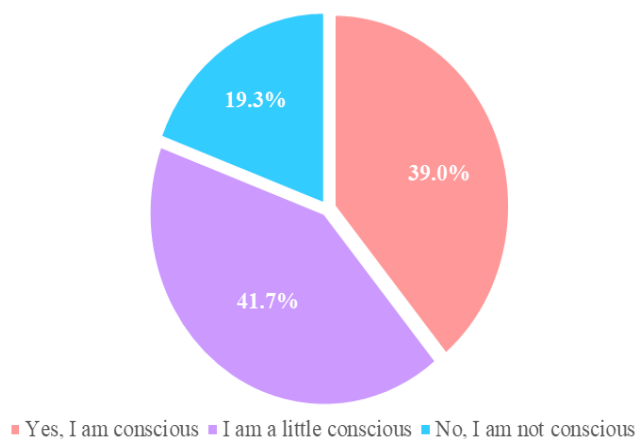


Fig. 3. Distribution of consumers' perceptions on how conscious they are regarding the plant-based foods

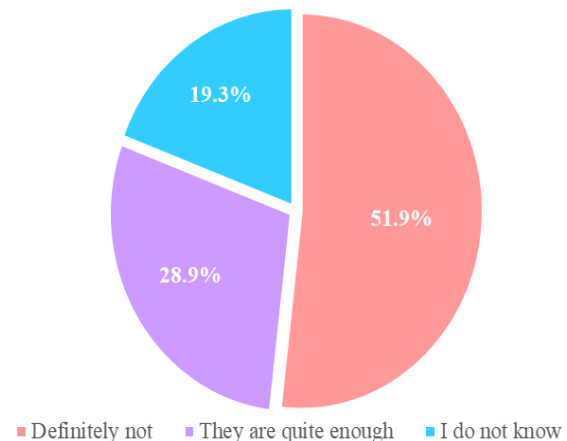


Fig. 4. Distribution of consumers' perceptions on the availability of plant-based food options in the domestic market

Table 4. *Data regarding the knowledge, attitudes & purchase intention of plant-based foods (n=186)*

Constructs	n	%	Constructs	n	%
Are you conscious about the specifics of plant-based foods?			Do you think there are enough plant-based food options on the domestic market?		
• Yes, I am conscious	73	39.0	• Definitely not	97	51.9
• I am a little conscious	78	41.7	• They are quite enough	54	28.9
• No, I am not conscious	25	19.3	• I do not know	36	19.3
Would you prefer to consume plant-based foods?			How important do you place the following attributes when purchasing plant-based foods?		
• Yes, I am convinced that PBFs will improve my health	124	66.3	• Price	99	53.0
• Yes, if I had more information	63	33.7	• Health benefits	49	26.6
What do you think might prevent people from including plant-based foods in their diet?			• Taste	23	12.4
• Lack of information	74	39.6	• Presence of Artificial Additives	8	4.0
• Shelf availability	24	12.8	• Efficiency	8	4.0
• Limited variety of products	17	9.1	What factors led you to try these products?		
• High price	33	17.6	• I wanted to try something new	104	55.4
• Giving up certain eating habits	22	11.8	• They looked healthy and nutritious	45	24.3
• Indigestion, bloating or flatulence	7	3.7	• I like and trust them	19	10.3
• Not knowing what to eat instead of meat	10	5.3	• They looked tasty	19	10.0

The survey participants were asked what do they believe can prevent them from purchasing the plant-based foods. The results show that the participants experienced barriers with PBF's high price (17.6%), PBF low availability on the market (12.8%) and difficulties in changing

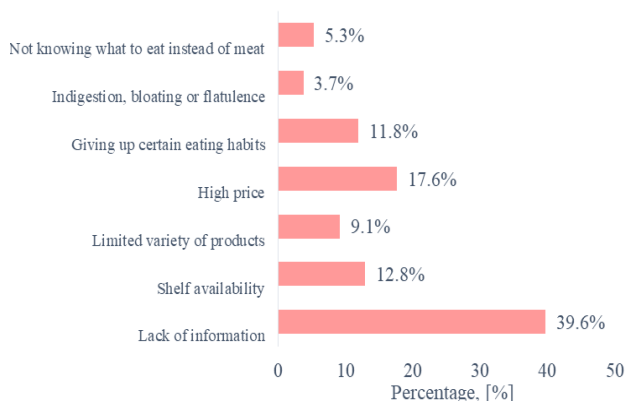


Fig. 5. *Distribution of consumers' perceptions on the prevention issues of including plant-based foods in diet*

It is important to note that 58% of respondents are ready to give up their bad habits that cannot be combined with proper nutrition. The respondents (27%), are sure that their diet is balanced and they have nothing to give up, and 15% of participants expressed that they do not want to change anything, since they are satisfied

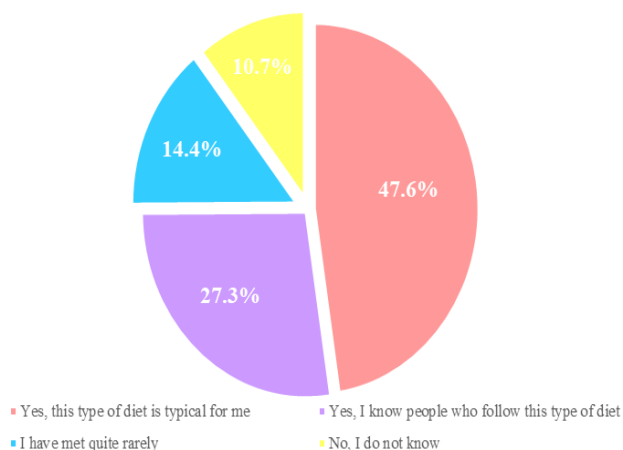


Fig. 7. *Distribution of consumers' perceptions regarding the people who have already implemented a plant-based diet*

Participants (47.6%) revealed that they know people who have already implemented plant-based diet and 14.4% expressed that have met quite rarely people consuming plant-based food. According to the results, the main hindering factor for the respondents, as previously revealed,

eating habits (11.8%) (Fig. 5, 6). Nevertheless, participants expressed a desire to consume PBF. An important factor in plant-based food purchase decision is a positive effect of plant-based food diet on health and the environment [22-24].

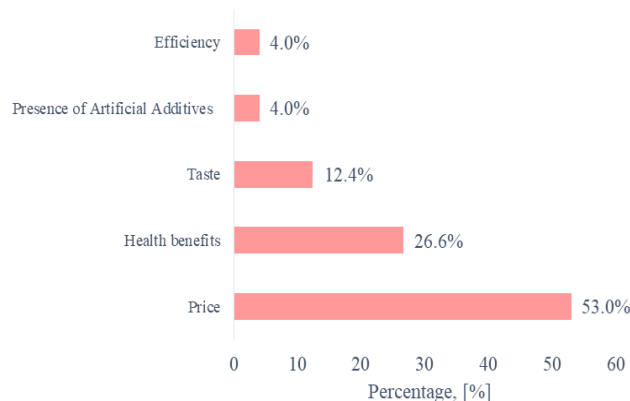


Fig. 6. *Distribution of consumers' perceptions on the attributes that influence the choice of purchasing plant-based foods*

with their diet. For a more detailed understanding, Moldavian consumers were asked regarding the positive effect of plant-based food on their health, and 79.7% of participants revealed that PBF may have a significant role on health and 9.1% replied that plant-based diet may have an insignificant role health (Fig. 7, 8).

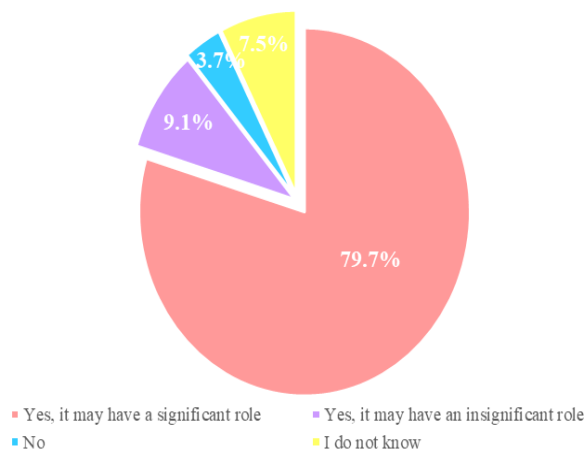


Fig. 8. *Distribution of consumers' perceptions regarding the positive effect of plant-based diet on health*

is insufficient awareness in the area of plant-based food. However, there were more people wishing to improve their knowledge. Almost all respondents expressed a desire to learn more about plant-based food and include PBF in their daily diet, thereby improving their health.

Table 5. *Results regarding the subjective norm, restaurants visits & environmental consciousness of plant-based food (n=186)*

Constructs	n	%	Constructs	n	%
Would you like to learn more about plant-based foods and their health benefits?			What plant-based foods would you like to see more often in a supermarket?		
• Yes, this information can be helpful in adopting healthy eating habits	170	90.9	• Meat	38	20.3
• No, I am not interested	17	9.1	• Cheese	36	19.4
Do you or someone close to you know people who have implemented a plant-based diet?			• Sauces	57	30.6
• Yes, this type of diet is typical for me	89	47.6	• Yoghurt	33	17.9
• Yes, I know people who follow this type of diet	51	27.3	• Ice cream	30	15.9
• I have met quite rarely	27	14.4	• Drinks	22	11.9
• No, I do not know	20	10.7	• Other	8	4.0
Do you think that a plant-based diet can positively contribute to the health of people who use it?			Would you like to visit a PBFs reasturants?		
• Yes, it may have a significant role	149	79.7	• If I have a chance, I will visit a PBFs restaurant	81	43.4
• Yes, it may have an insignificant role	17	9.1	• I will visit a PBFs restaurant	58	31.2
• No	7	3.7	• I would like to visit a PBF restaurant if it has a PBFs menu	47	25.4
• I do not know	14	7.5			
Do you think it is necessary to extand plant-based food options?			Do you think that plant-based food is environmentally friendly?		
• Yes	151	80.8	• Yes	118	63.3
• No	25	13.2	• No	46	24.7
• Li is difficult to judge	11	6.0	• I do not know	22	12.0

The most preferred plant-based food for Moldavian consumers was attested meat replacements (20.3%), cheese alternatives (19.4%), yoghurt substitutes (17.9%), and ice cream analogues (15.9 %) (Fig. 9). Respondents believe that lack of awareness is the main reason for the low popularity of plant-based food. It is

also affected by the high cost, low availability, and variety, sometimes poor quality and the need to change the food habits [25, 26].

When buying plant-based food, the most significant factors are the taste characteristics and benefits of PBFs, as well as the price/quality ratio, and the presence of artificial additives.

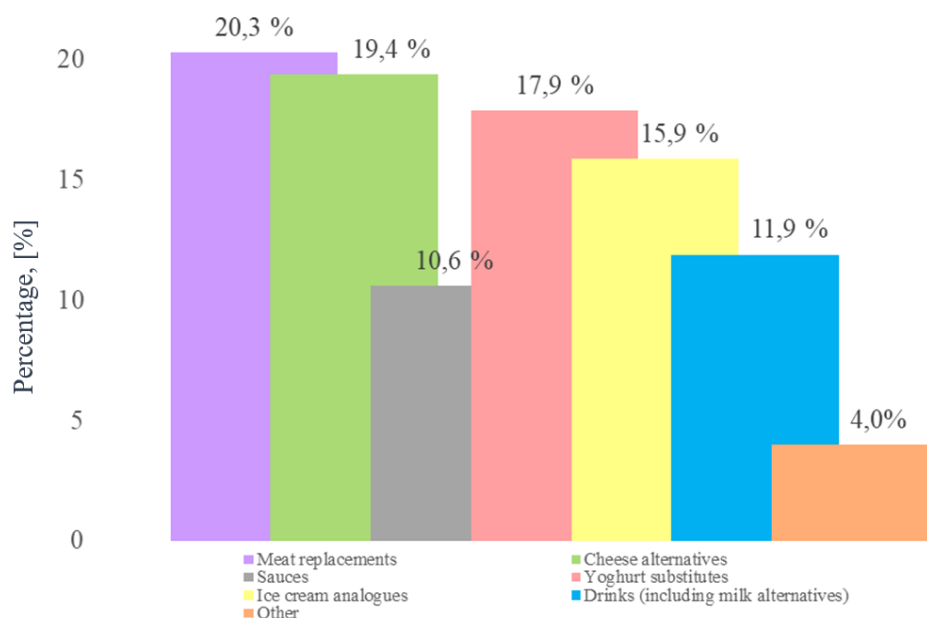


Fig. 9. Distribution of consumers perceptions regarding the most demanding categories of the plant-based foods in supermarket

More trust in plant-based food and diet among the respondents is caused by such sources of information as the Internet and mass media. The respondents are confident that the development

and distribution of new plant-based food will lead to a better health habits and will increase the restaurants visits with plant-based menu (Fig. 10, 11).

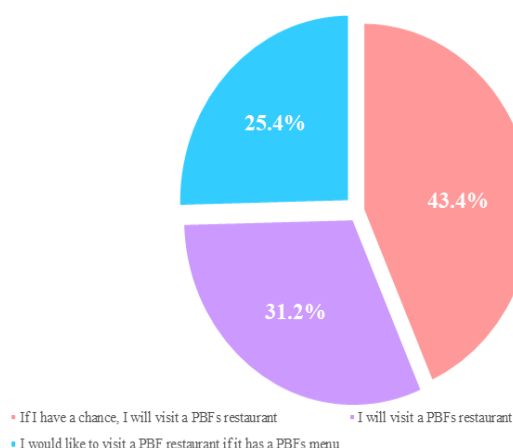


Fig. 10. Distribution of consumers perceptions regarding their willingness to visit a PBFs restaurants

The respondents have common identified problems: insufficient awareness about plant-based food and diet, a small variety of PBF products on the Moldavian market.

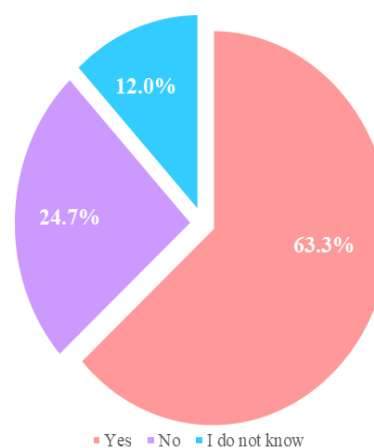


Fig. 11. Distribution of consumers perceptions if the plant-based food is environmentally friendly

Furthermore, the demand and relevance of the plant-based food consumption in the Republic of Moldova were identified.

4. Conclusions

The study contributes to the understanding and comparing Moldavian consumers' perceptions towards plant-based food and diet. The consumer's preferences for PBF did not differ between genders, but did between participants' age, education and diet. The purchase intention to buy the plant-based food can be increased if marketing campaigns will provide more information about PBF and will improve negative beliefs related to attributes such as healthiness and safety of PBF. At the same time, main part of the participants expressed a desire to consume BPF. The most important factor in the purchase intention of plant-based food was a positive effect on health and environment. There is an interest and demand from Moldavian consumers for plant-based food, which indicates the need to expand PBF variety. The insight provided by this study can help to increase the consumers' interest towards plant-based food and diet among Moldavian consumers. Future studies for specific PBF categories may offer new outcomes in consumer perception studies.

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References

1. Kershaw, J., Nolden, A., Ellinger, L., Dlamini, N.N. Consumers' perceptions of plant-based alternatives relative to the foods they directly imitate, *Food Quality and Preference*, vol. 129, p. 105519, 2025, doi: 10.1016/j.foodqual.2025.105519.
2. Popovici, C., Teng, X.M., Jadeja, R. Development of the plant-based cheese alternatives using walnuts nutritional potential. *Proceedings of the 7th International Conference New Trends on Sensing - Monitoring - Telediagnosis for Life Sciences NT-SMT-LS 2024*, Brasov, Romania: Transilvania University of Brasov. 2024.
3. Swann, C., Kelly, M. Disruption in the meat industry: new technologies in nonmeat substitutes, *Bus Econ*, vol. 58, no. 1, pp. 42–60, 2023, doi: 10.1057/s11369-023-00302-w.
4. Popovici, C., Bulgaru, V. Texture and sensory attributes development in plant-based cheese-like alternatives from walnuts (*Juglans regia* L.), *Book of Abstracts. IASICHEM 2024 Conference*, p. 68.
5. Hartmann, C., Furtwaengler, P., Siegrist, M. Consumers' evaluation of the environmental friendliness, healthiness and naturalness of meat, meat substitutes, and other protein-rich foods, *Food Quality and Preference*, vol. 97, p. 104486, 2022, doi: 10.1016/j.foodqual.2021.104486.
6. De Oliveira Padilha, L.G., Malek, L., Umberger, W.J. Consumers' attitudes towards lab-grown meat, conventionally raised meat and plant-based protein alternatives, *Food Quality and Preference*, vol. 99, p. 104573, 2022, doi: 10.1016/j.foodqual.2022.104573.
7. Knaapila, A., Michel, F., Jouppila, K., Sontag-Strohm, T., Piironen, V. Millennials' Consumption of and Attitudes toward Meat and Plant-Based Meat Alternatives by Consumer Segment in Finland, *Foods*, vol. 11, no. 3, p. 456, 2022, doi: 10.3390/foods11030456.
8. Onwezen, M.C., Bouwman, E.P., Reinders, M.J., Dagevos, H. A systematic review on consumer acceptance of alternative proteins: Pulses, algae, insects, plant-based meat alternatives, and cultured meat, *Appetite*, vol. 159, p. 105058, 2021, doi: 10.1016/j.appet.2020.105058.
9. Cardello, A.V., Llobell, F., Giacalone, D., Chheang, S.L., Jaeger, S.R. Consumer Preference Segments for Plant-Based Foods: The Role of Product Category, *Foods*, vol. 11, no. 19, p. 3059, 2022, doi: 10.3390/foods11193059.
10. Permana, M.A., Aprianingsih, A. A., Fadlullah, H.M. *Consumer Behavior and Perceive to Buy from Ready-to-Eat Meals Meat-Based Products: a Case Study of Rendang Tastes Processed Meats in Indonesia*, *JOSR*, vol. 2, no. 9, pp. 3098–3109, 2023, doi: 10.55324/josr.v2i9.1369.
11. Vaikma, H., Kern, M., Harwood, W., Almli, W.L. *Consumer perceptions of sustainability towards ingredients, packaging, labelling, and storage conditions in milk, burger products, and plant-based alternatives: A study in Sweden and Italy*, *Future Foods*, vol. 11, p. 100635, 2025, doi: 10.1016/j.fufo.2025.100635.

12. Scheibenzuber, S. et al. *Consumers acceptance of new food ingredients from the food industry's by-products—a focus group study*, *Front. Nutr.*, vol. 12, p. 1509833, 2025, doi: 10.3389/fnut.2025.1509833.
13. Kershaw, J., Nolden, A., Ellinger, L., Dlamini, N.N. *Consumers' perceptions of plant-based alternatives relative to the foods they directly imitate*, *Food Quality and Preference*, vol. 129, p. 105519, 2025, doi: 10.1016/j.foodqual.2025.105519.
14. Abu Bakar, A.R., Mahzan, N.A., Tarmazi, S.A.A., Tumin, S.A. *Plant-base Meat as Future Alternative: A Study of Malaysian Consumers Purchase Intention*, *MJSSH*, vol. 8, no. 7, p. e002397, 2023, doi: 10.47405/mjssh.v8i7.2397.
15. Sapio, S., Wang, Q.J., Vecchio, R. *Low-income consumers' perceptions of plant-based meat alternatives: A central location test*, *Food Quality and Preference*, p. 105601, 2025, doi: 10.1016/j.foodqual.2025.105601.
16. Park, C.I., Namkung, Y. *Consumer Values, Attitudes, and Behavior towards Plant-Based Alternatives*, *Foods*, vol. 13, no. 16, p. 2561, 2024, doi: 10.3390/foods13162561.
17. Giacone, L., Siegrist, M., Stadelmann, A., Hartmann, C. *Consumers' perceptions of healthiness and environmental friendliness of plant-based and dairy product concepts*, *Food and Humanity*, vol. 2, p. 100288, 2024, doi: 10.1016/j.foohum.2024.100288.
18. *Republic of Moldova Plant-based Food and Beverages market (2025-2031)*. Report, Available: www.6wresearch.com/industry-report/republic-of-moldova-plant-based-food-and-beverages-market
19. Luntraru, C. M., Apostol, L., Oprea, O. B., Neagu, M., Popescu, A. F., Tomescu, J. A., Gaceu, L. (2022). Reclaim and valorization of sea buckthorn (*Hippophae rhamnoides*) by-product: antioxidant activity and chemical characterization. *Foods*, 11(3), 462.
20. Apostol, L., Belc, N., Gaceu, L., Vladut, V., Oprea, O.B. (2019). Chemical composition and rheological parametrs of *Helianthus Tuberosus* flour used as a sources of bioactive compounds in bakery. *Rev. Chim*, 70(6), 2048-2053.
21. Mnerie, D., Gaceu, L., Gubenia, O., Shamtsyan, M., Birca, A., & Mnerie, G. V. (2016). Comparative study on the evolution of the food labeling quality in some countries from the Black Sea region. *J. of Hygienic Engineering and Design*, (14), 60-65.
22. Apostol, L., Belc, N., Gaceu, L., Oprea, O.B., Popa, M.E. (2020). Sorghum flour: A valuable ingredient for bakery industry?. *Applied Sciences*, 10(23), 8597.
23. Gaceu, L., Gadei, G., Oprea, O.B. (2014). Methodology for analyzing EU-conform label information content of meat products in Romania. *J. of Agricultural Informatics*, 5(1), 18-26.
24. Oprea, O.B., Gaceu, L. (2016). Application of multiple criteria decision making (mcdm) in bakery industry. Study case: wastes and by-products. *Bulletin of the Transilvania University of Brasov. Series II: Forestry• Wood Industry• Agricultural Food Engineering*, 89-94.
25. Oprea, O. B., Gaceu, L., & Gadei, G. (2013). Investigation methodology about labels information content of the meat products from Romania, in accordance with European Legislation. In *Proceeding of the international conference Agriculture Informatics*, (pp. 7-12).
26. Oprea, O. B., & Gaceu, L. (2020). Consumer acceptance and sensorial analysis of bread with grape seed flour. In *E3S Web of Conferences* (Vol. 215, p. 01005). EDP Sciences.

RESEARCH ON THE PHYSICAL PROPERTIES OF BIOMASS IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

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Abstract: The qualities of the fuel can be improved through the pretreatment technology of the wood material. This treatment can have a series of beneficial effects, to be used in the heating system with thermal plants.

The efficiency of heating system compared to fireplaces is considered better, fireplaces could even have a negative yield during the year, while internal heating is advanced and can achieve yields of 70-90% with reduced emissions. The applications of such systems are used in Scandinavia, Austria and Germany. Woody biomass is renewable because it recycles carbon dioxide. As trees grow, they use carbon dioxide from the atmosphere as a carbon source for their physiological growth needs. Carbon makes up 50% of the weight of wood. When woody biomass is burned, the carbon decomposes rapidly and the carbon dioxide returns to the atmosphere. Thus, burning wood does not contribute to climate change, as fossil fuels do. The main disadvantage of burning fossil fuels is that it increases the concentration of carbon dioxide in the atmosphere, increasing global warming by 30% compared to pre-industrial times. At the beginning of the industrial revolution the carbon dioxide concentration was 280 parts per million (ppm), compared to the year 2023 when it reached 370 ppm, respectively an increase of 40%.

Keywords: energy density, biomass, wood, pellet

1. Introduction

The annual amount of woody biomass that could be produced by introducing energy crops would be 72000-320000 tons/year for a cultivated area of 21000 hectares.

The amount of renewable energy that could be obtained would be 216-9606 Wh/year (considering 1 ton of air-dried wood equivalent energy of 3 MWh).

The cost of combustible biomass varies depending on the type of material (logs, wood chips), the type of vehicle used and the distance to the installation of the boiler. Taking into account these parameters, the unit price of the solid fuel can be determined as well as the price obtained for the heat produced by each type of fuel separately.

The production of bioenergy raw materials can create additional sources of income and help stabilize process for agricultural products, creating new opportunities for farmers to invest in production.

Biomass can contribute to meeting energy demand and reducing greenhouse gas emissions in a sustainable way.

In developing countries (Asia and Africa), the traditional use of biomass in stoves is the main source of energy in the residential sector.

Wood biomass brings added value as a result of the use of wood waste for the generation of electrical and thermal energy, the removal of these products from the forest and their use, contributing to the faster sanitation and regeneration of the forest on the one hand, as well as to the reduction of the risk of pollution through better management and use of wood waste (e.g. sawdust)

Biomass, raw waste from unsupervised sources, which leads to deforestation and soil degradation, the amount of carbon that must be stored in the biomass must be approximately 50% of the weight of the biomass and through heat treatment processes the amount of carbon increases and decreases the content of mineral substances. According to the Standards (CEN/TS 14961 and STAS 9279-89), the optimal moisture content for the storage of wood chips is 30%, and for use in thermal power plants it shouldn't exceed the moisture content of 20%.

2. Materials and method

The determination of the calorific value is almost similar to that of coal (as a solid fuel) and with few differences compared to liquid (gasoline, diesel) or gaseous (methane gas, biogas) fuels.

The number of tests required by the regulations is 10 tested samples (ASTM D 3286-96, DIN 51900-1, 2000, Dihoiu, 1995). The

installation used to determine the calorific value of woody biomass was the XRY-1C explosive combustion calorimeter, produced by Shanghai Changji Geological Instrument Co.

Before performing the actual test, the calorimeter bomb is calibrated with benzoic acid (benzoic acid with a known calorific value of 26463 kJ/kg is used). Figure 1 shows the working method for perform the test.

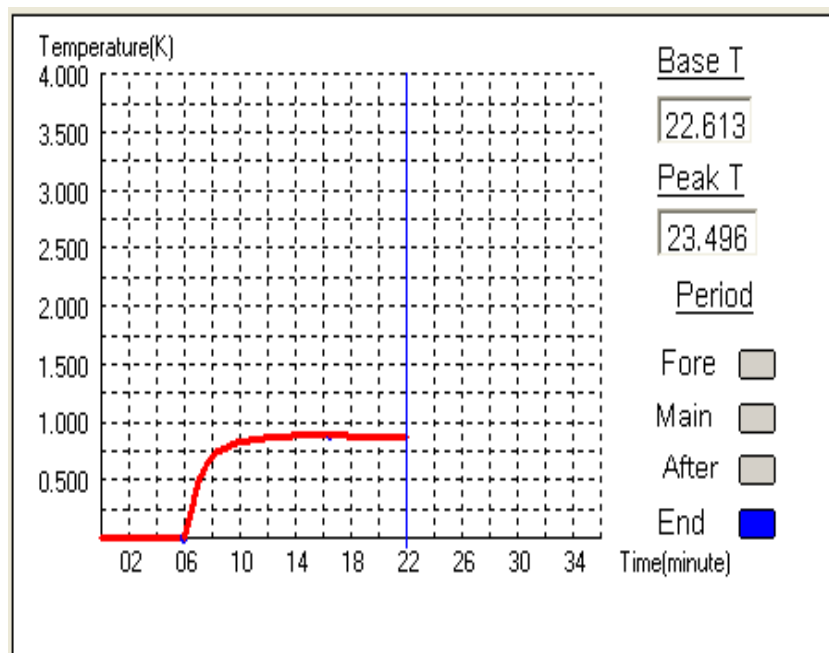


Fig. 1. Working diagram

Figure 2 shows the sketch for calorimeter bomb. The process of determining the calorific value of wood material refers first to the preparation of the raw material and the installation, then to the actual determination and finally to obtaining the fuel results.

Preparing the wood material for testing consists of taking a small portion of spruce or sugar cane pellets (0.6-0.8 grams of the whole material).

The weighed sample must have an accuracy of 0.0002 grams. The sample must be clean, made from freshly cut wood because old wood doesn't have all the volatile and flammable substances.

This sample is placed in a porcelain crucible and placed in a laboratory oven, in order to dry at 103 ± 2 °C.

It is checked by successive weighings until the difference between two successive weighings is less than twice the processing precision.

The test sample 1 is tied to the cotton thread 2 and placed in the bomb crucible 3. Tie the nickel

wire 4 to the sample and the cotton thread, then position the protective cap 5 correctly.

The crucible is connected to the calorimetric bomb lid 6 through 2 electrodes 7 and 8. By screwing on the cap of the cylinder 11 is converted to the oxygen cylinder through calorimeter bomb 12, registering 30 atmospheres.

The test contains three different periods, respectively:

- The initial period (fore), which aims to determine the temperature variations, of the water in the calorimeter, due to the exchange of heat with the outside before burning. During this period, usually 5 minutes, the precision thermocouple temperature is displayed and read minute by minute.

- The main period ("main") begins with the ignition of the sample and has as a consequence the increase of the water temperature in the calorimetric vessel, due to the burning of the wood particle and the emission of heat.

- The final period ("after") aims to determine the average temperature variation of the water in the calorimeter due to the heat exchange with the outside, after combustion.

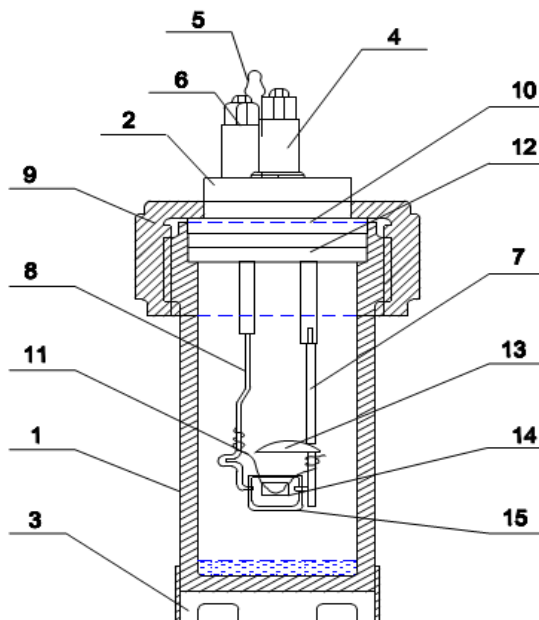


Fig.2. Sketch for calorimeter bomb

For the spruce pellets $U = 0\%$, $m = 0.9400$ g, higher caloric power = 18793 kJ/kg, lower caloric power = 18033 kJ/kg, energy density = 15.73 kJ/cm³, burning speed = 597 kJ/min, $U = 10\%$, $m = 0.7400$ g, higher caloric power = 16704 kJ/kg, lower caloric power = 15820, energy density = 10.64 kJ/cm³, burning speed = 376 kJ/min, $U = 20\%$, $m = 0.5300$ g, higher caloric power = 14996 kJ/kg, lower caloric power = 13227 kJ/kg,

energy density = 6.37 kJ/cm³, burning speed = 175 kJ/min, $U = 50\%$, $m = 0.6430$ g, higher caloric power = 9870 kJ/kg, lower caloric power = 5448 kJ/kg, energy density = 3.18 kJ/cm³, burning speed = 57 kJ/min.

The variation of the energy density for spruce pellets is presented in Fig. 3.

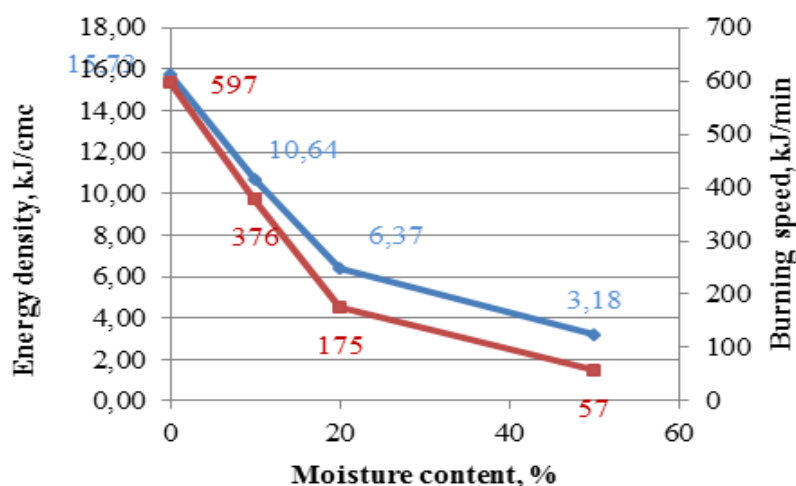


Fig. 3. The variation of the energy density for spruce pellets

For the sugar cane pellets $U=0\%$, $m=0.8600$ g, higher caloric power= 19873 kJ/kg, lower caloric power= 19221 kJ/kg, energy density = 15.28 kJ/cm³, burning speed = 525 kJ/min, $U=10\%$, $m=0.7500$ g, higher caloric power= 17745 kJ/kg, lower caloric power= 16984, energy density = 11.58 kJ/cm³, burning speed = 389 kJ/min, $U=20\%$, $m=0.8500$ g, higher caloric power = 15943 kJ/kg, lower caloric power =

14421 kJ/kg, energy density = 11.14 kJ/cm³, burning speed = 338 kJ/min, $U=50\%$, $m=0.7890$ g, higher caloric power = 10537 kJ/kg, lower caloric power = 6732 kJ/kg, energy density = 4.83 kJ/cm³, burning speed = 86 kJ/min.

The variation of the energy density for sugar cane pellets is presented in Fig. 4.

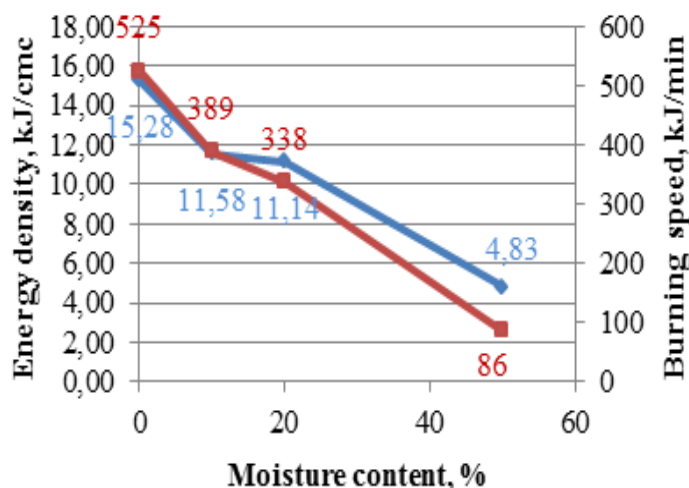


Fig.4. The variation of the energy density for sugar cane pellets

3. Conclusions

The physical characteristics and chemical composition of the biomass affect the quality of the woody material as a solid fuel.

The moisture content can vary between 20-55% compared to the dry mass of the material for firewood, or at moisture content levels lower than 10% for pellets and briquettes.

The traditional use of wood generally has a low efficiency (10%) and produces considerable emissions (dust, harmful gases).

References

1. Abassi, S.A., Nipanay, P.C., Schaumberg, G.D. Bioenergy potential of eight common aquatic weeds, *Biological Wastes*, vol.34, No.4, pag.359-366, 1990;
2. Doniță, N., Ceianu, I., Purcelan, S., Beldie, A. *Ecologie forestieră*, Ed. Ceres București, 1977;
3. Feng, S., Cheng, S., Yuan, Z., Leitch, M., Xu, C. Valorization of bark for chemicals and materials: A review. *Renewable and*

Sustainable Energy Reviews, vol.26, pag.560-578, 2013;

4. Fernandez, L. M.J., Carrasco G.J.E. Suitability of thermo-chemical corrections for determining gross calorific value in biomass, *Thermochimica Acta*, vol.468, pag.101-107, 2008;

5. Filipovici, J. *Studiul lemnului*, Editura didactică și pedagogică, București, 1984;

6. Friedl, A., Padouvas, E., Rotter, H., Varmuza, K. Prediction of heating values of biomass fuel from elemental composition, *Anal Chim ACTA*, vol.554, pag.191-198, 2005;

7. Gavrilescu, D. Energy from biomass in pulp and paper mills, *Environmental Engineering and Management Journal*, pag.537-546, 2009;

8. Grîu, T., Lunguleasa, A. Factors of influence combustion. *Proceedings Advances in Environment Technologies, Agriculture, Food and Animal Science*, International Conference WSEAS, pag.143-147, 2013;

9. Grotheim, K. Toorefaction and densification of biomass fuels for generating electricity, Milestone 9 Report. Minneapolis: Bepex International LLC, 2011;

10. Haugland, N. Guideline for classification of ash from solid biofuels and peat utilised for recycling and fertilizing in forestry and agriculture, NT Technical Report, TR 613, 2013;
11. Hu, X.Y., Dong, C.Q., Yang, Y.P., Zhang, J.J. The effect of biomass pyrolysis gas reburning on N₂O emission in a coal-fired fluidized bed boiler. *Chinese Science Bulletin*, Vol.56, Nr.14, pag.1429-1433;
12. Isabel, M., Jorge, G., Ines, M. Pereira, H. Fractioning and chemical characterization of barks of *Betula pendula* and *Eucalyptus globules*. *Industrial Crops and Products*, vol.41, pag.299-305, 2013;
13. Ionescu. M.F. Biomasa forestieră lemnoasă, un potential energetic nefolosit încă pe deplin de România, anul XX, Nr.36, pag.86-89, 2015;
14. Juran, M. Calitatea produselor, Ed. Tehnică, București, 1973;
15. Lako J., Hanesok J., Yuzhakova T. Biomass-A source of chemicals and energy for sustainable development, *Environmental Engineering and Management Journal*, vol. 7(5), pp. 499-509, 2009;
16. Larsson, S.H., Rudolfsson, M., Nordwaeger, M., Olofsson, L., Samuelsson, R. Effects of moisture content, torrefaction temperature and the temperature in pilot scale pelletizing of torrefied Norway spruce, *Appl. Energy*, vol.102, pag.827-832;
17. Lăzăroiu G, Mihăescu L. Combustion of pitcoal-wood biomass briquettes a boiler test-facility, *Environmental Engineering and Management Journal*, pp 595-601, 2008;
18. Lunguleasa A. The calorific power of wooden biomass, *Bulletin of the Transilvania University of Brasov-Series II*, vol.2(51), pp.65-70, 2010;
19. Mărăscu-Klein, V. Aspects regarding the implementation of waste products management in Romania, *Revista de inginerie industrială-Recent*. Ed. Universității Transilvania din Brașov, vol.7, Nr.1(16), 2006;
20. Moya R., Tenorio C. Fuelwood characteristics and its relation with extractives and chemical properties of ten fast-growth species in Costa Rica, *Biomass and Bioenergy*, vol.56, pp.14-21, 2011;
21. Nielsen NPK, Gardner D. Importance of temperature, moisture content a species for the conversion process of wood residues to fuel pellets, *Wood Fiber* vol.41, pp 414-425;
22. Pawlicka, A., Waliszewska, B. Chemical composition of selected species of exptoc wood derived from the region of Africa. *Acta Scientarium Polonorum-Silvarum Calendarum Ratio et Industria Lignaria*, vol.10, Nr.1, pag.37-41, 2011;
23. Petrovici, V.Gh., Agache, C. Chimia și prelucrarea chimică a lemnului, Universitatea Transilvania din Brașov, 1999;
24. Prasertsan S., Sajjakulnukit B. Biomass and bioenergy in Thailand: Potential , opportunity and barriers, *Renewable energy* , vol.31 , Nr.5, 2006;
25. Rahmann A, Masood, M.A. Influence of size and shape in the strength by briquettes, *Fuel Process Technology*, vol.22, pp125-145, 2013;
26. Roser D., Asikainen A. Sustainable use for Forest Biomass for Energy, *Springer Series in Wood Science*, 2006;
27. Spirchez, C., Gaceu, L., Gheorghe, I., Predan, G., Marutescu, L. (2017). Influence of microwave sterilization on the lignocellulosic biowaste streams conversion process using *Pleurotus* sp. *Romanian Biotechnological Letters* Vol., No. x, 2017.
28. Spirchez, C., Lunguleasa, A., Gaceu, L. (2019). Researches on grape husk waste obtained from the winery and its use as pellets for combustion. *Wood Res*, 64, 549-556.
29. Spirchez, C., Lunguleasa, A., Prună, M., Gaceu, L., Forfotă, R., Dumitrache, I. (2019). Research on the Calorific Value of the Hardwood Species. *Acta Technica Corviniensis-Bulletin of Engineering*, 12(1), 111-114.
30. Swithenbank, J, Chen, Q, Zhang, X, Sherif, V., Poukashamiani, M, Wood would burn, *Biomass and bioenrgy*, nr.3, 2011.
31. Teuch O, Hofeauer A, Troger F, From J. Basic properties of specific wood based materials carbonised in a nitrogen atmosphere, *Wood Science and Technology*, Springer, vol.38, nr.3, 2004;
32. Uslu A, Faaji A.P.C, Bergman P.C.A Pre-treatment technologies, and their effect on international bioenergy supply chain logistics. Techno-economic evaluation of torrefaction, fast pyrolysis and pelletisation, *Energy*, vol. 33(8), pp. 1206-1223.

FORMULATION AND EVALUATION OF TEXTURE AND COLOR PROPERTIES OF PLANT-BASED CHEESE ALTERNATIVES

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Abstract: The development of plant-based foods is one of the core contents of future food and an important way to achieve green and low-carbon development of the food industry. A prevailing food trend in the dairy industry is the demand to develop various plant-based alternatives to dairy products. Plant-based cheese alternatives, which are designed to mimic the appearance, texture, and flavor of traditional dairy cheese, can be produced from mixtures of pure and functional plant ingredients. For sliceable cheeses, texture and color are key attributes. In this context, the study formulated and characterized walnut plant-based cheese alternatives derived from walnuts, water, instant yeast, agar-agar, walnut oil, salt and sugar. Changes in texture profile and color parameters in all formulations were analyzed. It was found that the lowest and highest ratio of walnuts/water used for walnut plant-based cheese alternatives preparation has decreased in hardness values. The same correlation was attested for the walnut oil amount used for walnut plant-based cheese alternative formulations. However, higher content of instant yeast provided maximum hardness values of the product. The findings showed that the optimal walnut plant-based cheese alternative is walnuts/water ratio (1/2.56), walnut oil amount (12%) and instant yeast concentration (1.5%). This research explored the application potential of walnuts as a primary ingredient in plant-based cheese alternative formulation and contributed to sustainable development of the plant-based dairy products.

Keywords: walnuts, plant-based cheese alternative, texture profile analysis, color properties, optimization.

1. Introduction

Due to impacts from various aspects such as ethics, environment, health, and socio-economy, consumers worldwide have shown a further increased interest in plant-based diets [1, 2]. The plant-based dairy industry is projected to grow at a compound annual growth rate of 12.5 %, with global market size expected to reach \$52.58 billion by 2028. In dairy category plant-based cheese alternatives saw the most growth in retail sales comparison by increasing 95% in 2020 [3, 4]. Therefore, development of plant-based cheese alternatives is seen as a strategic alternative to traditional cheese.

On the other hand, the commercial market sales of plant-based cheese alternatives to consumers still need to be improved. Research into the nutritional value of plant-based cheese alternatives is beneficial to improve consumer understanding and acceptance. Currently, the market for plant-based cheese alternatives is

mainly dominated by products made from soy [5]. The consumers' concerns about genetically modified soybeans and the widespread occurrence of soybean allergies prevent it from replacing traditional cheese [3, 6].

Walnuts are among the most widely cultivated tree nuts globally. Walnuts are rich in substantial amounts of fats, proteins and phenolic compounds. Regular consumption of walnuts may have a positive effect on human health, cholesterol, anti-inflammation and reducing weight gain [7]. However, plant-based cheese alternatives also face some challenges. On the one hand, there may be a certain gap in texture, color and taste compared with traditional animal cheese. For example, due to the different properties of plant and animal proteins, plant-based cheese alternatives generally have texture problem. This needs to be solved by continuously improving the production process [8].

The Food and Health Survey consistently shows that taste is the number one driver behind purchase intention [9, 10], more important than price, convenience, and health. Therefore, it is important to develop a product that provides desirable texture characteristics [11, 12, 13]. In summary, the low sales margins indicate that the consumer market is left unsatisfied and there is substantial room for improvement and growth within this product category.

This study aims to research the impact of ingredients composition on the product characteristics of walnut plant-based cheese alternative, and to make a comparison between plant-based cheese alternative and animal cheese in some aspects such as texture and color properties. In addition, indicators such as antioxidant property, bioactive substances and fat of plant-based yogurt will be higher than those of animal yogurt.

2. Materials and methods

2.1. Experimental materials

Raw walnuts, instant yeast, agar-agar, walnut oil, salt and sugar were procured from the local market in Chisinau, Moldova. All chemicals used within this study were purchased from Eco-Chimie and Sigma-Aldrich (Chisinau, Moldova). All the chemicals used were of HPLC or

analytical grade. Distilled water was used throughout.

2.2. Preparation of walnut plant-based cheese alternative

Walnut plant-based cheese alternatives were prepared as described by Popovici, C., *et al.* [15, 16]. Briefly, all ingredients are weighed, combined and mixed in a blender bowl for 3 minutes until a homogeneous composition was formed. After that, prepared composition was boiled for 5 minutes until it became thicker. After the heat treatment, all formulations were placed in lidded storage containers (polycarbonate) and were kept at +4 °C for further color and texture evaluation [15].

2.3. Design of experiment

Response Surface Methodology (RSM) was used to investigate the main effects of ingredients on response variables, including color attributes (L^* , a^* and b^*) and texture parameters (hardness, adhesiveness, cohesiveness, springiness, gumminess, resilience, chewiness). The goal was to develop predictive models that maximize or minimize modellable response variables based on independent variables, and thereby optimizing amount of ingredients for walnut plant-based cheese alternatives making. (Table 1).

Table 1. Variables for optimization of walnut plant-based cheese alternative

Name	Units	Levels			
		Minimum	Maximum	Coded Low	Coded High
Walnuts/Water ratio	[c.u.]	0.07	0.39	0.14	0.33
Walnut oil	[%]	11.64	18.36	13.00	17.00
Instant Yeast	[%]	1.16	2.84	1.50	2.50

The three independent variables were walnuts/water ratio (0.07 – 0.39), walnut oil (11.64 – 18.36 %), and instant yeast (1.16 – 2.84%). A Central Composite design expert software (STAT-EASE 360) was generated 20 formulations, including 6 replicate center points [15, 16].

2.4. Evaluation of response variables

2.4.1. Texture Profile Analysis (TPA)

Samples of prepared walnut plant-based cheese alternatives were taken for texture

measurements. Each sample was cut from the central part of the products, resulting in 2×2×2 cm³ cubes, which was held in refrigerator at 5 °C before the measurements.

A Stable Micro Systems TA.HD plus C analyzer, UK was used for texture profile analysis of walnut plant-based cheese alternatives. All textural parameters were calculated considering the TPA curves (Figure 1).

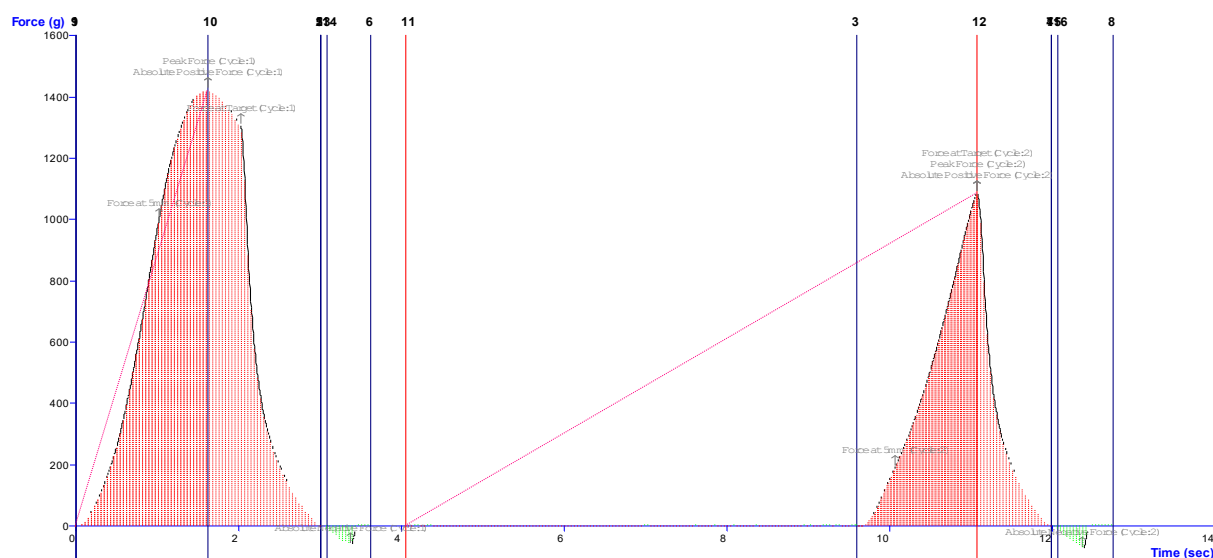


Fig. 1. Representative texture profile analysis curve for the 2nd formulation

To determine the textural properties of the walnut plant-based cheese alternatives, a double compression test was performed using spherical stainless 5 mm (P/5s), and respecting the following steps and parameters: pre-test speed—100 m/s; test speed—5 m/s; post-test speed—5 m/s, cell load—5 kg. Ten measurements were made on each product sample.

2.4.2. Surface Color Analysis

Colour analysis were performed using the CIELab system (Konica-Minolta 200). The calibration was performed using black and white enamel according to the producer's instructions. Each sample was cut from the central part of the walnut plant-based cheese alternatives, resulting in 2×2×2 cm³ cubes. Then, the measurements of cube samples were recorded in reflectance mode, color space CIELAB color system (L*, a*, b*).

2.5. Statistical Analysis

All experiments were carried out at least in triplicate and expressed results in mean±standard deviation. Design-expert software (v.13.0.5.0, USA) was used to design the experiments and statistical analysis of the findings. The statistical significance was determined by variance analysis (ANOVA).

The significant differences between the mean values were accepted at the ($p \leq 0.05$) probability level with a confidence level of 95 %.

3. Results and discussions

3.1. Analysis of variance (ANOVA) and regression coefficients for formulated walnut plant-based cheese alternative

Table 2 summarizes the ANOVA p-values of all studied responses (color and texture

parameters) for optimizing walnut plant-based cheese alternative formulation.

A special cubic model was used for the statistical data analysis of the responses. Table 2 reveals that in the color analysis, changes in L*, a* and b* parameters were found to be significantly influenced ($p < 0.05$) by the utilization of the three ingredients (walnut milk, walnut oil and instant yeast).

It shows a statistically significant relationship ($p \leq 0.05$) between all ingredients amounts. This is also supported by the fact that the p-values in all cases have higher values, which shows that the model is significant with better interaction between the variables. Moreover, the higher p-values for the model (as presented in Table 2) suggest that the model equation provides a satisfactory fit, supporting its effectiveness in formulating walnut plant-based cheese alternatives from the selected ingredients.

As seen in the ANOVA results in Table 2, high R² values and adjusted R² values demonstrate a strong correlation between response and independent variables. Furthermore, the selected model was found significant ($p \leq 0.05$) with a high confidence level based on adjusted R² values ranging from 0.95 to 0.98.

The lack-of-fit p-values for all the responses examined were relatively high (≥ 0.05), suggesting they are non-significant ($p \geq 0.05$). Moreover, the model's pure error was minimal, indicating high accuracy in the experimental response data.

Table 2. Analysis of variance (ANOVA) and regression coefficients of the models used for the prediction of the responses in walnut plant-based cheese alternative

Responses	Regressions coefficients										Adequacy of model					
	Intercept	Linear			Interactions			Quadratic			Lack of fit (p-value)	R ²	R ² _{adj}	Adeq _{ptrc}	SD	Mean
		A	B	C	AB	AC	BC	A ²	B ²	C ²						
Colour characteristics																
Colour (L)	226.96**	-108.24*	-26.09**	-17.01**	15.78**	-7.89***	-0.75*	388.70*	6.96*	0.70*	0.90 ^{NS}	0.99	0.95	24.41	0.79	59.07
Colour (a)	3.03**	0.24*	0.56***	-0.16*	0.75**	0.50***	-1.24*	0.35*	0.35*	-0.35*	0.92 ^{NS}	0.98	0.98	158.84	0.02	-0.69
Colour (b)	22.10**	0.10*	1.10*	0.95*	NS	NS	NS	NS	NS	NS	0.02 ^S	0.98	0.98	875.11	0.02	11.88
Texture parameters																
Hardness	1376.32**	-80.06*	-40.46*	-29.85*	42.95*	-71.85*	35.32***	-58.86*	-33.64*	-7.94***	0.52 ^{NS}	0.98	0.98	397.50	18.54	1794.22
Adhesiveness	1319.6**	-70.45*	-49.40*	-4.97*	53.81*	NS	12.54***	-33.15*	-49.34*	-64.68*	0.62 ^{NS}	0.98	0.98	47.838	12.79	1401.78
Springiness	1.13**	-0.01*	0.01*	-0.01*	-0.01*	0.02**	0.01*	-0.02*	0.01*	0.03*	0.78 ^{NS}	0.96	0.96	25.54	0.02	2.23
Cohesiveness	0.44**	0.01**	-0.01*	0.01*	0.01*	-0.01*	0.01*	NS	NS	NS	0.58 ^{NS}	0.98	0.98	65.89	0.02	0.17
Resilience	34.09**	-212.20*	609.23*	-212.20*	362.24*	-362.24*	-362.18*	-219.62*	1183.15*	-219.50*	0.24 ^{NS}	0.98	0.97	41.43	0.02	0.09
Gumminess	623.12**	-34.05*	-21.29*	-16.71*	18.01*	-43.01*	32.09*	-28.72*	16.16*	-7.90*	0.95 ^{NS}	0.98	0.98	131.84	1.98	401.52
Chewiness	705.21**	-40.77*	-15.88*	-21.23*	16.16*	-40.04*	43.79*	-44.27*	-15.48*	8.69*	0.77 ^{NS}	0.98	0.97	654.28	0.35	421.24

* p < 0.05, ** 0.05 ≤ p < 0.1, *** p ≥ 0.1

S – significant, NS – not significant

3.2. Color Analysis

The color is a critical quality attribute with significant economic implications, as it influences sensory perception and plays a key role in determining consumer acceptance of food

products [17]. Therefore, the influence of three independent factors on the color characteristics were evaluated and experimental data for walnut plant-based cheese alternative formulations are presented in Table 3.

Table 3. Effects of different walnut plant-based cheese alternative formulations on the color characteristics

Formulation	Color characteristics		
	L	a	b
1	51.07±0.07	5.05±0.05	29.75±0.07
2	60.14±0.02	2.32±0.07	20.35±0.05
3	68.46±0.05	1.23±0.03	25.15±0.02
4	56.58±0.03	3.45±0.05	25.29±0.07
5	63.21±0.02	3.74±0.02	23.34±0.03
6	54.36±0.07	3.56±0.11	26.35±0.02
7	65.25±0.05	2.85±0.07	25.69±0.11
8	65.75±0.03	3.69±0.05	20.58±0.05
9	67.96±0.02	0.45±0.02	20.47±0.07
10	58.45±0.03	3.65±0.11	25.48±0.03
11	63.25±0.07	1.78±0.03	25.59±0.02
12	63.04±0.05	2.36±0.07	21.23±0.05
13	61.36±0.11	2.78±0.05	18.19±0.07
14	63.85±0.02	2.16±0.02	20.78±0.11
15	68.98±0.05	2.18±0.03	20.67±0.02
16	69.36±0.07	0.25±0.05	20.56±0.05
17	67.78±0.03	2.12±0.07	21.48±0.03
18	69.36±0.05	-1.11±0.02	20.57±0.07
19	75.78±0.11	-2.36±0.05	22.26±0.05
20	66.55±0.02	1.37±0.07	17.28±0.02

The L^* parameter characterizes the brightness, which depends on the calibration used, and typically varies from 0, representing pure black, to 100, indicating a pure white [18].

In this study, although some significant changes in L^* values occurred, there were several variations, ranging from 51.07 to 75.78 between all formulations (Figure 2).

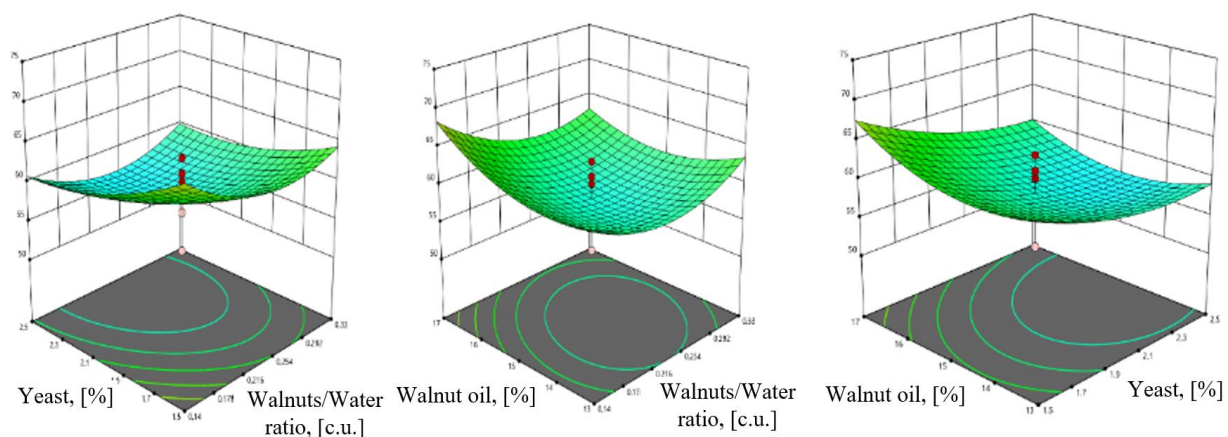


Fig. 2. Effect of different walnut plant-based cheese alternative formulations on the color (L) parameter

The statistical analysis showed a significant increase in the L^* parameter, which is attributed to the lower walnuts/water ratio in walnut milk used for walnut plant-based cheese alternative formulation and the lower lightness of the formulations due to the higher amount of instant yeast and less walnut milk concentration. Considering the walnut milk containing ingredient, it was observed that an increase in the walnuts/water ratio, from 0.33 to 0.394, resulted in a statistically significant reduction in lightness and lower values of the L^* parameter. When

comparing the color of the walnut plant-based cheese alternative formulations about the instant yeast used, it was observed that their addition resulted in lower L^* values (darker walnut plant-based cheese alternative formulations) compared to control samples.

The a^* parameter represents the color from red (positive values) to green (negative 210 values) [19]. The values of the a^* parameter for the control samples were 2.01 and 3.27 for commercially plant-based cheese and dairy cheese, respectively (Figure 3).

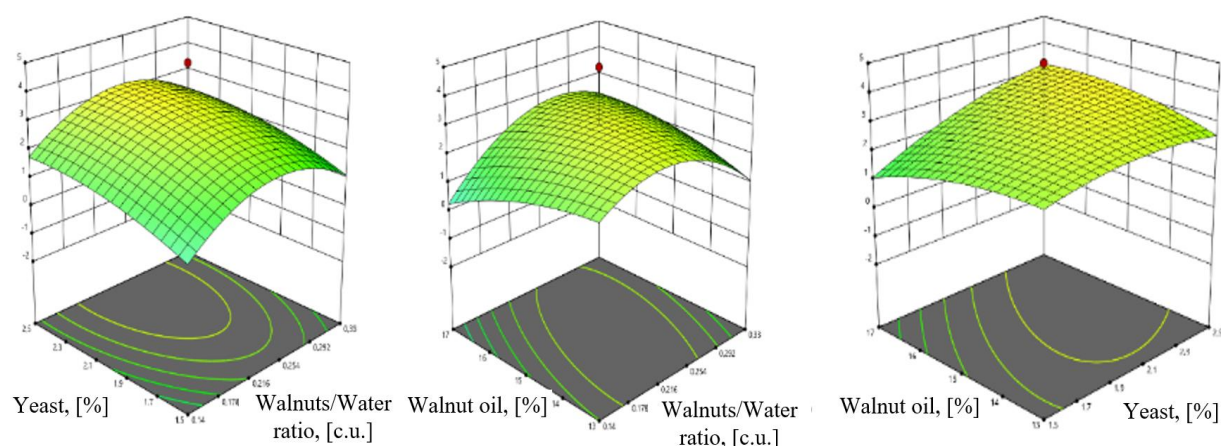


Fig. 3. Effect of different walnut plant-based cheese alternative formulations on the color (a) parameter

All the formulations with the addition of walnut milk showed the positive values for parameter a^* , and the presence of more concentrated walnut milk resulted in higher values (3.69-5.05) compared to the commercial plant-based cheese sample (1.05). Taking into account the instant yeast amount used, it was observed that an increase in the concentration from 2.5 to 2.84 % increased the value of the a^* parameter, from 1.78 to 3.69. The b^* parameter indicates the color between blue (positive values)

and yellow (negative values) [20]. The values of the walnut plant-based cheese alternative formulations with the addition of more concentrated walnut milk showed lower values (18.19-20.47). Taking into account the instant yeast concentrations, it was observed that the increase in concentration from 2.5 to 2.84 % increased the value of the parameter b^* in the walnut plant-based cheese alternative formulations from 22.26 to 26.35 (Figure 4).

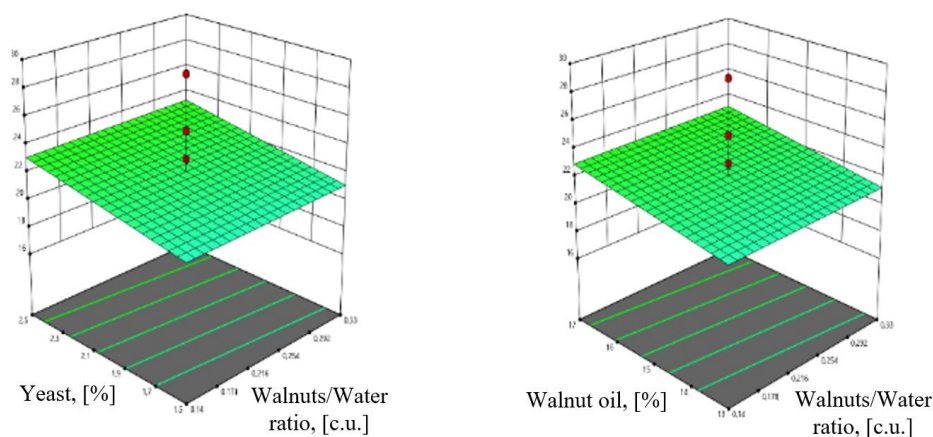


Fig. 4. Effect of different walnut plant-based cheese alternatives formulations on the color (b) parameter

The walnut plant-based cheese alternative formulations containing lower walnut milk concentration and less amount of instant yeast showed a statistically significantly lighter color (parameter L^*) in comparison to control samples. Control cheese samples were slightly yellow (negative parameters b^*).

The color of the walnut plant-based cheese alternative formulations was affected by the natural color of walnut milk, which was expected to be obtained in this study as one of the main ingredients for walnut plant-based cheese alternative production.

3.3. Texture Profile Analysis (TPA)

In addition to the color analysis, Texture Profile Analysis also gives valuable information about the quality of walnut plant-based cheese alternative formulations. This method involves subjecting each sample to 2 cycles of compression and decompression, with a maximum strain applied at 70%.

This method is widely employed to simulate the repetitive and large-scale deformations that occur during mastication, providing an indirect assessment of sensory food perception [21].

Changes in texture can reflect the structural alterations of ambient plant-based cheese to some

extent, correlating partially with the product's syneresis [22].

The texture analysis of the walnut plant-based cheese alternative formulations was undertaken against commercial plant-based cheese and dairy cheese. The TA.HDplusC texture analyzer was used in order to determine the physical properties of the walnut plant-based cheese alternative formulations such as: hardness, adhesiveness, springiness, cohesiveness, resilience, gumminess and chewing ability.

The texture parameters, as well as the obtained values during the texture analysis of walnut plant-based cheese alternative formulations are presented in Table 4.

The hardness is an important textural parameter, which is related to the strength of the cheese formulation under compression, and it is defined as the peak force during the first compression cycle [23].

The interaction effect of the walnuts/water ratio, amount of walnut oil and instant yeast was studied using response surface plots, which helped predict the optimal levels of each ingredient to achieve acceptable hardness values (Figure 5).

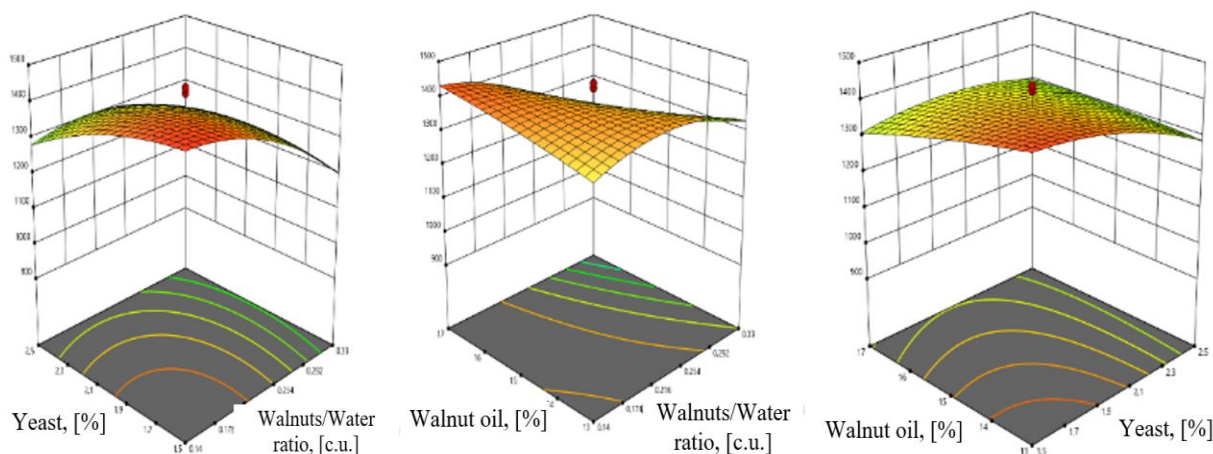


Fig. 5. *Effect of independent variables on hardness attribute of the walnut plant-based cheese alternatives*

It was found that the lowest and highest ratio of walnuts/water used for walnut plant-based cheese alternatives preparation has decreased in hardness values. The same correlation was attested for the walnut oil amount used for walnut

plant-based cheese alternative formulations. However, higher content of instant yeast provided maximum hardness values of the product.

Table 4. *Effects of different walnut plant-based cheese alternative formulations on the texture parameters*

Formulation	Texture parameters						
	Hardness, [g]	Adhesiveness, [g·s]	Springiness, [%]	Cohesiveness, [%]	Resilience, [%]	Gumminess, [g]	Chewiness, [g]
1	1319.23±3.04	1314.03±1.41	1.08±0.07	0.45±0.03	0.40±0.03	605.42±1.45	658.64±2.19
2	1424.67±2.14	1133.84±3.01	1.24±0.03	0.45±0.05	0.76±0.07	641.92±3.05	799.20±1.43
3	1294.67±1.44	1238.02±4.01	1.14±0.05	0.46±0.07	0.53±0.05	601.45±1.03	690.76±3.07
4	1353.21±3.24	1476.47±2.17	1.06±0.04	0.42±0.04	0.31±0.03	577.33±2.18	614.38±1.17
5	1438.29±4.04	1408.86±1.04	1.13±0.07	0.45±0.03	0.47±2.12	659.70±1.07	746.52±2.13
6	1271.03±2.11	1165.80±1.49	1.16±0.05	0.44±0.05	0.55±0.07	570.32±1.11	664.24±3.02
7	1141.92±1.47	1031.73±3.04	1.16±0.03	0.44±0.07	0.56±0.03	503.59±3.03	587.14±1.42
8	1306.09±2.11	1057.35±3.03	1.24±0.05	0.44±0.05	0.76±0.07	575.37±3.01	718.67±3.07
9	1356.25±1.51	1151.88±1.71	1.16±0.07	0.47±0.04	0.62±0.04	639.66±1.94	743.96±1.53
10	1367.73±3.07	1364.27±2.11	1.09±0.04	0.45±0.07	0.43±0.03	620.45±2.11	681.28±2.16
11	998.18±2.17	1088.82±1.37	1.05±0.03	0.43±0.03	0.29±0.04	438.49±1.75	461.23±3.01
12	1107.63±1.91	933.34±1.52	1.23±0.05	0.40±0.05	0.68±0.07	452.09±3.03	559.03±1.56
13	1347.67±1.57	1212.08±3.04	1.15±0.03	0.46±0.03	0.59±0.05	630.57±1.31	729.07±1.96
14	1443.05±1.77	1265.07±2.13	1.16±0.04	0.44±0.07	0.60±0.03	645.59±2.13	753.58±2.18
15	1332.75±3.01	1243.42±1.97	1.11±0.07	0.45±0.04	0.46±0.04	603.94±3.09	671.27±1.74
16	1114.59±1.59	1082.19±1.73	1.10±0.05	0.43±0.05	0.43±0.07	488.64±1.92	540.35±3.02
17	1393.40±2.13	1249.17±3.01	1.18±0.03	0.45±0.03	0.60±0.05	637.53±2.17	752.07±1.93
18	1462.94±1.93	1411.95±1.56	1.07±0.04	0.45±0.07	0.39±0.03	664.69±1.79	711.43±1.59
19	1405.10±3.09	1409.48±2.15	1.09±0.05	0.43±0.05	0.40±0.07	605.13±3.03	664.91±2.14
20	1276.35±2.19	1145.50±3.07	1.13±0.07	0.45±0.03	0.53±0.05	579.65±2.11	659.30±3.05

Adhesiveness is another textural parameter, and it is defined as the capacity of a material to stick to another substance; therefore, it depends upon the surface characteristics of the product [24]. It was found, that the application of instant yeast improved the adhesiveness of walnut plant-based cheese alternative formulations (Figure 6).

Incorporation of this ingredient into walnut plant-based cheese alternative formulation increased the product range. According to Table 2, formulations 4, 5, 10, 18 showed higher adhesiveness values in the formulations with a quantity of instant yeast of 2% and increased walnuts/water ratio.

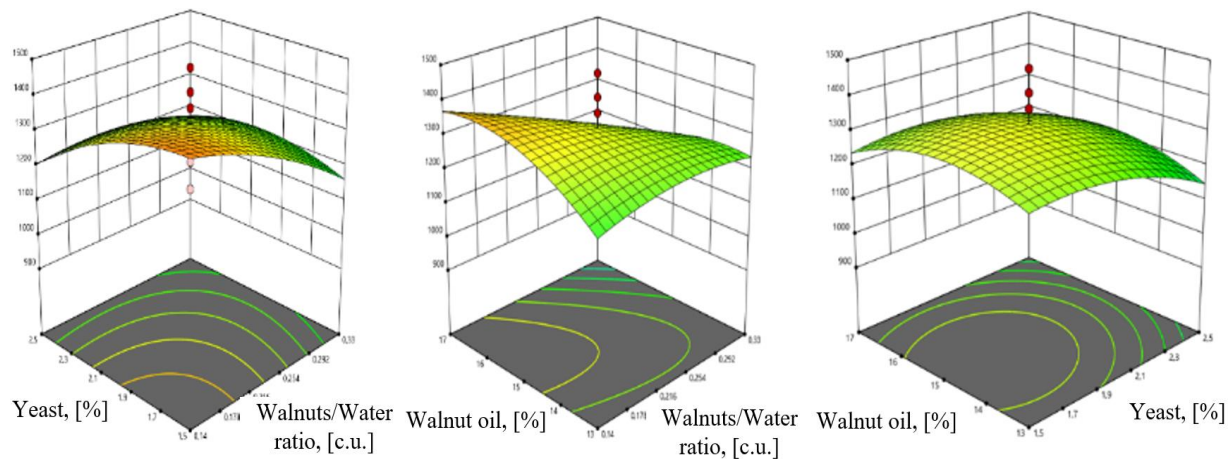


Fig. 6. *Effect of independent variables on adhesiveness attribute of the walnut plant-based cheese alternatives*

The springiness is another textural parameter, which is related to the elasticity of the sample. Springiness in TPA is related to the height that the cheese recovers during the time that elapses during the end of first bite and the start of the second bite [23]. In figure 7, the response variable for springiness attributes has a good correlation with increased walnuts/water ratio

and with walnut oil content of 15% and instant yeast of 2.0%. Higher springiness values were obtained for the 2nd and 8th formulation, indicating enhanced elastic properties of these walnut plant-based cheese alternatives, while the lowest elasticity was obtained for the 11th formulation.

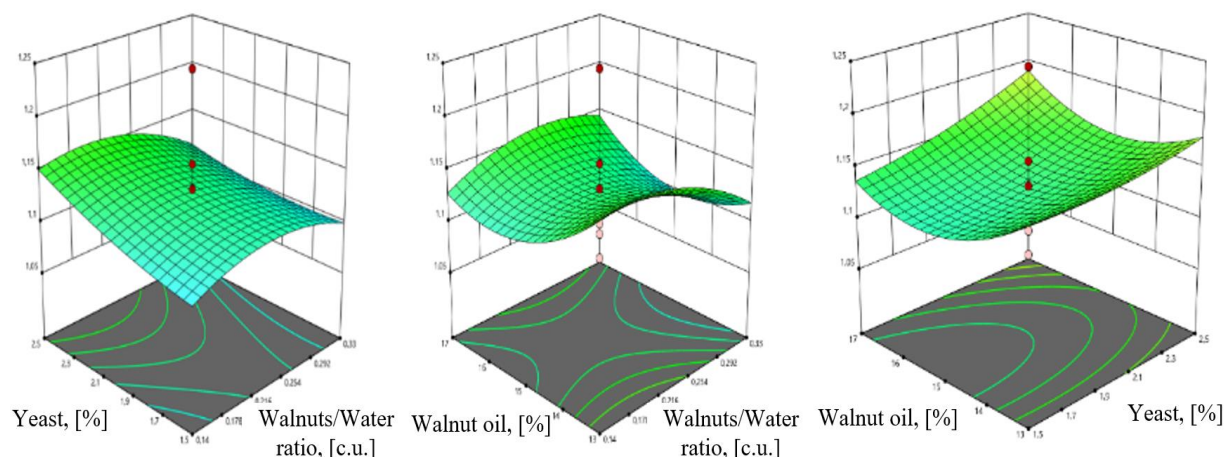


Fig. 7. *Effect of independent variables on springiness attribute of the walnut plant-based cheese alternatives*

The cohesiveness is also known as consistency, and it indicates the strength of internal bonds that make up the body of cheese and the degree to which a cheese can be deformed before it breaks [23]. As indicated by

Chandra et al., it was also defined as the ratio of the positive force area during the second compression to that of the first compression because cohesiveness indicates the ability of the cheese to hold together [23]. Referring back to

the results that are shown Figure 5, the cohesiveness values of walnut plant-based cheese alternative formulations were found in the range of 0.40–0.47. The Figure 8 represents the highest cohesiveness values and the corresponding combination of the independent factors required to achieve this level of cohesiveness. The results

showed that the best combination of the variables to maximize consistency was incorporation of instant yeast of 2.5% and walnuts/water ratio of 0.24. The results showed that different amounts of walnut oil influenced insignificantly on cohesiveness of the walnut plant-based cheese alternative formulations.

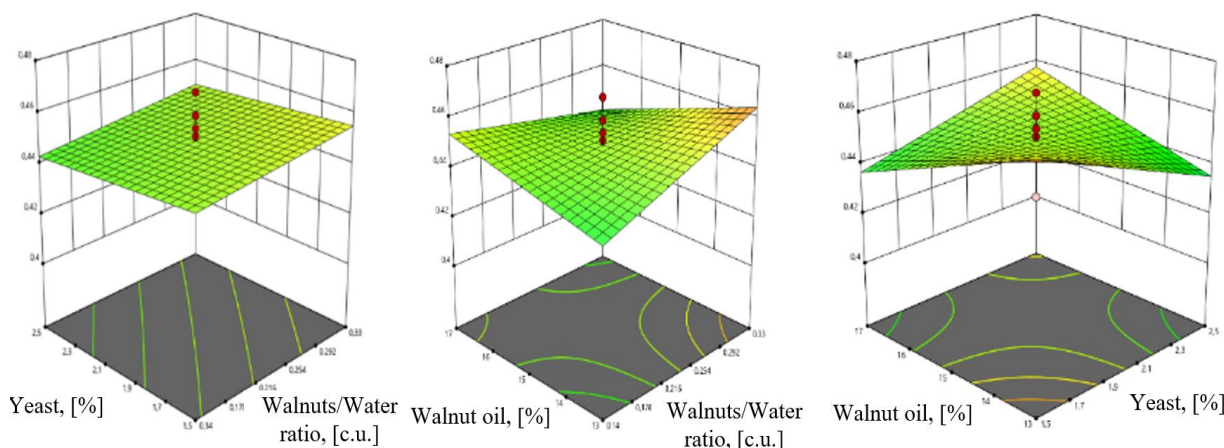


Fig. 8. *Effect of independent variables on cohesiveness attribute of the walnut plant-based cheese alternatives*

The resilience represent a capacity over time of a food product and its units at multiple levels, to provide sufficient, appropriate and accessible food to all, in the face of various and even unforeseen disturbances [25]. The Figure 9 represents the highest liking of resilience and the corresponding combination of the independent

factors required to achieve this level of resilience. The results showed that the best combination of the variables was walnuts/water ratio in the range between 0.24-0.3, content of walnut oil between 14-16 % and instant yeast in the range of 1.9-2.2%.

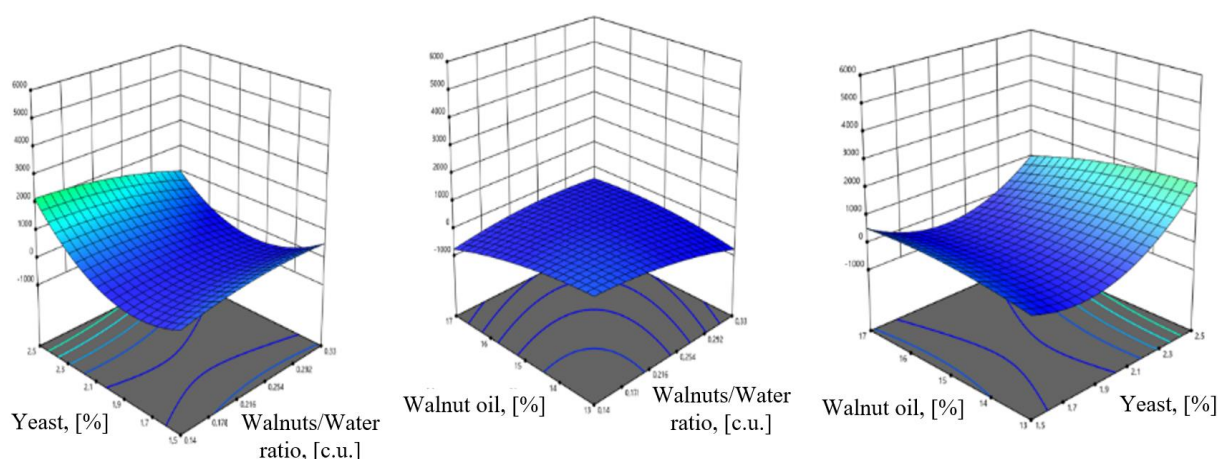


Fig. 9. *Effect of independent variables on resilience attribute of the walnut plant-based cheese alternatives*

As indicated by Delgado and Bañón, [26] gumminess and chewiness are generally used as the texture descriptors together with hardness. Gumminess is defined as the product of hardness and cohesiveness; therefore, higher hardness led to high gumminess, and it is considered as an

important textural parameter for semi-solid foods [23] In this study, the highest gumminess was found for the 5th formulation (659.70), while the lowest gumminess was found for the 11th formulation (438.49) (Figure 10).

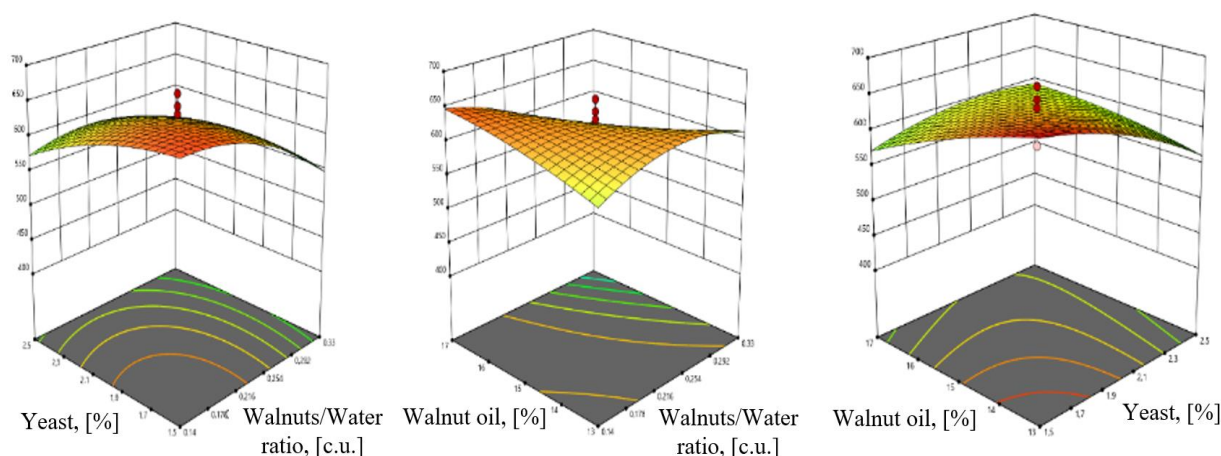


Fig. 10. *Effect of independent variables on gumminess attribute of the walnut plant-based cheese alternatives*

The last textural parameter seen in Table 4 was the chewiness, and it was defined as the measure of energy that is necessary to masticate the food and is generally reported for solid foods [23]. It is calculated as the product of gumminess

and springiness that is equal to hardness $\times$ cohesiveness $\times$ springiness [23]. As seen in Figure 11, the highest chewiness values were found for the 2nd formulation (799.20).

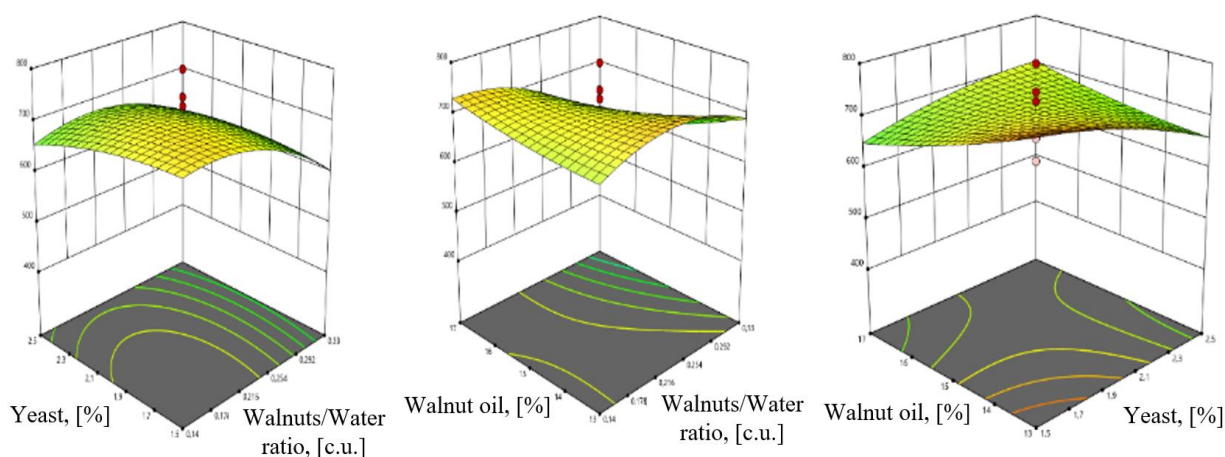


Fig. 11. *Effect of independent variables on chewiness attribute of the walnut plant-based cheese alternatives*

To conclude, with regard to the TPA of the formulations, it is definite that the utilization of higher walnuts/water ratio and instant yeast amount in the walnut plant-based cheese alternative formulations led to the formation of desirable textural characteristics in walnut plant-based cheese alternative.

It is well known that texture and color properties of food products are the most important attributes as they are the most apparent to consumers [27-35]. While attributes such as hardness, adhesiveness, springiness were predicted by the models, a higher ratio of walnuts/water used for walnut plant-based cheese alternative preparation was achieved when product optimization was carried out based on

texture and color evaluation which subsequently produced a product with lower walnut oil content and increased instant yeast content.

4. Conclusions

This study aimed to explore the functional and nutritional potential of walnuts for plant-based cheese alternative formulation. Through the texture profile analysis and color parameters, it revealed the significant impact of the walnuts/water ratio, amount of walnut oil and instant yeast on the hardness, adhesiveness, cohesiveness, springiness, gumminess, resilience and chewiness values and L^* , a^* and B^* attributes of the walnut plant-based cheese alternatives. The findings indicated that the

incorporation of walnut milk with higher walnuts/water ratio enhanced the hardness, springiness, and chewiness of the cheese formulations, while simultaneously reducing its adhesiveness and optimizing its texture. This study further explored the potential applications of walnuts in plant-based cheese alternative and introduced walnut oil to meet the diverse dietary needs of consumers. This research will continue to aim at contributing valuable insights and references to support the ongoing development of the plant-based dairy sector.

5. Acknowledgements

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References

1. Clay, N., Garnett, T., Lorimer, J. *Dairy Intensification: Drivers, Impacts and Alternatives*. *Ambio* 2020, 49 (1), 35–48. <https://doi.org/10.1007/s13280-019-01177-y>.
2. Falkeisen, A., Gorman, M., Knowles, S., Barker, S., Moss, R., McSweeney, M. B. *Consumer Perception and Emotional Responses to Plant-Based Cheeses*. *Food Res. Int.* 2022, 158, 111513.
3. Short, E. C., Kinchla, A. J., Nolden, A. A. *Plant-Based Cheeses: A Systematic Review of Sensory Evaluation Studies and Strategies to Increase Consumer Acceptance*. *Foods* 2021, 10 (4), 725.
4. Dobson, S., Marangoni, A. G. *Methodology and Development of a High-Protein Plant-Based Cheese Alternative*. *Curr. Res. Food Sci.* 2023, 7, 100632.
5. Waehrens, S. S., Faber, I., Gunn, L., Buldo, P., Bom Frøst, M., Perez-Cueto, F. J. A. *Consumers' Sensory-Based Cognitions of Currently Available and Ideal Plant-Based Food Alternatives: A Survey in Western, Central and Northern Europe*. *Food Qual. Prefer.* 2023, 108, 104875.
6. Grossmann, L., McClements, D. J. *The Science of Plant-Based Foods: Approaches to Create Nutritious and Sustainable Plant-Based Cheese Analogs*. *Trends Food Sci. Technol.* 2021, 118, 207–229. <https://doi.org/10.1016/j.tifs.2021.10.004>.
7. Fabiszewska, A., Wierzychowska, K., Dębkowska, I., Śliczniak, W., Ziółkowska, M., Jasińska, K., Kobus, J., Nowak, D., Zieniuk, B. *Plant-Based Alternatives to Mold-Ripened Cheeses as an Innovation among Dairy Analogues*. *Foods* Basel Switz. 2024, 13 (14), 2305. <https://doi.org/10.3390/foods13142305>.
8. Giaccone, L., Siegrist, M., Stadelmann, A., Hartmann, C. *Consumers' Perceptions of Healthiness and Environmental Friendliness of Plant-Based and Dairy Product Concepts*. *Food Humanity* 2024, 2, 100288. <https://doi.org/10.1016/j.foohum.2024.100288>.
9. Jaeger, I., Köhn, C. R., Evans, J. D., Frazzon, J., Renault, P., Kothe, C. I. *Nutritional and Microbial Profiles of Ripened Plant-Based Cheese Analogs Collected from the European Market*. *Food Res. Int.* 2024, 191, 114724. <https://doi.org/10.1016/j.foodres.2024.114724>.
10. Braitmaier, H., Wahl, A.-L., Hinrichs, J., Atamer, Z. *Can Plant-Based Cheese Alternatives Be Characterized by Methods for Dairy Cheese? Extending Dairy Cheese Methods to Characterize Plant-Based Cheese Alternatives*. *Int. Dairy J.* 2024, 159, 106056. <https://doi.org/10.1016/j.idairyj.2024.106056>.
11. Etter, B.; Michel, F.; Siegrist, M. *Consumers' Categorizations of Dairy Products and Plant-Based Milk, Yogurt, and Cheese Alternatives*. *Appetite* 2024, 203, 107658. <https://doi.org/10.1016/j.appet.2024.107658>.
12. Ruby, M. B., Graça, J., Olli, E. *Vegetarian, Vegan, or Plant-Based? Comparing How Different Labels Influence Consumer Evaluations of Plant-Based Foods*. *Appetite* 2024, 197, 107288.
13. Amyoony, J., Moss, R., Dabas, T., Gorman, M., Ritchie, C., LeBlanc, J., McSweeney, M. B. *An Investigation into Consumer Perception of the Aftertaste of Plant-Based Dairy Alternatives Using a Word Association Task*. *Appl. Food Res.* 2023, 3 (2), 100320. <https://doi.org/10.1016/j.afres.2023.100320>.
15. Popovici, C., Teng, X.M., Jadeja, R. *Walnut cheese-like alternatives as an innovation among dairy analogues*. In: *Journal of EcoAgriTourism*, 2024, ISSN 1844-8577, Vol. 20, no. 2, 5-12 p.
16. Popovici, C., Gaceu, L., Teng, X.M., Jadeja, R. *The application of response surface methodology for development of sensory acceptable walnut cheese-like alternatives*. In: *Journal of EcoAgriTourism*, 2024, ISSN 1844-8577, Vol. 20, no. 2, 34-42 p.

17. Kasprzak, M. M., Najgebauer-Lejko, D., Pluta-Kubica, A., Turek, K., Domagała, J., Czaja, T. P. *Impact of Milk Fat Globule Replacement with Emulsified Canola Oil Droplets on the Composition, Structure, Texture, Sensory Properties, and Lipid Oxidation of Fresh Soft Rennet Cheese*. *J. Dairy Sci.* 2025, 108 (8), 8259–8272.
18. Jayakumar, D., Santhapur, R., McClements, D. J. *Preparation and Characterization of Plant Protein-Mushroom Hybrids: Toward More Healthy and Sustainable Foods*. *Food Biophys.* 2024, 19 (4), 1077–1094. <https://doi.org/10.1007/s11483-024-09879-x>.
19. Giusti, M. M., Gordillo, B., González-Miret, M. L. *Color Analysis*. In Nielsen's Food Analysis; Ismail, B. P., Nielsen, S. S., Eds.; Food Science Text Series; Springer International Publishing: Cham, 2024; p. 509–522.
20. Bhargava, N., Sharanagat, V. S., Mor, R. S., Kumar, K. *Active and Intelligent Biodegradable Packaging Films Using Food and Food Waste-Derived Bioactive Compounds: A Review*. *Trends Food Sci. Technol.* 2020, 105, 385–401.
21. Kasprzak, M. M., Najgebauer-Lejko, D., Pluta-Kubica, A., Turek, K., Domagała, J., Czaja, T. P. *Impact of Milk Fat Globule Replacement with Emulsified Canola Oil Droplets on the Composition, Structure, Texture, Sensory Properties, and Lipid Oxidation of Fresh Soft Rennet Cheese*. *J. Dairy Sci.* 2025, 108 (8), 8259–8272.
22. Xu, C. F., Lu, Z. J., Sheng, Z. Y., Wang, P. J., Zhang, X. Y., Zhang, Y., Zhang, J., Fan, X. K., Luo, J. *Textural Changes and Mechanisms in UHT-Treated Ambient Cheese Products under Different Storage Conditions*. *J. Dairy Sci.* 2025, S0022030225005028.
23. Chandra, M. V., Shamasundar, B. A. *Texture Profile Analysis and Functional Properties of Gelatin from the Skin of Three Species of Fresh Water Fish*. *Int. J. Food Prop.* 2015, 18 (3), 572–584.
24. Slavutsky, A. M., Bertuzzi, M. A. *Formulation and Characterization of Hydrogel Based on Pectin and Brea Gum*. *Int. J. Biol. Macromol.* 2019, 123, 784–791.
25. Tendall, D. M., Joerin, J., Kopainsky, B., Edwards, P., Shreck, A., Le, Q. B., Kruetli, P., Grant, M., Six, J. *Food System Resilience: Defining the Concept*. *Glob. Food Secur.* 2015, 6, 17–23.
26. Delgado, P., Bañón, S. *Determining the Minimum Drying Time of Gummy Confections Based on Their Mechanical Properties*. *CyTA - J. Food* 2015, 13 (3), 329–335.
27. Birwal P, S. P., Bk, Y. *Importance of Objective and Subjective Measurement of Food Quality and Their Inter-Relationship*. *J. Food Process. Technol.* 2015, 06 (09).
28. Luntraru, C. M., Apostol, L., Oprea, O. B., Neagu, M., Popescu, A. F., Tomescu, J. A., Gaceu, L. (2022). Reclaim and valorization of sea buckthorn (*Hippophae rhamnoides*) by-product: antioxidant activity and chemical characterization. *Foods*, 11(3), 462.
29. Apostol, L., Belc, N., Gaceu, L., Vladut, V., Oprea, O.B. (2019). Chemical composition and rheological parametrs of *Helianthus Tuberosus* flour used as a sources of bioactive compounds in bakery. *Rev. Chim.* 70(6), 2048-2053.
30. Mnerie, D., Gaceu, L., Gubenian, O., Shamtsyan, M., Birca, A., & Mnerie, G. V. (2016). Comparative study on the evolution of the food labeling quality in some countries from the Black Sea region. *J. of Hygienic Engineering and Design*, (14), 60-65.
31. Apostol, L., Belc, N., Gaceu, L., Oprea, O.B., Popa, M.E. (2020). Sorghum flour: A valuable ingredient for bakery industry?. *Applied Sciences*, 10(23), 8597.
32. Gaceu, L., Gadei, G., Oprea, O.B. (2014). Methodology for analyzing EU-conform label information content of meat products in Romania. *J. of Agricultural Informatics*, 5(1), 18-26.
33. Oprea, O.B., Gaceu, L. (2016). Application of multiple criteria decision making (mcdm) in bakery industry. Study case: wastes and by-products. *Bulletin of the Transilvania University of Brasov. Series II: Forestry• Wood Industry• Agricultural Food Engineering*, 89-94.
34. Oprea, O. B., Gaceu, L., & Gadei, G. (2013). Investigation methodology about labels information content of the meat products from Romania, in accordance with European Legislation. In *Proceeding of the international conference Agriculture Informatics*, (pp. 7-12).
35. Oprea, O. B., & Gaceu, L. (2020). Consumer acceptance and sensorial analysis of bread with grape seed flour. In *E3S Web of Conferences* (Vol. 215, p. 01005). EDP Sciences.

HYGIENIC DESIGN OF PROFESSIONAL KITCHENS IN THE HORECA INDUSTRY. WASTEWATER MANAGEMENT IN PROFESSIONAL KITCHENS: CONCEPTS, TECHNOLOGIES AND PRACTICAL APPLICATIONS

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Abstract: *The paper examines the role of hygienic design as a fundamental component in ensuring food safety and operational efficiency within professional kitchens in the HoReCa sector. Hygienic design is presented as a structural approach that integrates food safety, process reliability and sustainability, emphasizing the prevention of contamination risks through optimized infrastructure. Special attention is given to wastewater management, highlighting the importance of drainage systems as critical hygienic elements rather than secondary technical accessories. The study presents design principles aligned with European regulatory frameworks and EHEDG guidelines, illustrating practical benefits through an industrial case study involving the implementation of ACO hygienic drainage technology. Results demonstrate significant improvements in maintenance, sanitation efficiency, environmental impact and overall food safety assurance. The conclusions reinforce the necessity of integrating hygienic design from the initial planning stages of professional kitchens to support long-term durability, cost reduction and enhanced public health protection.*

Keywords: *Hygienic design, Food safety, Professional kitchens, Wastewater management, EHEDG standards*

1. Theoretical foundations of hygienic design

Hygienic design is an integrated approach to the design and operation of spaces, installations and equipment, which aims to prevent the accumulation of dirt, organic matter and residual moisture, as well as to facilitate cleaning and disinfection. In contrast to a purely operational, procedure-focused view, hygienic design places the infrastructure at the heart of the food safety system. In this logic, hygiene is not just behavior and routine, but a structural property of the built environment.

Epistemically, hygienic design links three registers: food safety, process reliability and sustainability. Their interdependence is obvious: an infrastructure designed to facilitate hygiene reduces the need for prolonged washing, reduces hot water and detergent consumption and limits unplanned shutdowns. At the same time, it reduces the risk of sanitary incidents, product recalls, sanctions and reputational damage.

The hygienic approach starts from several recurring premises in food engineering: ease of sanitation, accessibility, drainability, material robustness and flow control. Surfaces are designed as active barriers against microbial adhesion and colonization; joints and edges are shaped to eliminate stagnation areas; the paths of people, food, packaging and waste are separated to minimize critical intersections.

A key attribute is material integrity. In professional environments, cleaning agents, steam, hot water, fatty acids and food salts exert considerable chemical and mechanical stresses. Materials must be corrosion resistant, easy to inspect, non-porous and smooth enough to prevent particle retention.

The hygiene framework operates as a risk management cycle: identification, analysis, control, verification and review. In this loop, design decisions – from material selection to gutter detailing – are treated as control measures in their own right. Verification goes beyond

visual audits; it includes cleaning samples, microbiological validations and periodic monitoring to confirm that the design intent is translating into actual performance.

Sustainability is not a by-product, but a corollary of hygienic operation. Easy-to-clean spaces require fewer cycles and shorter times, which reduces water and energy consumption. Surfaces that do not retain organic matter reduce the doses of chemicals and the frequency of aggressive interventions. Reduced contamination translates into less food waste, while the durability of materials reduces the need for replacements and the volume of industrial waste. At European level, the European Hygienic Engineering and Design Group (EHEDG) was founded in 1989 as a non-profit consortium of equipment manufacturers, food manufacturers, suppliers to the food industry, research institutes and universities, health authorities and various government organizations interested in food safety. Currently, EHEDG has around 1,270 key

contact persons worldwide, 270 individual members, 393 partner companies and institutes.

The main objective of EHEDG is to support food safety through the hygienic design of food-related equipment and technologies, as well as through the application of specific standards in all aspects of food production.

EHEDG actively supports European legislation, which requires that food handling, processing and packaging be carried out hygienically, using equipment in accordance with the Food Hygiene Directive, the Machinery Directive and the Food Contact Materials Directive (EC Directive 2006/42/EC for equipment, EN 1672-2 and EN ISO 14159 on hygiene requirements for the design of equipment). Equipment manufacturers and their users are responsible for implementing these requirements and EHEDG provides them with support on essential hygienic design standards in accordance with national and international legislation (Table 1).

Table 1. *Areas of action of the concept of "hygienic design"*

Building hygiene	• Floors, ceilings, walls and sanitary drains • Zoning • Food safety • HVAC, wiring, ductwork, cabinets
Hygienic utilities	• Water, steam • Air
Hygiene equipment and process design	• Building Materials • Hygienic Welding • Maintenance • Cleaning and Drainage
Cleaning and disinfection	• CIP Design • Dry Cleaning, Cleaning in Open, Demountable Installations • Cleaning Procedures • Cleaning Validation • Cleaning Chemicals

The mission of EHEDG is defined as: "EHEDG facilitates the production of safe food by providing authoritative guidance in hygienic engineering and design". Starting with November 1, 2016, EHEDG is also represented in Romania www.ehedg.org.

2. Correct design of waste and by-product flows

A high-performance professional kitchen is designed based on flow diagrams. Raw materials follow clear paths to processing points, without interfering with the flow of dirty dishes, residues or waste. Staff circuits are designed so that the transition between areas with high microbial load and finishing areas involves hygienic barriers, from changing equipment to checking footwear and hand hygiene.

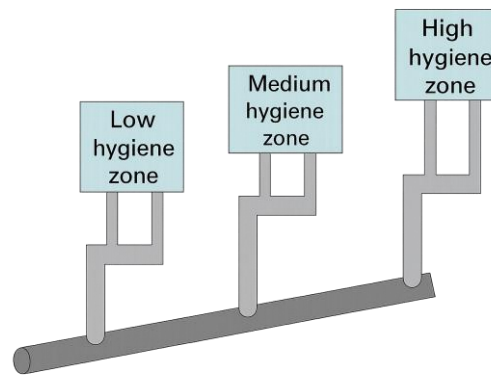


Fig. 1. *Correct design of waste and by-product flows*

Walls, floors and ceilings are treated as a coherent whole. Continuity of materials, sealed joints, sanitary skirting boards and avoidance of blind spots facilitate mechanized washing and reduce operator exposure time. Ventilation is sized to control condensation and prevent the migration of potentially contaminating aerosols between areas with distinct risk profiles.

3. The importance of hygienic drainage in professional kitchens

In any professional kitchen, waste water control is one of the essential pillars of hygiene and food safety. If the water used in the washing, sanitizing and cooking processes is not properly managed, multiple risks arise: the accumulation of bacteria and biofilms, slips and work accidents, damage to construction materials and even contamination of dishes. For this reason, drainage systems cannot be seen as simple technical accessories, but as fundamental infrastructures for the optimal and sustainable functioning of a kitchen.

ACO offers a range of hygienically designed drain solutions that reflect modern industry standards. They combine proven hygienic engineering principles with practical industry experience and provide case studies relevant to the HoReCa environment.

Professional kitchens operate with considerable quantities of water: for washing raw food, cleaning dishes and trays, sanitizing surfaces, rapidly cooling certain products or maintaining environmental cleanliness. These processes inevitably generate wastewater loaded with organic matter, fats, salts and cleaning agents.

If wastewater is not discharged quickly and completely, the consequences can be serious:

- the appearance of bacterial biofilms on wet surfaces;
- unpleasant odors generated by the decomposition of organic matter;
- risks to personnel health through slips and accidents;
- degradation of floors and walls through water infiltration;
- increased consumption of sanitizing substances to compensate for poor hygiene.

For these reasons, the design of drainage systems must be integrated from the kitchen design phase. Drains, gutters and grease traps are not peripheral elements, but constituent parts of the sanitary and hygienic infrastructure.

3.1. Basic principles of hygienic design in water drainage

Hygienic drainage must respect the same fundamental principles as the rest of the food infrastructure. Among these, we highlight

- Complete drainability: water must drain completely, without leaving puddles or residues.
- Smooth and non-porous surfaces: to prevent dirt from adhering and the formation of biofilms.
- Accessibility for cleaning: elements must allow easy disassembly and sanitation.
- Chemical compatibility: materials must be resistant to detergents, acids, alkaline solutions and high temperatures.
- Mechanical durability: drains must withstand heavy loads, the passage of trolleys or heavy equipment.
- These principles translate into concrete technical solutions, presented below.

3.2. ACO drains with hygienic design

ACO drains, specially designed for professional kitchens and the food industry, are constructed from high-quality stainless steel and

include multiple configuration options. An ACO hygienic drain includes several parts fig 2.:

- stainless steel body, with smooth walls and connection to the sewer;
- fixing ring or frame, which ensures continuity with the floor;
- upper grate, available in several models (non-slip, perforated, with slots);
- waste retention basket, which prevents solid waste from entering the network;
- siphon with anti-reflux system, which prevents odors and water from returning from the sewer.



Fig. 2. ACO drain systems designed for hygienic purposes

1 - grate, 2 - alluvial basket, 3 - hydraulic guard, 4 - hydraulic guard support, 5 - spout body (fixed or telescopic), 6 - upper body (telescopic), 7 - collection ring, 8 - height adjustment foot

The water from washing food and dishes → passes through the upper grates → solid residues are retained in the basket → the water drains through the siphon → the anti-reflux system prevents the return of gases → the water reaches the grease separator → then into the public sewer network. This scheme reflects the logic of a

hygienic flow, in which each component has its precise role.

- The characteristics of such an ACO system are:
- hygienic design according to EN 1672, EN ISO 14159 and EHEDG No. 8, 13 and 4;
 - drains made of stainless steel, in accordance with SR EN 1253

- hydraulic guard made of stainless steel, completely removable and easy to clean
- Available in two versions of stainless-steel grade 1.4301 (304) and 1.4404 (316L)
- Wide range of gratings - load classes: L 15, R 50, M 125 and N 250 (EN 1253)
- Certified fire protection solution available, in accordance with SR EN 13 501-2, resistance class EI 90 – EI 180
- High flow rate: 1.4 - 1.6 l/s
- Outlet DN 70 / DN 100 (OD 75/110)
- Optional alluvium basket

To understand the practical relevance of these solutions, ACO offers a case study from the field of industrial kitchens.

In a university cafeteria with over 2000 servings per day, wastewater came from washing vegetables, meat and dishes. The old drainage system was frequently blocked, leading to persistent odors and time wasted on unclogging.

Solution

ACO telescopic drains with catch basins and grease separators were installed. This allowed:

- quick cleaning of food residues before discharge;
- elimination of odors through the anti-reflux siphon;
- perfect adaptation to the thickness of the new epoxy resin floor.

Results

After implementation, the time allocated to maintenance decreased by 40%, detergent consumption by 15%, and the number of blockage incidents was reduced to almost zero. Table 2 presents the advantages of the ACO solution over classic variants.

Table 2. *Comparison: traditional solutions vs. ACO solutions*

Characteristics	Traditional drain	ACO hygienic drain
Material	Cast iron or plain steel	Food grade stainless steel
Internal surface	Roughness, porosity	Smooth, polished
Access for cleaning	Limited	Completely accessible
Residue retention basket	Lack	Included
Anti-reflux siphon	Occasionally	Standard
Adaptability to the floor	Reduced	Fix or telescopic
Lifetime	5–10 years	15–25 years

A key aspect is the correlation between hygienic drainage and sustainability. ACO systems contribute to:

- reducing water consumption, through faster cleaning;
- reducing the use of detergents and disinfectants;
- extending the life of floors and equipment;
- preventing pollution by intercepting grease and solid residues.

Hygienic drainage is not a secondary detail, but a structural condition for food safety and sustainability. Hygienic design drains represent modern, flexible and durable solutions, capable of meeting both the technical needs of professional kitchens and legal and environmental requirements.

4. Discussions

This paper has highlighted the complexity and importance of hygienic design in professional kitchens in the HoReCa industry, underlining the fact that food safety cannot be conceived in the absence of an intelligently and responsibly built infrastructure. The conclusions derived from the analysis are multiple and can be organized in several major directions: Hygienic design is not just a set of technical rules, but an integrative concept that places infrastructure at the center of hygiene assurance processes. Through it, spaces, equipment and operational flows are designed in such a way as to prevent dirt accumulation, reduce stagnant areas and facilitate cleaning and disinfection processes. This structural approach limits the dependence on reactive interventions and transforms hygiene into an intrinsic characteristic of the built environment.

Another major result of the research is the demonstration that hygiene and sustainability are

not opposing objectives, but complementary. A well-designed hygiene infrastructure shortens cleaning cycles, reduces water and energy consumption and minimizes the use of aggressive chemicals. Therefore, investing in hygienic design generates economic, environmental and operational benefits, while reducing contamination risks and reputational losses.

An efficient professional kitchen requires careful organization of the flows of raw materials, finished products, waste and personnel. Flow diagrams and circuit separation prevent critical intersections and reduce the likelihood of cross-contamination. At the same time, the integration of hygienic barriers and specific procedures for moving from one area to another strengthen control over microflora and increase the overall level of safety.

The chapter dedicated to hygienic drainage clearly showed that wastewater management is one of the biggest challenges in HoReCa. Water from washing food, dishes or cleaning spaces is a major source of contamination if not disposed of quickly and correctly. Drains, gutters and grease traps cannot be treated as simple technical elements, but must be designed and maintained in accordance with precise standards. The ACO case study demonstrated the advantages of modern technologies in practice: reduced detergent consumption, reduced maintenance time and elimination of blockages, confirming the practical value of theoretical principles.

Another essential aspect highlighted is the integration of EHEDG principles and European directives in the design and operation of professional kitchens. Compliance with the norms is not only a legal obligation, but a guarantee of competitiveness and sustainability. Adopting EHEDG standards gives HoReCa operators access to international best practices and allows them to meet the expectations of consumers, who are increasingly attentive to food safety and quality.

A correctly implemented hygienic design not only has direct effects on food safety, but also contributes to protecting public health, reducing the incidence of foodborne infections. At the same time, sustainability integrated into processes – through reduced consumption of water, energy and chemicals – reduces the negative impact on the environment, supporting sustainable development objectives and the transition to a circular economy.

Following the analysis, several application directions can be formulated:

- integration of hygienic design principles from the planning phase of a professional kitchen;
- use of durable materials, resistant to chemical agents and easy to clean;
- implementation of certified drainage systems adapted to the specifics of each unit;
- continuous training of staff to comply with hygienic barriers and maintenance procedures;
- collaboration with suppliers that comply with EHEDG standards and European norms.

Conclusions

The paper confirms that hygienic design is the key to the optimal functioning of professional kitchens in HoReCa, while being an investment in safety, efficiency and sustainability. Without a correctly designed and maintained infrastructure, even the most rigorous operational procedures cannot guarantee the elimination of risks. On the contrary, a well-designed infrastructure reduces costs in the long term, improves the quality of services and contributes to the protection of the environment and public health.

Thus, hygienic design should not be perceived as a simple compliance with standards, but as an integrated risk management strategy, essential for the competitiveness and social responsibility of the HoReCa industry.

References

1. EHEDG Guideline Doc. 6. (2018). *Continuous UHT sterilization of liquid food*; Available at: <https://www.ehedg.org/guidelines/>;
2. EHEDG Guideline Doc. 8. (2020). *Hygienic equipment design criteria*; Avail. at: <https://www.ehedg.org/guidelines/>;
3. EHEDG Guideline Doc. 14. (2022). *Hygienic design of valves for food processing*; Avail. at: <https://www.ehedg.org/guidelines/>;
4. EHEDG Guideline Doc. 16. (2023). *Hygienic pipe couplings*; Avail. at: <https://www.ehedg.org/guidelines/>;
5. EHEDG Guideline Doc. 17. (2023). *Hygienic design of pumps, homogenizers and dampening devices*; Avail. at: <https://www.ehedg.org/guidelines/>;
6. EHEDG Guideline Doc. 20. (2024). *Hygienic design and safe use of double-seat mix proof valves*; Avail. at: <https://www.ehedg.org/guidelines/>;
7. EHEDG Guideline Doc. 32. (2024). *Materials of construction for equipment in contact with food*; Avail. at: <https://www.ehedg.org/guidelines/>;

8. EHEDG Guideline Doc. 35. (2025). *Welding of stainless-steel tubing in the food industry*; Avail. at: <https://www.ehedg.org/guidelines/>;
9. EHEDG Guideline Doc. 37. (2025). *Hygienic design and application of sensors*; Avail. at: <https://www.ehedg.org/guidelines/>;
10. Gaceu, L. (2016). *Hygienic engineering and design in Romania*. J. of EcoAgriTourism, 12(2), 154-159;
11. Gaceu, L. (2017). *Assessment method for hygienic design in food industry*. Water drainage and water saving study case. J. of EcoAgriTourism, 13(2), 53-56;
12. Gaceu, L. (2018). *Comparative study on European legislation about hygienic engineering and design*. J. of EcoAgriTourism, 14(2), 42-47;
13. Gaceu, L. (2020a). *Design principles for assuring food safety in Romanian mountain dairy farms*. J. of EcoAgriTourism, 16(2), 21-25;
14. Gaceu, L. (2020b). *Food safety in pasteurization of liquid food-basic elements for mountain farmers*. J. of EcoAgriTourism, 16(2), 51-55;
15. Gaceu, L., Samoilă, N.R., Gruia, R. Oprea, O.B. (2021). *Use of Essential Oils from Aromatic and Medicinal Plants to Increase the Shelf Life of Mountain Dairy Products in Romania*, J. of Montology, 15, 7-20;
16. Gruia, R., Gaceu, L., Oprea, O. B. (2025). *The Pillars of Societal Bioharmonism a Conceptualist Contribution to the Evolution of the Contemporary Society*. Challenges, 16(1), 16. <https://doi.org/10.3390/challe16010016>;
17. Gruia, R., Florescu, G.I., Gaceu, L., Oprea, O.B., Țane, N. (2021). *Reducing environmental risk by applying a polyvalent model of waste management in the restaurant industry*. Sustainability, 13(11), 5852. <https://doi.org/10.3390/su13115852>;
18. Lelieveld, H., Holah, J., Domago, G. (2016) *Handbook of Hygiene Control in the Food Industry*, ISBN: 978-0-08-100155-4, Elsevier, DOI: 10.1016/C2014-0-01825-4;
19. Lelieveld, H. & Holah, J. (2016). *Specific Requirements for Equipment for Aseptic Processing*. Woodhead Publishing Series in Food Science, Technology and Nutrition, ISBN: 9780081001554. 10.1016/B978-0-08-100155-4.00029-7;
20. Oprea, O.B. (2017). *Operational management of sanogeneous nutrition. Case study Covasna County*. J. of EcoAgriTourism, 13(2), 39-47.
21. Oprea, O.B.; Samoilă, N.R.; Spirchez, Gh.C. (2018). *A Review of the Antimicrobial Activity of Thymus Vulgaris, Malaleuca and Ocimum Basilicum*. J. of EcoAgriTourism, 14(1), 135-140;
22. www.ehedg.org
23. www.aco.ro

INSULATION TECHNIQUES USING RENEWABLE VEGETABLE FIBERS FOR IMPROVING INSULATION DESIGN OF BUILDINGS USED IN RURAL TOURISM

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Abstract: The article presents a model of sustainable design for the tourism economy starting from using the natural resources found in the rural areas of Romania. This article proposes the use of multi-purpose crops with the aim to use agricultural land to produce both food products and renewable construction materials to be used as building renewable construction materials for accommodation facilities. This model of local circular economy based on the local biodiversity resources represents a key stone in achieving climate neutrality of the future.

Keywords: circular economy, vegetable fibers, renewable materials, renewable energy, rural tourism, renewable construction materials.

1. Introduction

The circular economy represents a key strategy at national level to tackle the fossil fuel dependency in all levels of industry and economy. Legislative and directional actions were proposed in the new circular economy action plan (CEAP) from March 2020 by the European Commission. The main foundation of the European new economy agenda for sustainable growth is the transition to a circular economy that aims to create sustainable

economic growth and form new jobs based on the use of plant based renewable natural resources. [1]

This model of circular economy can be defined as “living of the land” and thus a development strategy in a new way to achieve the climate neutrality target and to enhance biodiversity.

This new development strategy plan proposes development of consumers products that are naturally sustainable with the environment in all areas, as well as tourism. [1]

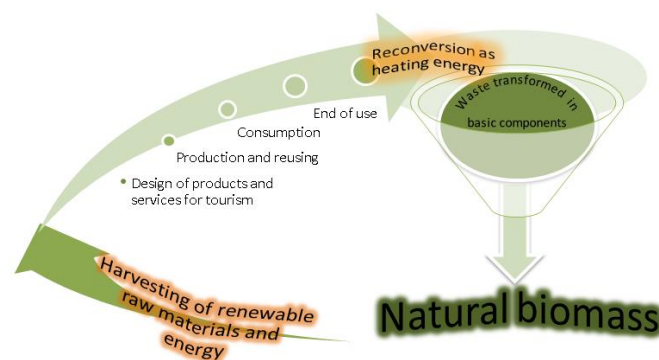


Fig. 1. Diagram of circular economy development strategy.

The circular economy emphasizes on how products and services are designed, so that the sustainable consumption is promoted and waste becomes the a new resource to be used further more in the economy for other products until it

becomes reabsorbed in nature as the most basic form (figure 1).

Tourism is one of the most developed sectors worldwide, with tourist numbers growing from 25 to 100 million over the year world-wide. This

growth trend is expected to increase up to 1.8 billion tourists by 2030, with a strong environmental impact, and positive socio-economic benefits [3]. From the environmental point of view, tourism is however a highly water- and energy consumption sector. Tourism is also one of the main contributors to global greenhouse gas (GHG) emissions but also an indispensable socio-economic sector [3].

Tourism is dependent on the global building industry that represents a large portion from the energy-related greenhouse gas releases share that tourism is generating and consumes. Approximately one-third of the entire final energy consumed in tourism is used for the living conditions inside the living spaces of accommodation. This energy used for ensuring basic accommodation conditions results in greenhouse gas emissions in the form generated by producing the construction materials and producing energy for cooling and heating of the tourist accommodation spaces. Consequently, from the sustainability point of view, it is critical to minimize the energy consumption of buildings and the associated carbon dioxide emissions generated from burning of fossil fuels or producing the construction materials needed to build the accommodation facilities used in tourism.

The main hospitality form in tourism is to provide the optimum living conditions inside the

space where touristic services take place by implementing adequate ventilation and heating, for the well-being of the tourists [4].

The building insulation envelope is considered a crucial component in enhancing the thermal performance of the building, since 50–60 % of the heat transfer with the outside environment is exchanged through the buildings outside walls.

In order to enhance indoor thermal comfort and reduce the energy consumed for cooling/heating operations, the insulation of the buildings must meet a certain minimum thickness depending on the geographical region. Additionally, energy is consumed to produce the materials used for the insulation that generates a carbon foot print depending on the fuel used.

A favorable net energy balance is achieved, when greenhouse gas emissions are reduced [8] when less energy is consumed for well insulated buildings so that the reduction in energy consumed is greater than the energy required to produce the insulation materials.

The primary factor leading to heat dissipation is the inadequate thermal insulation of the building, insulation system defined by material properties and structural characteristics that influences the heat transfer coefficient as a measuring unit for the determination of the building thermal performance. [2]

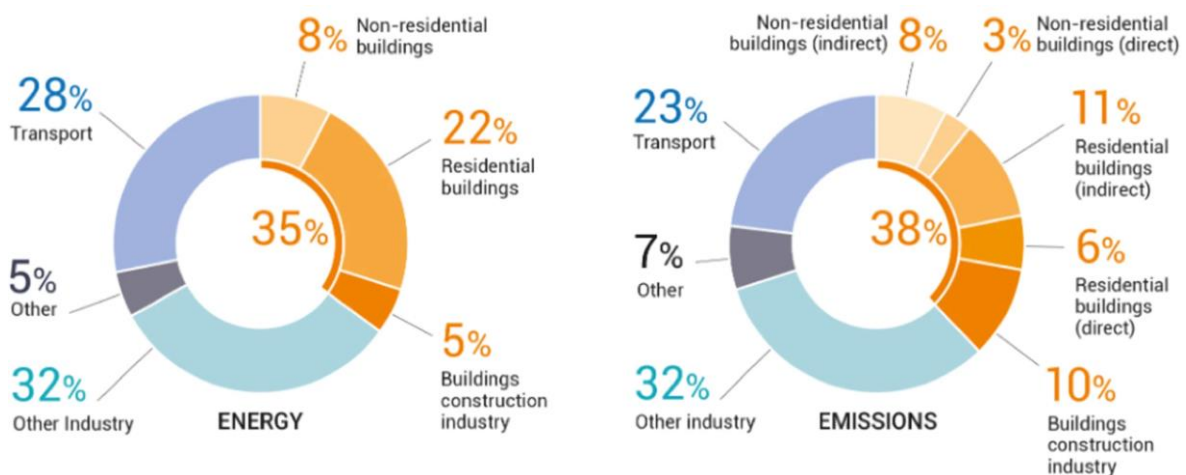


Fig. 2. Global share of buildings and construction final energy and emissions, 2019 (UNEP 2020). Buildings construction industry is the portion (estimated) of overall industry devoted to manufacturing building construction materials such as steel, cement and glass. Indirect emissions are emissions from power generation for electricity and commercial heat.[2]

At industry level environmental sustainability projects are focused on reducing the energy consumption of buildings and utilization of

environmentally efficient use of building materials. Also implementation of recovered waste materials into new building products is

another design direction by which production processes target reuse, recovery and recycling of waste to develop the ideal nearly-zero-energy buildings (European Commission 2019) [2].

Construction materials demanded in circular economy are defined to be products that do not contain hazardous substances and are composed of:

- reused or recycled materials that account for at least 15% of the weight of the product, assessed on the total of all the materials used. [2]

The European strategy for reducing dependency of fossil energy involves also solutions for reducing the use of resources developed from petrol raw material and in the same time designing more products based on natural renewable raw materials. [6]

The industry focus will be on products that are environmentally well integrated at the end of their life cycle. This requirement needs development of products that decompose as waste in a form and allows the re-absorbent into the natural environment as the most basic and simple molecules. The resulted waste at the end of the life cycle should be ideally in a molecule form that is used in nature as the building blocks for the generation of natural resources that will be harvested for the future generation of construction products.

The European sustainable approach for the building industry, proposed in 2015 designing of construction materials that are made up of components that are in harmony with the environment during their entire life cycle. This proposal changes the design perspective from the traditional linear economic model to a circular economic model. [2]

The old way of producing goods was based on the principle “extract, produce, use and discard”, production that required large quantities of extracted materials and energy extracted from nature, and generated that at the end of the life cycle large quantities of waste difficult or impossible to be re-absorbed in nature. [2]

The move to a circular economy model is founded on the principle that waste can be another form of raw materials for another product or can be reduced to the lowest form of matter that becomes a new source of raw materials destined to produce a new product or an energy source for heating. This principle allows waste to become a basic molecule to be re-absorbed in nature and become the building block of the future biomass grown from the waste of the obsolete construction materials.

This circular economy design generates natural renewable raw materials, reinvents logistics of supplies and focuses on local resources to avoid useless energy consumption for transport operations. The decommissioning of construction materials provides new sources of raw materials for other consumer products or energy sources.

The European proposal seeks to rethink the actual economic model to an economic model that is as independent as possible on non-renewable energy and raw materials resources. [6]

The transition to a different model of economy based on the circular life cycle of goods, has the potential to make efficient use of natural resources and to re-use secondary raw materials resulted from conversion of waste. This offers the advantage of reducing the pressure on the extraction industry upon the environment and the discovery of new sources of supplies, technological innovations and new business and employment solutions.

Various European initiatives promoted environmental sustainability projects:

- projects focused on the energy efficiency of buildings,
- projects that targets environmental efficient use of construction materials,
- projects that implement various waste into being reused, recovered and recycled into new products,
- projects that seeks solutions to design ideal zero-energy buildings. [1]

The EU's legislative packages drive the economy towards environmental sustainability by designing legislation regulates procurement by the public administration, develop directions for sustainable technologies and products in various sectors that are environmentally compatible. One main economy sector with a high potential in innovation technologies is the construction sector, one that provides and builds accommodation facilities in tourism that have a low environmental foot print and high energy efficiency. [2]

2. Exploring the potential to use and design environmental friendly construction materials

The design of construction building materials is founded on the minimum environmental impact on the product life cycle and aims construction products that are used in new constructions, renovations and maintenance of buildings. The

construction industry can benefit the most from using sustainable and energy-efficient construction materials that are fully integrated in the future European circular economy.

This design of products uses both recycled materials and new natural raw materials to produce final products that can be used for an extended period of time with many environmental advantages. By using decommissioned products to obtain raw materials for new products, a sustainable circle of production is formed on the continuous transformation of materials based on the principle of conservation of mass where nothing is lost and everything is transformed. [5]

Thermal insulation panels used in the insulating of buildings in order to minimize heat losses, is one construction material that has a high potential to be a product that fits easily in the new circular economy model. Specifically, thermal and acoustic insulation materials can integrate different levels and types of recycled materials (e.g. from decommissioned mineral, glass or rock wool insulation or from textiles residues from commercial activities) together with fiber-based plants that are environmentally friendly and convertible into heating energy at the end of their life cycle. [5]

Properties of vegetable fibers that make them suitable for the building techniques using renewable materials:

- breathability: Natural fibers have moisture absorption capability being known to absorb moisture and releasing it back in environment, making them suitable for insulation panels of walls and ceiling.
- biodegradability: vegetable fibers decompose over time after they are decommissioned from a building breaking down into natural materials that enrich the soil. This property makes them an ideal solution for geotextiles compared to man-made synthetic fibers.
- eco-friendly: unlike synthetic fibers, vegetable fibers do not release harmful chemicals into the environment in their entire life cycle.
- low thermal conductivity of the vegetable fibers makes them a good choice in manufacturing of insulation panels that do not transfer heat easily, thus preserving the building energy for heating or cooling.
- resistance of natural fibers is expressed as high tensile strength that withstands tension or stress without breaking. This property makes them durable and with long-term use in construction materials and landscaping.

- renewability of vegetable fibers: are extracted from crops that produce the plants to be harvested for fibers or for dual purpose making them a renewable source for both food sources and renewable raw materials for construction industry.

- expensive, unfortunately the costs for crops, harvesting and processing combined with their limited production makes vegetable fibers more expensive than man-made synthetic fibers. The costs are often related to the need to use fossil fuels for the agricultural machineries, human laborer payments and cost for plant protection and growth additives.

Vegetable fibers are classified depending on their origin from the plant that produces them. The vegetable fibers are classified as follows:

- Bast fibers are obtained from the stem of plants like flax, hemp, and jute. Bast fibers are most desired as they are long, have good strength and flexibility.

- Leaf fibers are obtained from the leaves of the plant. Examples of fiber leafy plants are sisal and henequen. These types of fibers are stiff with rough texture.

- Seed fibers originate from the seeds of fiber plants, such as cotton. These fibers are soft and smooth making them suitable for clothing industry and also insulation matting.

- Fruit fibers are obtained from the fruits of plants, such as coconut.

- Mushroom fibers are obtained from mushrooms, such as mushroom silk, and are used for insulation and soil erosion control.

In the case of insulation panels for thermal insulation, a wide range of choice of recovered raw materials can be used for the production of new products. These sources include recycled materials, low-impact and renewable raw materials, byproducts from industrial processes or agricultural waste. For example, glass wool wastes can be either recycled into new insulation products with synthetic fibers recovered from textile wastes, expanded polystyrene (EPS) insulation can contain up to 60% recycled and/or recovered materials from plastic wastes, cardboard packaging wastes can be converted into pulp insulation in combination with natural short fibers from agricultural wastes. [5]

In general, it is considered that a product is environmentally friendly if it uses as raw materials sources that are fully or partially recycled materials, natural local raw materials that were made with locally manufactured or locally extracted raw materials. The production is

defined by as simple as possible operations with consequent lower production costs for the products and lower transport costs by reducing the distance inside the local supply chain and economy.

This paper targets the possibility to produce insulation systems that can combine natural fibers with residues or products harvested from agriculture crops destined for food and combines them with wastes resulted from the tourism activities from rural regions.

Rural regions have the advantage of infrastructure development that can develop selective collection of commercial wastes that can be processed to become a raw material in combination with other components from food crops waste or animal fibers such as sheep wool of low quality that can be used as insulation materials.

Insulating panels can be made from natural waste materials generated during the processing of agricultural crops, such as fibers and cellulose, which can be combined with fibers residues that are unsuitable for textiles or cellulose from recycled packaging. Sheep wool residues from textile industry can be used in insulation materials instead of being discarded as waste. Waste materials can be repurposed as insulation

material, offering a sustainable source of preserving heating energy in buildings and finally can be converted into heating energy when decommissioned by burning. [9]

3. Designing of insulation solutions that use renewable raw materials in rural tourism

Designing of new insulation solutions based on renewable raw materials obtained from natural fiber plants can be applied on all areas of thermal insulation needed to cover the necessities of a touristic accommodation building. The water vapor regulating insulating panels are made from hemp fiber with fibers newly extracted and recycled fibers. This solution offers a circular economy sustainable, eco-friendly solution, offering excellent thermal and acoustic insulation. [6]

Thermal insulation of buildings can be made by using agricultural vegetable fibers available especially in the rural areas and resulting from post harvest operations. These natural fibers have good thermal insulation properties and many of them are found technical crops such as straws from cereals, or fiber crops such as hemp, flax, reed etc.

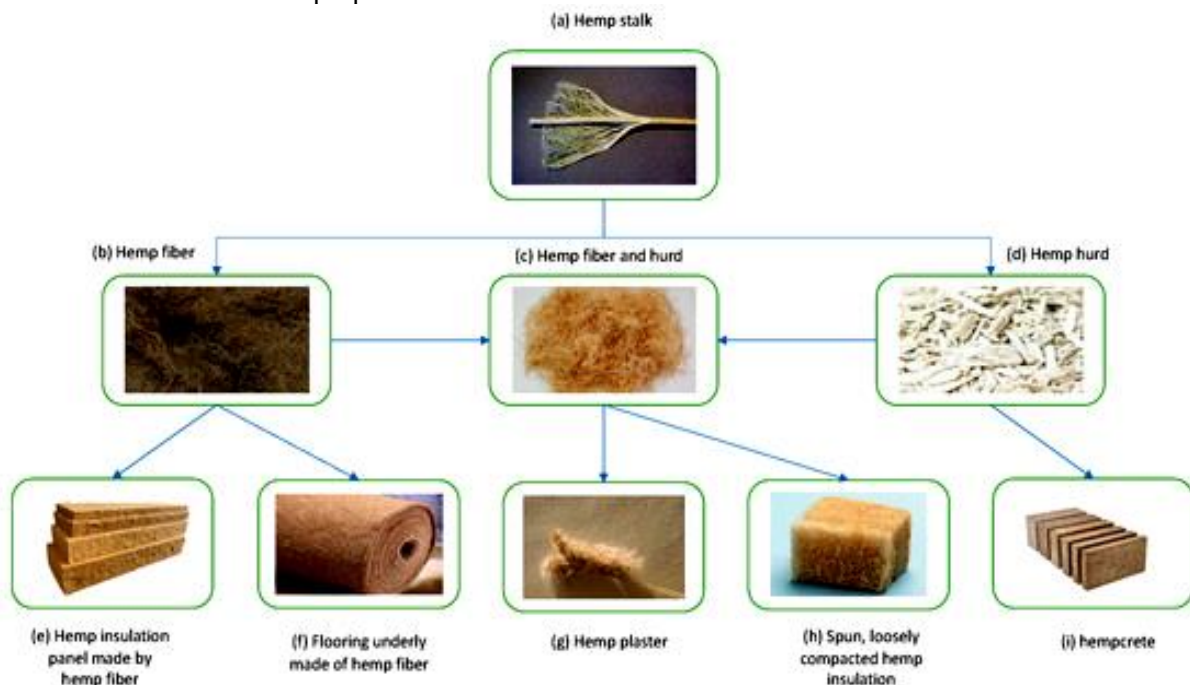


Fig. 3. Thermal insulation products that use hemp fibers and hurds in buildings. [7]

Natural fibers thermal insulation products are presented in figure 3 originating from the hemp stalk fig.3a that can be used as is for support in

mortar application. Hemp stalk contains fibers and a woody core (named shives or hurds), which can be used to produce different construction

materials. [6] Hemp hurds are used primarily to produce light and super-light concretes and mortars, as well as infills for cavities and under floors substrate for thermal insulation and support. There are over 100 hemp-based construction products available on the market produced by various companies. [6]

4. Conclusions

Vegetable natural fibers have a large number of plant species that can offer properties, such as durability, resistance, moisture absorption properties, to make them suitable options for thermal insulation and construction materials.

Vegetable fiber-based insulation materials are an excellent option from the environmental point of view. However, from the economical point of view synthetic fibers are cheaper to produce, have no production limitation depending on the seasonal plant growth. There is also a shortage of natural fiber cultivars, equipment, techniques, and expertise since the synthetic fibers technology was highly developed. Meanwhile, natural fibers crops are not economical compared to technical food crops and they are not attractive unless subsidized by government funding.

Harvesting and post-harvest operations of fiber crops are high energy consumption and human manual labor, and thus production price of these fibers is higher than the synthetic fibers. This higher cost for implementation can be lowered by the costs of decommissioning of the natural insulation products compared to the synthetic products that require higher costs for waste treatments.

Furthermore, natural fibers plants used as a building material are not accepted by national building codes as approved materials since they are not sufficiently standardized.

The economic and technological barriers need to be lifted before the environmentally friendly thermal insulation materials can replace the synthetic products currently used.

Future technology development and a higher production of natural fibers could supply a mass

production of construction materials that will partially replace synthetic fibers materials.

References

1. European Commission, Environment, https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en, (Accessed 25 Sept 2025).
2. European Parliament (2015), Circular economy: definition, importance and benefits. Available at: <https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits>. (Accessed 01 Apr 2025).
3. Rossana Strippoli, et al., Circular economy and sustainable development in the tourism sector – An overview of the truly-effective strategies and related benefits, Ed. Heliyon, Volume 10, Issue 17, 2024, ISSN 2405-8440.
4. Saboor Shaik, et al., Innovate, insulate, integrate: Embracing circular economy in innovative insulations for reduced air conditioning expenses and carbon mitigation in fly ash brick buildings, Energy and Buildings, Volume 322, 2024, ISSN 0378-7788.
5. Savio, L., et al. Natural Fiber Insulation Materials: Use of Textile and Agri-food Waste in a Circular Economy Perspective. Mater Circ Econ 4, 6 (2022). <https://doi.org/10.1007/s42824-021-00043-1>.
6. Liu, C.H.J.; Pomponi, F.; D'Amico, B. The Extent to Which Hemp Insulation Materials Can Be Used in Canadian Residential Buildings. Sustainability 2023, 15, 14471. <https://doi.org/10.3390/su151914471>
7. Canapuglia Website, https://canapuglia.it/en/products/pannelli-isolanti-in-fibra-di-canapa?srltid=AfmBOorz28reWqA3frQj0zUUv0J3HWFidgP_5KZXBfrhTkiZAzRldo5j, (Accessed 25 Sept 2025).
8. Thierheimer, W. et al. Risk Arising from Transport Activities. Environmental Engineering & Management Journal (EEMJ), [s. l.], v. 9, n. 12, p. 1667–1670, 2010.
9. Spirchez, Gh.C., Lunguleasa, A. Gaceu, L. Research on the Energy Yield of Wood Composite Materials. Journal of EcoAgriTourism, 2023, Vol 19, Issue 1, ISSN 1844-8577.

INTEGRATING SMART SOLUTIONS AND RENEWABLE RESOURCES INTO URBAN HOTEL INFRASTRUCTURE

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Abstract: *The study analyzes the feasibility and benefits of integrating smart technologies and renewable energy solutions into urban hotel infrastructure. Recognizing that the hospitality sector is a major consumer of non-renewable resources, the research evaluates the technical, economic and environmental potential of solar energy, heat pump systems and heat recovery ventilation, based on the energy profile of a medium-sized hotel. International best practices and European policy frameworks are correlated with the Romanian context to identify viable pathways for the transition toward nearly zero-energy buildings. The results demonstrate significant advantages in terms of operational cost reduction, improved energy independence, decreased CO₂ emissions and enhanced competitiveness through sustainability-driven branding. Recommendations focus on the implementation of integrated renewable systems, smart energy management and public-private partnerships to accelerate sustainable development in urban hospitality.*

Keywords: *Urban hotels, Renewable energy integration, Smart infrastructure, Energy efficiency, Sustainable hospitality.*

1. Introduction

The acceleration of urbanization processes and the intensification of the consumption of non-renewable energy resources have led to an alarming increase in the pressure on the environment. Buildings, especially those in urban areas, are responsible for a significant share of total energy consumption and greenhouse gas emissions. Urban hotels, as an integral part of the hospitality industry, are distinguished by a constant and high energy consumption, which makes them ideal candidates for the application of energy efficiency technologies.

The present paper aims to investigate and analyze the concrete possibilities of integrating renewable energy sources into urban hotel infrastructure, starting from international examples and adapting the solutions to the national context.

The general objective of the research is to evaluate the technological, economic and ecological potential of these solutions, in order to substantiate sustainable development directions applicable to the urban tourism sector.

The methodology followed combines an interdisciplinary approach, which combines elements of architecture, engineering, economic analysis and environmental considerations.

The paper is structured as follows: a bibliographic study of current directions, a presentation of the research methodology, the results obtained from the integrated analysis of technical and economic solutions, conclusions and recommendations for practical application in the hospitality industry.

2. Bibliographic study

The integration of sustainability principles into tourism has become a central research direction in the last two decades. The World Tourism Organization defines sustainable tourism as one that takes into account both economic, social and environmental impacts, in the short and long term. The specialized literature shows that the hotel sector has a key role in implementing these principles, by using green technologies and by adapting to increasingly stringent consumer and regulatory requirements.

Studies such as those conducted by Gössling, Scott & Hall (2015) have shown that urban hotels are not just accommodation spaces, but strategic elements in urban development. They influence mobility, resource consumption and the quality of life in cities. Floricic (2020) highlights that the integration of renewable energies in hotels is not only an ecological necessity, but also a competitive strategy, as customers are

increasingly sensitive to the environmental impact of tourist establishments.

Among the technologies identified as relevant for the hotel sector are photovoltaic panels, solar thermal panels, air-to-water and geothermal heat pumps, heat recovery units and storage batteries. International examples, such as the Crowne Plaza Copenhagen Tower in Denmark, the Marcel Hotel in the United States or the Verde Hotel in South Africa, demonstrate the applicability of these solutions and the associated economic benefits. These hotels have managed to reduce their dependence on conventional resources and

obtain internationally recognized environmental certifications, such as LEED and Green Key.

At national level, research (Mionel, V., 2024) shows that only 12-15% of the energy consumption of hotel structures comes from renewable sources, which indicates a considerable potential for growth. Government programs, such as ElectricUp or Casa Verde for legal entities, provide funding for the installation of photovoltaic panels and heat pumps, thus facilitating the transition of urban hotels to clean energy.

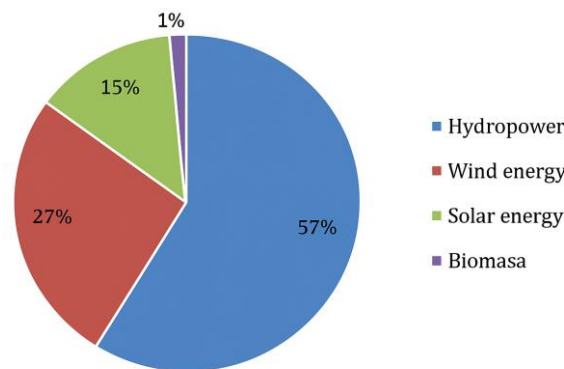


Fig.1 *Distribution of renewable energy capacity in Romania (2024)*

3. Research methodology

The research methodology is based on a multidimensional analysis, combining technical, economic and environmental aspects. The first step consisted of carrying out a SWOT analysis to assess the advantages and limitations of integrating renewable energy solutions in an urban hotel. Among the strengths identified are the availability of solar resources in Romania and access to financing programs. Among the weaknesses are the high initial costs and the reluctance of some investors.

Subsequently, the energy consumption of a medium-sized urban hotel (32 rooms) was modeled, with an estimated monthly consumption between 7500-8500 kWh. Depending on this consumption, photovoltaic systems, heat pumps and heat recovery units were sized. The analysis included climatic data for the Vrancea area, where the number of hours of sunshine per year is approximately 2200-2400, which supports the viability of solar solutions. The economic evaluation was carried out based on investment costs, operating expenses and the payback period. At the same time, European

legislation (Directive 2010/31/EU on the energy performance of buildings, Directive 2018/2001 on the promotion of renewable energy) and international environmental certification standards (LEED, BREEAM, ISO 50001) were taken into account.

4. Proposed constructive solution. Technical installations and equipment

The hotel will be equipped with modern, integrated and energy-efficient technical systems, designed to provide increased comfort, operational safety and reduced resource consumption, in accordance with the requirements of nearly zero-energy buildings.

Hotel air conditioning and ventilation:

Heating and cooling are achieved through a variable refrigerant flow (VRF) system, based on air-to-air heat pumps, which allow individual temperature control in each room and in common spaces, the solution is scalable and ensures high efficiency in both heating and cooling modes.

The image shows a three-pipe VRF system, designed to provide simultaneous heating and

cooling of several zones, depending on the needs of each room.

At the bottom is the outdoor unit (air-to-air pump) containing the compressors and heat exchangers, from here three pipes start, the green pipe for the evaporated refrigerant back to the unit, the red pipe for the hot vapor refrigerant to the interior, and the blue pipe for the cold liquid refrigerant to the indoor units.

These feed the control valves, which distribute the agent to the indoor units, each unit is controlled by a thermostat, providing personalized thermal comfort.

Ventilation is centralized, with heat recovery units with an efficiency of over 80%, ensuring a continuous supply of fresh and filtered air without significant energy losses. The entire HVAC system is automatically controlled and

connected to a building management system (BMS – Building Management System), which allows temperature regulation, operation monitoring and optimization of energy consumption in real time, the system sends alerts in the event of malfunctions.

Lighting within the hotel:

All spaces will be equipped with LED lighting fixtures that offer low consumption and a long lifespan. In common spaces, such as corridors and bathrooms, presence sensors will be installed that reduce unnecessary consumption. In the rooms, the lighting system will be controlled by switches activated with the access card, which contributes to saving energy during unoccupied periods.

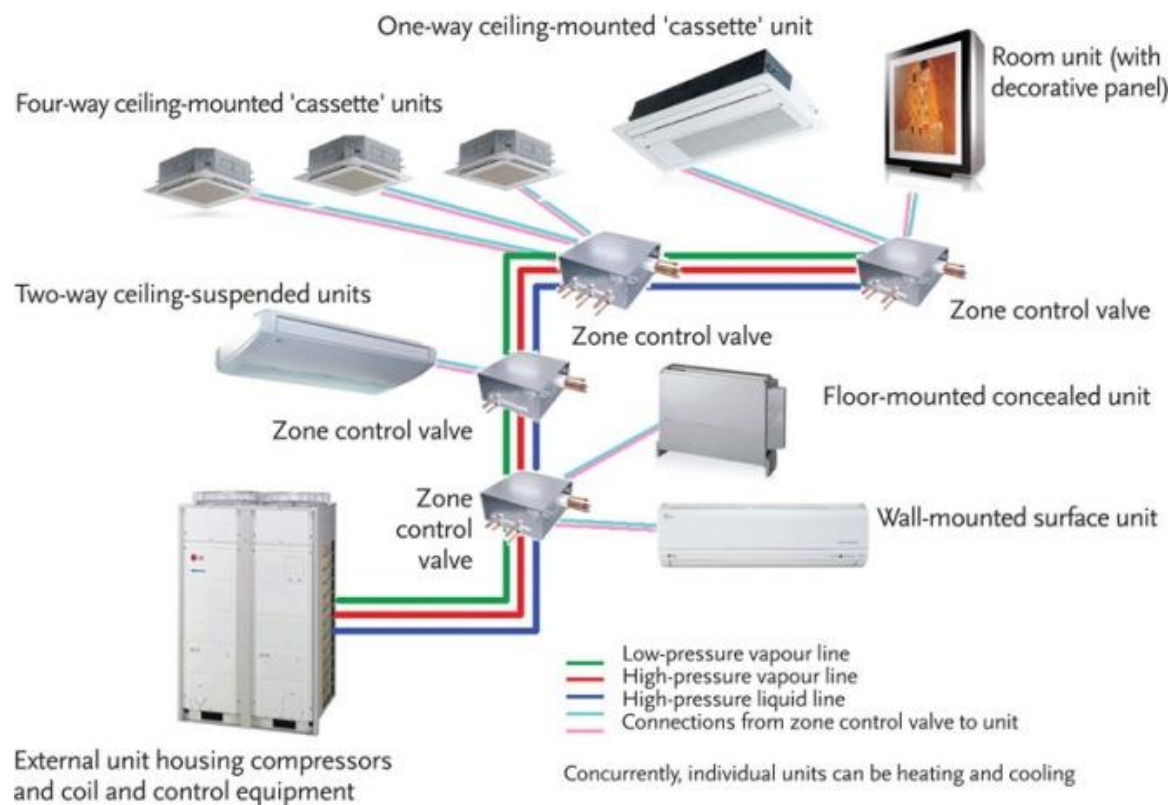


Fig. 2. Three-pipe VRF system (Source: <https://me HVAC.wordpress.com/tag/mitsubishi-electric/>)

The hotel's electrical installation:

The distribution of electricity will be carried out through a general switchboard with automatic protections, with permanent monitoring of consumption, for the safety of the supply in case of failure, a high-capacity electric generator is installed, complemented by uninterruptible power supplies. The electrical installation will be sized according to the regulations in force, and the

cables used will be fireproof and protected in metal tubing.

Hotel plumbing:

Cold water supply is provided by an automated pumping system, ensuring optimal pressure, and domestic hot water is produced by a heat pump, connected to an accumulation tank sized for daily needs.

Hotel safety and fire protection:

The building will be equipped with an automatic fire detection and signaling system, with smoke and temperature sensors, with internal hydrant networks, automatic sprinkler extinguishing systems and portable fire extinguishers in traffic areas.

Hotel auxiliary and control systems:

Access to rooms and the unit is via electronic locking systems, integrated into a centralized control platform, and video surveillance of common areas will be via a digital monitoring system.

Table 1. Technical equipment used

No.crt.	Equipment name	Figure	Source
1.	LED linear light fixture		https://www.archilight.ro/corp-iluminat-liniar-led-50w-cu-difuzor-lumina-alb-calda-3000k-finisaj-alb-12160
2.	Presence sensor		https://case-smart.ro/produs/senzor-de-prezenta-si-miscare-ovibo-protocol-zigbee/
3.	Heat pump for domestic hot water with boiler		https://www.trust-expert.ro/project/pompa-de-caldura-pentru-apa-calda-menajera-cu-boiler-de-apa-calda-integrat/
4.	Accumulation tank		https://www.emag.ro/rezervor-de-acumulare-puffer-cu-o-serpentina-sunsystem-pr-1000l-cu-izolatie-din-poliuretan-presiune-lucru-3-bar-gri-negru-pr1000l/pd/D1ZMTZBBM/
5.	Smoke sensor/detector		https://www.spy-shop.ro/detector-de-fum-si-temperatura-satel-tds-1-led-ip20-12-vdc.html
6.	Surveillance camera		https://www.emag.ro/camera-de-supraveghere-smart-tp-link-cu-pan-tilt-360-grade-full-hd-1080p-utilizare-baby-monitor-wireless-audio-video-night-vision-detectarea-miscarilor-two-way-audio-alarma-sonora-si-luminoasa-control/pd/DWYTRGBBM/

In order to adequately size the resources and substantiate the operational costs related to the

hotel's operation, we have made an estimate of the main utility consumption. The analysis is

based on an operating scenario with an average occupancy rate of 75% and a total capacity of 32 rooms. The estimates reflect the daily and annual resource needs, including both the specific consumption of accommodation rooms and that related to the activities carried out by the hotel staff and auxiliary services.

The table below (table 2) summarizes these values, along with mentions regarding the power sources and technologies used to increase energy efficiency.

Table 2. *Estimating utility consumption*

Utility type	Estimated daily consumption	Estimated annual consumption	Observations
Electricity	Approximately 170 kWh	Approximately 62.000 kWh	Consumption partially covered by photovoltaic panels.
Cold drinking water	Approximately 6.000 L	Approximately 2.200.000 L	Includes total consumption for accommodation, hotel staff and operational activities.
Heating/cooling	Approximately 90 kWh	Approximately 32.000 kWh	VRF type system equipped with air-to-water heat pumps, with an estimated average coefficient of performance (COP) of 4.0.
Domestic hot water	Approximately 1.000 L	Approximately 365.000 L	Produced with a heat pump with boiler.

6. Results

The research results showed that integrating renewable resources into an urban hotel is feasible and offers multiple benefits. The photovoltaic system sized at 60 kWp can cover 70-80% of the annual energy consumption, reducing CO₂ emissions by approximately 18-20%. Air-to-water heat pumps complete the heating and cooling needs, ensuring a performance coefficient of 2.5-4.5. Heat recovery units contribute to reducing energy losses through ventilation, recovering up to 90% of the thermal energy.

The economic analysis demonstrated that the amortization period of the investment is between 7 and 9 years, depending on the level of financing obtained. The high initial costs are offset by the long-term savings achieved and the competitive advantages in the tourism market. The implementation of these solutions not only reduces operating costs, but also increases the attractiveness of the hotel for environmentally conscious customers.

Compared to international examples, the solutions proposed for the Romanian urban context is adapted to the local specifics, taking into account the available resources and national policies.

However, the general directions coincide: reducing dependence on conventional resources, optimizing costs and contributing to sustainable urban development.

7. Conclusions

The study confirms that urban hotels are a fertile ground for the integration of renewable energy resources. The benefits are obvious: reduced operational costs, increased energy independence, reduced carbon footprint and strengthened brand image. In addition, investments in green technologies are supported by European policies and national funding programs.

The main recommendations include the adoption of an energy mix based on photovoltaic panels, heat pumps and heat recovery, as well as the implementation of an intelligent energy management system (BMS). In addition, partnerships between the public and private sectors can accelerate the transition to a sustainable hotel infrastructure.

In the long term, the generalization of such practices can transform the Romanian hospitality sector into a regional model of best practices, aligned with the objectives of the European Green Deal and the requirements of climate neutrality for 2050.

References

1. Gössling, S., Scott, D., & Hall, C.M. (2015). *The Routledge Handbook of Tourism and Sustainability*. Routledge, 1st Edition, ISBN 9781138071476;
2. Floricic, T. (2020). *Sustainable Solutions in the Hospitality Industry and Competitiveness*

- Context of “Green Hotels”. *Civil Engineering Journal*. 6. 1104-1113.
3. Gaceu, L., Gruia, R. (2009). Education in food and tourism area using moodle management courses system in Transilvania University of Brasov. *J. of EcoAgriTourism*, 2009, Vol. 5, No. 1, 43-49 ref. 12.
 4. Luo H., Yang, Y., (2011). Study on the Location of Urban Hotels Based on the Theory of Industrial Spatial Organization and the Method of Spatial Econometrics. *Tourism Tribune / Lvyou Xuekan*, 2011, Vol 26, Issue 12, p71;
 5. Ellabban, O., Abu-Rub, H., & Blaabjerg, F. (2014). Renewable energy resources: Current status, future prospects and their enabling technology. *Renewable and Sustainable Energy Reviews*. Vol. 39, p. 748-764;
 6. MacArthur, J. (2019). Energy transitions and sustainability in the hospitality sector. *Energy Research & Social Science*.
 7. Mionel, V., Kanovici, A., Gavri, A., Mionel, O., Neacsu, M., Popescu, C. (2024). Sustainability Implementation in Romanian Tourism: From the Paris Agreement to Electric Up. *Amfiteatru Economic*. 26. 1177.
 8. Gaceu, L., Oprea, O.B., Summary on the role of Informational Content in the Communication and Promotion of Tourism Services in Romania. *J. of EcoAgriTourism*, 2024, Vol. 20, no.1;
 9. Gaceu, L. (2024). Study on the Possibilities of Digitalization of the Agri-Food Logistic Chain in the Mountain Area. *Journal of EcoAgriTourism*, 20(1).
 10. Tanhua, D., Tuomi, E. O., Kesti, K., Ogilvie, B., SAHAGÚN, C. D., Rodriguez, J. N. A., ... & Gaceu, L. (2024). Digital Maturity of the Companies in Smart Industry Era. *Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development*, 24(3).
 11. Directive 2010/31/EU on the energy performance of buildings. <https://eur-lex.europa.eu/eli/dir/2010/31/oj/eng>
 12. Directive (EU) 2018/2001 on renewable energy promotion. <https://eur-lex.europa.eu/eli/dir/2018/2001/oj/eng>
 13. European Green Deal (2019). European Commission. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

REDUCING FOOD WASTE THROUGH INTEGRATED FOOD POLICIES

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Abstract: *The article examines the phenomenon of food loss and waste in the university context and how integrated urban food policies, education and technological innovations can contribute to its reduction. Starting from global and European data on food loss and using practical examples from universities (international and Romanian), the paper discusses the legislative framework, good practices, pedagogical and technological interventions, as well as a set of recommendations for higher education institutions that want to reduce their food footprint. Research directions and public policies are also proposed to support the transition to more circular and resilient food systems.*

Keywords: *food waste, urban food policies, composting, biodigestion, education.*

1. Introduction

Food waste is a complex problem, combining technological, economic, social and cultural components. In addition to the loss of goods themselves, waste involves the unnecessary use of natural resources (water, land, energy), economic costs for actors in the food chain and greenhouse gas emissions resulting from production, transport and disposal.

Although on a global scale problems such as hunger coexist with food surplus and waste, coordinated efforts can bring significant benefits. In this context, universities have a dual role: on the one hand they are consumers of resources on their own campuses (canteens, events, practical schools), and on the other hand, they are training institutions that can shape behaviours and generate innovations applicable to the wider community.

The aim of this article is to detail examples of good university practices, to analyse the national legislative framework and opportunities for integrated urban food policies, and to provide practical recommendations and research directions for the large-scale implementation of food waste reduction measures.

1.1. Context and premises of the food waste phenomenon

Approximately one third of food produced for human consumption is lost along the food chain (FAO). This includes losses in the production, processing, storage, distribution and final consumption phases.

At the European Union level, about 20% of all food produced ends up being lost or wasted, and in Romania estimates show an annual amount of approximately 1,353,077 tones, equivalent to 70 kg/capita/year. It is important to note that loss can be expressed both in mass units (kg) and in energy (kcal); losses express significant reductions in overall caloric availability. The environmental impact of food waste is considerable: the EU food supply chain is responsible for approximately 17% of direct greenhouse gas emissions and uses approximately 28% of material resources.

Moreover, food production is a water and energy intensive process, thus, reducing waste directly contributes to reducing pressure on natural resources and achieving the environmental objectives of the European Union and Romania. The demographic outlook (forecast for 2050) underlines the urgency: a global population estimated at almost 9.8 billion people will require a substantial increase in agricultural production (some estimates speak of +60%).

In such a context, reducing losses and waste becomes a strategic component of food security and the resilience of food systems.

2. National legislative framework and policy instruments

Public policies provide the necessary framework to transform isolated initiatives into scalable practices. In Romania, Law no. 217/2016 is one of the first normative acts that aimed to reduce food waste, introducing obligations and measures for food sector operators. More recently, Law no. 49/2024 has consolidated this framework, aligning the country with the objectives of the 2030 Agenda (such as the target of reducing waste by 50% by 2030).

Legislative measures focus on several directions: prevention (planning, clear labelling, optimization of supply chains), facilitation of redistribution (encouraging food donation, fiscal and logistical provisions for NGOs), reporting obligations (national platform for reporting redistributed/discarded quantities) and solutions for the recovery of products not recommended for human consumption (animal feed, composting, biogas).

The role of regulations is twofold: they create responsibilities for economic actors and provide incentives and mechanisms for action. Practical examples adopted in other jurisdictions include: removing legal barriers to donation, tax deductions for operators donating surplus food, and standards for measuring and reporting waste (common methodologies that allow for comparability across institutions).

3. Good university practices — examples, mechanisms and impact

3.1. International examples and applicable mechanisms

Universities can function as innovation laboratories for waste reduction. International examples describe a wide range of mechanisms: technological (AI for prediction and reservation), operational (portion control, flexible menu), social (donation, community engagement) and infrastructural (composting, biodigestion).

Meal reservation systems based on predictive algorithms (e.g., University of Tehran) allow for

more accurate planning of prepared quantities. The model reduces resource consumption by preparing only the number of servings needed. Implementation requires historical data collection on student preferences, integration with payment systems and student cards, and flexibility in kitchen operations.

Initiatives such as those at UC Berkeley or UC Santa Barbara demonstrate the usefulness of processing marginal (slightly spoiled) foods for safe food purposes (soups, smoothies), as well as campus-scale composting. UC Davis adds value by transforming organic waste into bioenergy, in a circular model that reduces disposal costs and produces local energy resources.

3.2. Examples and potential in Romania

Romanian universities have started to implement various measures, from surplus collection and donation (University of Bucharest) to educational programs and composting pilot projects (USAMV Cluj-Napoca). These projects lay the foundations for a systematic expansion: several universities can adopt common policies, share infrastructure (regional composting or biodigestion centers) and create partnerships with local markets and NGOs.

A key aspect for Romania is adapting solutions to available resources: not all campuses can immediately support a biodigester, but many can start with simple, cost-effective measures: periodic food audits, portion control, seasonal menus based on local raw materials, promotion of portioned packages and awareness campaigns.

4. Integrated urban food policies and the CLIC concept

Integrated urban food policies aim to approach the food system in a holistic way, focusing on the connections between production, distribution, consumption and waste management.

The «CLIC» concept proposed in the material connects the components: Co-benefits (actors), Linkages (resources and flows), Inclusion (technology, practices) and Connectivity (public-private partnerships).

Table 1. *The CLIC concept*

C	L	I	C
CO-BENEFITS	LINKAGES	INCLUSION	CONNECTIVITY
Interconnected economic, social and environmental objectives. Synergies through recognition of sustainability strategies	Creating or strengthening beneficial environmental, socio-cultural and economic links between urban, peri-urban and rural areas	Inclusion of all actors in the food system, while ensuring a fair distribution of its performance	The relationships between the food system and other policy priorities (e.g. climate change, resource scarcity, biodiversity conservation, sustainable transport, affordable housing and jobs)

By implementing such an approach, cities can achieve collateral benefits: increasing social inclusion (by redistributing food surplus to vulnerable groups), local economic development (creating services related to organic recycling, composting), and improving public health (access to fresh and nutritious food).

European projects such as ZeroW highlight the innovative potential of transnational collaborations in testing and implementing scalable solutions.

5. Practical recommendations and operational plan for universities

Based on the best practices and identified limitations, we propose a set of operational steps for higher education institutions interested in reducing waste:

1. Initial food audit and ongoing monitoring: measuring the quantities thrown away, identifying the main sources (uneaten portions, overcooked food, expired products).

A good audit uses food diaries and periodic assessments.

2. Menu optimization and portion control: adapting portions to real needs, introducing “small portion” options and personalized menus, implementing meal reservation systems.

3. Redistribution and partnerships: collaborating with food banks and NGOs to donate surplus; developing logistics protocols for fast and safe collection.

4. Organic waste management: starting with small-scale composting, moving to biodigestion where feasible, and exploring biogas-based micro-energy infrastructure.

5. Education and engagement: including food systems modules, practical workshops, interdisciplinary projects and awareness campaigns for students and staff in university curricula.

6. Digitalisation and reporting: integration with electronic payment systems, meal booking apps and reporting platforms (in line with national requirements) to ensure transparency and traceability.

6. Conclusions

Reducing food waste in academia represents a clear opportunity to combine education, innovation and public policy to achieve multiple benefits: economic, social and environmental. Higher education institutions can become catalysts for change, both by adopting good operational practices and by training responsible professionals and citizens.

Implementing the recommendations presented — audits, menu optimization, redistribution, composting/bio digestion, education and digitalization — can lead to significant waste reduction at the campus level. Collaboration with local authorities, the private sector and civic organizations is essential to scale these solutions and integrate universities into modern urban food policies.

References

1. FAO. Global Food Losses and Food Waste: Extent, Causes and Prevention. Rome, 2011. <https://www.fao.org/4/mb060e/mb060e.pdf>
2. European Commission. EU Platform on Food Losses and Food Waste reports and recommendations. https://food.ec.europa.eu/food-safety/food-waste/eu-actions-against-food-waste/eu-platform-food-losses-and-food-waste_en
3. Legea nr. 217/2016 privind diminuarea risipei alimentare (România). <https://www.madr.ro/docs/ind-alimentara/2019/Legea-217-2016.pdf>
4. Oprea, O.B., Gaceu, L., & Tucu, D. (2017). Valorisation of winery waste by using GSP (grape seed powder) as flour substitution in bakery industry. Proceedings of the 45th

- International Symposium on Agricultural Engineering, Actual Tasks on Agricultural Engineering, 21-24 February 2017, Opatija, Croatia, 2017, 371-376;
5. Legea nr. 49/2024 privind gestionarea risipei alimentare (România). <https://www.madr.ro/comunicare/9165-a-fost-actualizata-legislatia-privind-diminuarea-risipei-alimentare.html>
 6. Oprea, O. B., & Gaceu, L. (2016). Application of multiple criteria decision making (mcdm) in bakery industry. Study case: wastes and by-products. *Bulletin of the Transilvania University of Brasov. Series II: Forestry• Wood Industry• Agricultural Food Engineering*, 89-94.
 7. ZeroW Project. Systemic innovations to reduce food waste. Horizon 2020. <https://www.zerow-project.eu/>
 8. Sustainable food systems (UCLA) https://www.ioes.ucla.edu/wp-content/uploads/2016/12/Food_Sustainability_Final_Report-r4-oab.pdf
 9. Campus Race to Zero Waste — Stanford University initiatives. <https://sustainable.stanford.edu/progress/zero-waste/>
 10. Munch — aplicație pentru reducerea risipei alimentare (articole și lansare în România). <https://bonapp.eco/>
 11. Gruia, R., Florescu, G. I., Gaceu, L., Oprea, O. B., & Țane, N. (2021). Reducing environmental risk by applying a polyvalent model of waste management in the restaurant industry. *Sustainability*, 13(11), 5852.
 12. Oprea, O. B., Gaceu, L., & Gadei, G. (2013). Investigation methodology about labels information content of the meat products from Romania, in accordance with European Legislation. In *Proceeding of the international conference Agriculture Informatics*, pg (pp. 7-12).
 13. Reports and policy briefs on urban food policies and food systems integration. <https://foodclie.eu/news/policy-recommendations-building-resilient-and-sustainable-food-systems>

SMART RESTAURANT AND ENERGY TRANSITION: RENEWABLE SOLUTIONS FOR HORECA SECTOR

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Abstract: The paper explores the integration of renewable energy resources and smart energy solutions into the HoReCa sector, with a focus on fast-food restaurants as high-consumption facilities in urban environments. Based on a multidisciplinary research methodology, including bibliographic review, comparative analysis and applied technical-economic modeling, the study demonstrates that photovoltaic systems, heat pumps and mixed renewable configurations can significantly reduce operating costs and environmental impact. Results show that covering approximately 50% of annual consumption with a photovoltaic system yields rapid payback periods of 2–3 years, while ensuring enhanced energy independence and reduced greenhouse gas emissions. The findings confirm that renewable-based restaurant infrastructures contribute to sustainability goals, improve brand image and represent a competitive advantage in a market increasingly driven by ecological responsibility.

Keywords: Smart restaurant, Renewable energy, HoReCa sustainability, Photovoltaic systems, Energy efficiency.

1. Introduction

The energy transition and sustainable development are major strategic directions of the contemporary economy. In a global context characterized by the climate crisis, increasing resource consumption and pressure on the environment, society is called upon to adopt sustainable models of production and consumption. Among the sectors with a significant impact on the environment is the hospitality and public catering industry, known under the generic name HoReCa (Hotels – Restaurants – Catering). This industry, although it has an essential role in satisfying the food and recreational needs of the population, is distinguished by high energy consumption, intensive use of natural resources and the generation of considerable amounts of waste.

In this context, the integration of renewable energy resources in the operation of public catering units becomes a viable and necessary solution. Photovoltaic panels, solar heating systems, small-scale wind turbines, bioenergy or other green technologies can transform these units from traditional energy consumers into models of efficiency and ecological responsibility.

By reducing dependence on fossil fuels and decreasing greenhouse gas emissions, these units

contribute not only to protecting the environment, but also to creating an innovative and attractive commercial image for consumers.

The present paper aims to carry out a scientific synthesis on the possibilities of using renewable energies in public catering, with an emphasis on the practical dimension and economic feasibility of these investments.

The approach is multidisciplinary, bringing together perspectives from the fields of energy engineering, food technology, management and public policies. The general objectives of the paper are:

1. Analysis of the current state of renewable energies at global and national levels, with relevance for the HoReCa sector.
2. Evaluation of the possibilities of integrating green solutions in public catering establishments, based on case studies and specialized literature.
3. Presentation of a methodology for designing a modern fast-food establishment with reduced energy consumption, including relevant calculations and technical parameters.
4. Identification of the economic and social advantages generated by the use of renewable resources.
5. Formulation of conclusions and recommendations for the expansion of this model in Romania.

The scientific importance of the approach derives from the fact that the paper is not limited to a simple descriptive analysis, but proposes a conceptual and methodological framework applicable to the design and evaluation of sustainable HoReCa units. By combining specialized literature with technical and economic data, the study validates the relevance of renewable energies not only as an environmental protection tool, but also as a strategic resource for the competitiveness of the public catering industry.

The practical relevance is doubled by multiple effects: reducing operational costs by decreasing conventional energy consumption, creating green jobs, strengthening the relationship with local producers and improving the public image of restaurants that adopt these technologies. In addition, in the context of European and national legislation, which promotes buildings with nearly zero energy consumption and supports investments in green infrastructure, public catering units have the opportunity to access non-reimbursable funds and support schemes.

2. Bibliographic study

Renewable energy is one of the central themes of the 21st century, being closely linked to the transition to a green economy and to international efforts to reduce greenhouse gas emissions. In the specialized literature, numerous authors emphasize that sustainable development cannot be conceived without the integration of technologies based on renewable resources, such as solar, wind, hydro, geothermal or bioenergy. This chapter synthesizes the main theoretical and applied contributions, following both global and European trends, as well as concrete cases of implementation in the HoReCa sector.

2.1. The global context of renewable energies

The evolution of renewable resources globally reflects a gradual transition from fossil fuels to clean and sustainable sources. Since the 1970s, with the oil crisis, developed countries have begun to invest in research on solar panels and wind turbines. Currently, over 80% of the newly installed electricity generation capacity worldwide comes from renewable sources, according to Irena (2023). Countries such as Germany, Denmark and Spain have become leaders in the wind sector, while China dominates the photovoltaic sector through large-scale production and installation. At the same time, the

USA and Japan are investing heavily in geothermal energy and advanced energy storage technologies.

The Paris Agreement (2015) and the UN 2030 Agenda are essential milestones for the development of green energy. These documents set clear objectives to limit global warming to below 2°C and increase the share of renewable energies in the global energy mix. The European Union, through the European Green Deal, has committed to climate neutrality by 2050, and the REPowerEU plans are accelerating investments in green energy infrastructure.

2.2. Types of renewable energy resources

Renewable resources are characterized by the fact that they regenerate naturally, in a practically inexhaustible cycle on the scale of human time. The specialized literature classifies these resources into six broad categories: solar, wind, hydroelectric, geothermal, bioenergy and marine energy.

Solar energy is considered the most abundant resource, as in a single hour the Earth receives from the Sun an amount of energy greater than the annual consumption of humanity. Photovoltaic technologies, with efficiencies between 15–21%, transform solar radiation into electricity, and solar thermal systems provide water heating and air conditioning. Wind energy is generated by converting the kinetic energy of wind into electricity, with modern offshore turbines reaching capacities of 10–12 MW each. Hydropower has a tradition of over a century and remains the source with the largest share in the global renewables mix.

Geothermal energy harnesses the Earth's internal heat, which is constant and independent of weather conditions. Geothermal heat pumps are widely used in countries such as Iceland and Switzerland. Bioenergy comes from biomass (agricultural, forestry waste, food residues) and can generate both electricity and green fuels such as biogas or bioethanol. Finally, marine energy includes the conversion of waves, tides and salinity differences, and is still in its early stages of development.

2.3. The use of renewable resources in HoReCa – international perspectives

The HoReCa sector has a considerable energy impact, and the integration of renewable resources is becoming a central element in sustainability strategies. The literature records multiple international examples.

Uncommon Ground (Chicago, USA) is recognized as one of the greenest restaurants in America, using solar panels, an urban rooftop garden and responsible farming practices. BOCA (Dubai, United Arab Emirates) operates exclusively on certified renewable energy and reports its carbon footprint annually. Merriman's Waimea (Hawaii) uses 90% local ingredients and became the first CarbonNeutral restaurant in the region.

In Europe, many hotels and restaurants are adopting green standards. Germany and Sweden are actively supporting the implementation of photovoltaic panels in HoReCa establishments, and France is promoting legislation that obliges large restaurants to reduce food waste and recycle organic waste. Thus, the HoReCa sector is becoming a laboratory of applied sustainability.

2.4. The use of renewable resources in HoReCa – national perspectives

In Romania, the HoReCa sector is gradually starting to adopt green technologies. Existing examples illustrate the potential for integrating renewable energies.

KFC Drive Thru Galați (2025) is the first unit of the network in Romania equipped with 47.5 kW solar panels, covering about 50% of energy consumption. The Pescăruș Restaurant in Bucharest uses a 122.1 kWp photovoltaic system, significantly reducing dependence on the national grid. The Păstrăvăria Albota tourist complex (Sibiu) combines solar panels and a micro hydropower plant, ensuring partial energy autonomy.

These initiatives, although numerically limited, demonstrate the technical and economic feasibility of renewable energies in HoReCa. However, their expansion depends on legislative support, access to financing through the PNRR and better awareness among entrepreneurs.

2.5. Critical synthesis

The analysis of the literature and case studies reveals several major directions. First, photovoltaic panels represent the most widespread solution, due to their low cost and adaptability to existing infrastructure. Second, there is a trend towards combining renewable sources (solar + biomass, hydro + solar), to increase stability and reduce weather dependence.

Economically, investments in green technologies pay for themselves in the medium term, in 5–10 years, and establishments that adopt such solutions gain in competitiveness and

public image. Socially, green HoReCa creates jobs and strengthens short supply chains with local producers. However, barriers remain significant: high initial costs, lack of information and difficulties in accessing European funds.

In conclusion, the literature confirms that the integration of renewable resources in public catering is no longer a marginal option, but a strategic direction that will mark the transformation of the HoReCa sector in the coming decades.

3. Research methodology

3.1. General considerations

The research methodology represents the set of tools, techniques and procedures used to achieve the proposed objectives of the study. In this case, the research aims to analyze the potential for integrating renewable energies in public catering units and evaluate the technical and economic feasibility of such investments.

The methodology adopted is of a mixed type (qualitative and quantitative research), based on:

- bibliographic analysis of specialized studies, international and national reports;
- comparative analysis between international and national models of green HoReCa units;
- applied case study (fast-food unit powered by renewable sources);
- modeling and technical-economic calculation (photovoltaic system sizing, consumption assessment, investment amortization).

3.2. Specific research objectives

1. Identification of the most relevant renewable sources applicable to the HoReCa sector.
2. Analysis of the legislative framework and European and national strategies in the field of green energy.
3. Comparison of the technical and economic performance of different renewable energy solutions.
4. Development of a methodological model for assessing the feasibility of a restaurant powered predominantly by renewable sources.

3.3. Working assumptions

The research starts from several hypotheses:

- Hypothesis 1: The integration of renewable energies in HoReCa can significantly reduce long-term operational costs.
- Hypothesis 2: The high initial investments can be amortized within a period of 5–10 years,

depending on the type of resource used and the available financial support.

- Hypothesis 3: Consumers are increasingly receptive to "green" food establishments, which increases economic competitiveness.

3.4. Research stages

1. Bibliographic data collection – selection of scientific articles, IRENA, Eurostat, ANRE reports and case studies.
2. Comparative analysis – correlation of international and national data to identify similarities and differences.
3. Case study selection – choice of a typical public catering unit (fast-food with 50–100 seats), for applying the calculations.
4. Energy modeling – estimation of daily electricity and thermal energy consumption, sizing of the photovoltaic system and identification of possible complementary sources (biomass, hydro, network).
5. Economic analysis – calculation of investment cost, annual savings and payback period.
6. Interpretation of results – comparison with the specialized literature and formulation of conclusions.

3.5. Methods and tools used

- Bibliographic analysis method – for synthesis of current knowledge.
- Comparative method – for assessing the differences between international and national models.
- Case study method – for practical application of the results.
- Modeling and simulation method – for estimating energy parameters.
- Cost–benefit analysis method – for assessing economic feasibility.

3.6. Research limitations

Any research has certain limitations. In this case:

- Economic and technical data are based on statistical averages and may vary depending on location and equipment suppliers.
- Energy and technology price developments may change the amortization terms.
- The case study is limited to one type of establishment (fast food), which may limit the generalizability of the results.

3.7. Relevance of the methodology

The proposed methodology is of an applied nature and can be replicated for various types of

HoReCa units. By combining theoretical and practical data, the research provides a robust framework for assessing the feasibility of investments in renewable energies, contributing to both the scientific literature and managerial practice.

4. Calculations and analysis

4.1. General considerations

An essential element in assessing the feasibility of using renewable resources in HoReCa is energy and economic calculations. These allow for the correct sizing of equipment, the estimation of costs and savings obtained, as well as the establishment of the investment payback period.

For the present analysis, a fast-food restaurant with 80 seats was considered, with an operating schedule of 12 hours/day, 30 days/month.

4.2. Energy consumption estimation

Total energy consumption is determined by:

- cooking equipment (electric stoves, ovens, fryers, microwave ovens);
- refrigeration systems (refrigerated display cases, cold rooms, freezers);
- indoor and outdoor lighting;
- HVAC systems (heating, ventilation, air conditioning);
- auxiliary equipment (computers, cash registers, pumps).

According to average data from the specialized literature and technical reports (ANRE, 2023):

- Cooking equipment: ~ 450 kWh/day
- Refrigeration: ~ 200 kWh/day
- Lighting: ~ 50 kWh/day
- HVAC: ~ 250 kWh/day
- Auxiliary: ~ 50 kWh/day

Total estimated daily consumption = 1,000 kWh/day

Which means ~30,000 kWh/month and ~360,000 kWh/year.

4.3. Dimensioning of the photovoltaic system

The installation of a photovoltaic system on the roof of the building is considered.

- Average annual solar radiation in Romania: ~1,300 kWh/m²/year (in the southeast).
- Photovoltaic panel efficiency: 18%.
- Panel power: 400 W.
- Panel surface: ~1.9 m².
- Average annual production per panel: ~520 kWh/year.

To cover 50% of the annual requirement (180,000 kWh):

Number of panels = $180,000/520 \approx 346$ panels

Total installed power:

$$346 \times 0.4 \text{ kW} = 138.4 \text{ kW (1)}$$

Necessary area:

$$346 \times 1.9 \approx 658 \text{ m}^2 \text{ (2)}$$

It turns out that a medium-sized roof can support a such system.

4.4. Costs and depreciation

- Average cost of installed panel: 800 €/kWp.

- Total investment cost:

$$138.4 \times 800 \approx 110,720 \text{ € (3)}$$

Annual savings (energy produced $\times$ energy price):

- Energy price: 0.25 €/kWh.

- Annual energy produced: 180,000 kWh.

- Savings: 45,000 €/year.

Payback period:

$$110,720/45,000 \approx 2.46 \text{ years (4)}$$

Thus, the investment pays for itself in less than 3 years, which confirms the high economic feasibility.

4.5. Analysis of alternative scenarios

Scenario A – 100% photovoltaic system

- Requires doubling the number of panels (≈ 700 panels, 276 kWp).

- Required area: $\sim 1,300 \text{ m}^2$.

- Very high costs, but complete autonomy.

Scenario B – Mixed system (photovoltaic + biomass)

- 50% solar energy + 30% biomass + 20% grid.

- Allows diversification of sources and use of food waste.

Scenario C – Mixed system (photovoltaic + hydro)

- Possible in mountainous areas or with access to micro-hydropower plants.

- Significant reduction in dependence on weather conditions.

In table 1 a comparative economic analysis is presented.

Table 1. Comparative economic analysis

Scenario	Investment (€)	Annual savings (€)	Amortization (years)	Energy autonomy
50% PV	110.720	45.000	2,5	50%
100% PV	221.440	90.000	2,46	100%
Solar + biomass	160.000	70.000	2,28	80%
Solar + hydro	180.000	75.000	2,40	85%

The analyses and calculations performed show that:

- Investments in photovoltaic systems for HoReCa are feasible and have a rapid payback.
- Mixed scenarios offer better energy stability and capitalize on local resources.
- Complete autonomy is possible, but requires considerable areas and investments.

5. Results and discussion

5.1. Results of sizing and energy analyses

Based on the calculations performed, the following main results were obtained:

- The annual energy consumption of an 80-seat fast-food establishment was estimated at 360,000 kWh/year.

- A photovoltaic system sized at 138.4 kWp (346 panels) could cover approximately 50% of the consumption, producing approximately 180,000 kWh/year.

- The required investment is approximately €110,720, with a payback period of 2.5 years.

- In alternative scenarios, energy autonomy can vary between 50% and 100%, with payback periods ranging from 2.3 to 2.5 years.

These results demonstrate that the adoption of renewable energies in HoReCa is economically feasible and can be achieved without major financial risks.

5.2. Comparison of the analyzed scenarios

The scenarios simulated in the previous chapter reveal several key aspects:

- The 50% photovoltaic scenario is the most balanced, requiring moderate investments and ensuring a high degree of sustainability.
- The 100% photovoltaic scenario offers complete independence, but requires large areas for panels and double the investments compared to the basic variant.
- The mixed solar + biomass scenario is advantageous by capitalizing on organic waste (including food scraps), reducing the impact on the environment.

- The mixed solar + hydro scenario is feasible only in certain geographical regions, where there are exploitable water sources.

Comparatively, mixed scenarios bring additional benefits of energy resilience, reducing dependence on weather variations.

5.3. Discussions on economic feasibility

From a cost perspective, investments in photovoltaic systems and renewable sources prove to be very attractive, especially in the context of increasing electricity prices.

Within a period of 3–5 years, the HoReCa unit could become completely energy independent and would continue to generate significant savings thereafter. Also, financing opportunities through PNRR, non-reimbursable European funds and ANRE support schemes can reduce the effective amortization period to less than 2 years.

5.4. Impact on the environment and society

The implementation of renewable energies in public catering generates multiple positive effects:

- Reduction of CO₂ emissions – for 180,000 kWh/year saved from the network, approximately 85 tons of CO₂/year are avoided.
- Reduction of dependence on fossil fuels, with macroeconomic benefits.
- Creation of green jobs in the field of equipment maintenance and installation.
- Increased commercial attractiveness – consumers are increasingly attentive to the sustainability of HoReCa businesses.

5.5. Comparison with the literature

The results obtained align with the international studies analyzed in Chapter 2:

- Payback periods between 2–5 years are confirmed by recent research (Sampaio & Gonzalez, 2017; IRENA, 2023).
- The feasibility of mixed scenarios is discussed in the specialized literature as a solution to increase energy resilience.
- International examples of green restaurants confirm that sustainability not only reduces costs, but also improves public image.

6. Conclusions

The main objective of the synthesis paper was to evaluate the possibilities of using renewable energy resources in the HoReCa sector, with a focus on technical and economic feasibility and environmental impact. The analysis of the

specialized literature, statistical data and national and international case studies led to the following essential conclusions:

1. Renewable resources represent a viable and sustainable alternative for public catering, being available in multiple forms (solar, wind, hydro, geothermal, bioenergy).
2. Photovoltaic panels are the most widely used solution in the HoReCa sector, due to their high efficiency and decreasing installation costs.
3. Mixed scenarios (combining solar energy with biomass or hydro) are the most resilient, reducing dependence on weather conditions and leveraging local resources.
4. Economic analyses demonstrate that investments can be quickly amortized (2–5 years), especially in the current context of rising energy prices and the existence of European funds.
5. The environmental impact is considerable, by reducing CO₂ emissions, and the social benefits include the creation of green jobs and increased commercial attractiveness.

References

1. Askari, M. B., Mirzaei, V., Mirhabibi, M. și Dehghani, P. (2015) „Hydroelectric Energy Advantages and Disadvantages”, *American Journal of Energy Science*, p. 17.
2. Doss, G. (2003). „IS project management handbook”, *Aspen Publisher*, p. 8.
3. Ellabban, O., Abu-Rub, H. și Blaabjerg, F. (2014) „Renewable and Sustainable Energy Reviews”, *Elsevier*, pp. 749-764.
4. Fereres, S. (2018) „Renewable Energy Engineering: Solar, Wind, Biomass, Hydrogen and Geothermal Energy Systems”, V. 3, *Bentham eBooks*, p. 10.
5. Foster, R., Ghassemi, M. și Cota, A. (2010) „Solar Energy: Renewable Energy at the Environment. Energy and the Environment Series”, *CRC Press*, p. 4.
6. He, Y. L., Qiu, Y., Wang, K., Yuan, F., Wang, W. Q., Li, M. J. și Guo, J. Q. (2020) „Perspective of concentrating solar power”, *Elsevier*, pp. 1-2.
7. Hosenuzzaman, M., et al. (2015) „Global prospects, progress, policies, and environmental impact of solar photovoltaic power generation”, *Elsevier*, pp. 284-297.
8. Khan, M.Z.A., Khan, H.A., Aziz, M. (2022) „Harvesting energy from ocean: Technologies and perspectives”, *Energies*, p. 25.
9. Martinot, E. (2016) „Grid integration of renewable energy: flexibility, innovation and

- experience”, *Annual Review of Environment and Resources*, pp. 223–251.
10. Silveira, J. L., Tuna, C. E. și Lamas, W. Q. (2013) „The need of subsidy for the implementation of photovoltaic solar energy as supporting of decentralized electrical power generation in Brazil”, *Elsevier*, 133–141.
 11. Gruia, R., Florescu, G. I., Gaceu, L., Oprea, O. B., & Țane, N. (2021). Reducing environmental risk by applying a polyvalent model of waste management in the restaurant industry. *Sustainability*, 13(11), 5852.
 12. Gaceu, L., Gruia, R. (2009). Education in food and tourism area using moodle management courses system in Transilvania University of Brasov. *J. of EcoAgriTourism*, 2009, Vol. 5, No. 1, 43-49 ref. 12.
 13. Gaceu, L., Oprea, O.B., Summary on the role of Informational Content in the Communication and Promotion of Tourism Services in Romania. *J. of EcoAgriTourism*, 2024, Vol. 20, no.1;
 14. Gaceu, L. (2024). Study on the Possibilities of Digitalization of the Agri-Food Logistic Chain in the Mountain Area. *Journal of EcoAgriTourism*, 20(1).
 15. Tanhua, D., Tuomi, E. O., Kesti, K., Ogilvie, B., SAHAGÚN, C. D., Rodriguez, J. N. A., ... & Gaceu, L. (2024). Digital Maturity of the Companies in Smart Industry Era. *Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development*, 24(3).
 16. Singh, B., Sharma, H.N. (2024) „An Overview of Green Energy & Applied Science”, 1st Ed., S.R. *Scientific Publication*, pp. 102–103.
 17. Srirangan, K., Akawi, L., Moo-Young, M., Chou, C.P. (2012) „Towards sustainable production of clean energy carriers from biomass resources”, *Applied Energy*, p. 173.
 18. Gruia, R., Popescu A., Gaceu, L. The Bioharmonized Reconnection of the Agricultural System in Romania's Territory in the Process of Administrative Reorganization. *Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development*, 2024/7/1
 19. IRENA. (n.d.). Geothermal energy. Disponibil la: <https://irena.org/Energy-Transition/Technology/Geothermal-energy> [Accesat la: 18 ianuarie 2025].