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CONTEMPORARY CHALLENGES FACING THE FOOD INDUSTRY

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Abstract. The report explores the sustainable management of plastic packaging in the sustainable management of the application in the food sector production, with a special focus on innovation and smart management systems. The study aims to assess the impact of the regulatory policy on the development and implementation of sustainable packaging solutions in the food industry. The study uses qualitative and quantitative methods to evaluate and analyse the data. Examples from the practice of using new materials are analysed. The results referred to in this article are obtained based on the work on the dissertation and a research project with filing number НИ-4-2022.

Keywords: circular economy; smart business; knowledge economy; smart packaging; food industry

JEL: *Q01, M21, I23*

1. Introduction

The food industry plays an important role in the global economy, meeting basic consumer needs and offering a variety of products on the market.

Food packaging is essential to the functioning of the food industry, providing the necessary protection, extending shelf life, and facilitating the distribution of food to consumers. With a growing world population forecasted to reach 9.7 billion people by 2050 (Ncube et al., 2021), increased demand for food necessitates a significant increase in production and therefore in packaging materials use.

Plastic, as the main type of packaging material, provides exceptional functionality and economy, making it preferred for use in a wide range of applications including the food industry. Historically, plastic has been discovered as a material with unique properties for easy formation and flexibility, making it ideal for packaging. In recent decades, its technological and engineering qualities have significantly improved, but is this enough to avoid the problems it creates?

The purpose of the study is to clarify the impact of the use of plastic packaging on the quality of products produced in the food industry. The publication focuses on

the challenges associated with plastic pollution and the possibilities for solving the case through the entry of the food industry into the circular economy.

The study also draws attention to the negative consequences of recycled plastic by mentioning the presence of multiple chemicals in it, which can affect the safety of food consumed. In the context of the knowledge economy, the study focuses on the need for innovation in recycling processes and raising public awareness of the sustainable use of resources.

"In Bulgaria, enterprises in the food industry reported a record turnover for the last 12 years, which grew by more than 36 per cent on an annual basis in 2022. The industry includes more than 5,000 companies, employing about 70,000 people. ... The food industry is among the sectors that have been developing sustainably in recent years in Bulgaria, but it has much greater potential."[1]

2. The food industry in the context of the circular economy

The circular economy emerged as a reaction to the linear economic model that formed during the Industrial Revolution in the 18th and 19th centuries. In this period, mass production resulted in significant resource costs and generated huge amounts of waste. As the 20th century progressed, it became increasingly obvious that resources are not infinite, and the environmental consequences of unsustainable practices are beginning to be felt. These problems are driving the development of sustainable resource and waste management concepts.

In the 1970s, in the context of the oil crisis, interest in new economic models that promote recycling and reuse accelerated. In the 1990s, the term "circular economy" began to gain popularity, and legislative initiatives aimed at resource efficiency and waste management were introduced in Europe and Japan. At the beginning of the 21st century, the concept of a circular economy is receiving increasing attention, especially in relation to climate change. Global consumption of natural resources grew, reaching 92.1 billion tonnes in 2017, an increase of 254% from 27 billion tonnes in 1970 (Narasimmalu & Ramasamy, 2020). In Bulgaria, the total consumption of natural resources in 2020 was about 20.6 million tonnes (IRENA, 2024; Lazarevic et al., 2010).

The Ellen MacArthur Foundation plays a key role in promoting the concept of a circular economy. The European Union, through the Green Deal, is actively engaged in the transition to a circular economy, which has established itself as a global goal for sustainable development.

The main methods of waste management in the context of the circular economy include the prevention of waste generation through optimized product design, material reductions and the use of longer-lasting components.

[1]Published data from the Ministry of Economy and Industry

Table 1. The main methods of waste management in the world

Method	Percentage reduction of waste/ resources	Sources
Initial prevention	60–70%	UNEP
Recycling	30–50%	Ellen MacArthur Foundation
Composting	25–40%	Sustainable Waste Management

According to a United Nations Environment Programme (UNEP) report, approximately 60–70% of waste can be avoided through effective prevention strategies, such as reducing packaging and changing production processes.[2]

According to data from the **National Statistics**, about **80%** of waste in Bulgaria is disposed of at landfills, and only **20%** is managed through recycling and composting.[3]

The concept of sustainable resource management is not devoid of criticism. Critics have characterized it as politically convenient and potentially vague, stressing that it is often presented as a universal solution that is difficult to question. They argue that supporters of the circular economy often focus on conflict-free and cost-effective strategies that do not adequately reflect the complexity of the challenges associated with the overall economic transformation. This includes ignoring possible social, environmental, and economic conflicts arising in the process of transitioning to more sustainable models of resource management (Corvellec, Stowell & Johansson, 2021).

Directive (EU) 2019/904, known as the Single-use Plastics Directive, is a legislative measure adopted by the European Union to reduce the impact of certain types of plastic products on the environment.

The specific requirement related to SUP[4] bottles reads:

"*These bottles must contain at least 25% recycled plastic in their production by 2025 (for PET bottles) and 30% by 2030 (for all bottles)" (Directive (EU) 2019/904).*

3. Effects on the food industry from the resources used

PET bottles are plastic containers made of polyethylene terephthalate (PET), which are widely used for packaging beverages and food products.

The *Food Packaging Forum*[5] currently has a database comprising a total of

[2] https://www.unep.org/

[3] https://www.nsi.bg

[4] The term "SUP bottles" generally refers to disposable plastic beverage bottles that are subject to regulation under European Union Directive (EU) 2019/904. "SUP" is an acronym of the English phrase "Single-Use Plastics"

[5](FPF) is an independent organization focused on the safety and health information aspects of

1,355 scientific studies, information on more than 4,200 chemicals intended to come into contact with food, CAS registry numbers and over 24,000 records in the database as a whole.

853 FCCs[6] were found in recycled polyethylene terephthalate (PET), 58% of which were found in only one study.

With repeated use of pet bottles, especially with exposure to high temperatures or mechanical damage, the migration of chemicals from the bottle to the contents can be increased. Some studies show that prolonged use and refilling of pet bottles may result in the accumulation of microorganisms and chemicals that may potentially pose a health risk.

Examples from research:

Groh, Geueke & Muncke (2017) show that chemical migration from recycled and reusable food contact plastics can include priority hazardous chemicals.

Muncke et al. (2023) emphasize the importance of developing new methods to assess the safety of food contact plastics, including the routine use of biological analyses.

materials used for food packaging. The organisation provides reliable and scientifically sound information on chemicals in packaging, their potential health and environmental impacts, and legislative measures to control these risks.

[6] Food Chemicals Codex: A publication that provides standards for the identity and quality of food ingredients used in the manufacture of foods. This includes additives, preservatives, sweeteners, and other chemicals used in the food industry.

Table 2. Effect on milk product

Type of packaging	Migration of substances	Concentration (μg/L)	Additional information	Sources
Plastic bottle (PET)	Antimony	0.2 – 0.5	Phthalate migration: 0.01–0.08 depending on storage conditions.	Food Packaging Forum, Sustainability
Glass bottle	No migration of harmful substances	0	Inert material, with minimal impact on the taste and quality of the milk, even with long-term storage.	ScienceDirect
Outer carton (Tetra Pak)	Aluminium migration	Below 0.01	Packaged products can be stored for up to 6 months without loss of nutritional characteristics.	International Journal of Food Science
Edible/ biodegradable packaging	No evidence of migration	Immeasurable	No specific migration data; possible shorter shelf life of the product.	Trends in Food Science & Technology

This table summarizes the migration data of substances from different milk packaging, providing the sources of information for a more detailed study.

Glass packaging is a safe choice for food products, as it does not migrate chemicals into the contents and does not absorb odours. They are heat-resistant and contain no additives that could cause side effects. However, their severity and the risk of breakage may cause inconvenience and hazards.

In the context of sustainability, innovative packaging made from natural ingredients such as rice or potato starch offers promising alternatives to traditional plastics. It demonstrates good barrier properties against moisture and oxygen, which can extend the shelf life of foods while being safe for consumption. These new packaging solutions highlight the need for sustainable practices in the food industry.

The use of PET for packaging in industry brings economic benefits thanks to the low cost, lightness, and strength of the material. However, in addition to the environmental challenges associated with plastic waste, there is evidence of the migration of PET chemicals into products, especially in the case of long-term storage. This migration may include substances such as antimony and acetaldehyde, which may have a negative effect on the quality of food and beverages and, in certain cases, on the health of consumers. This highlights the need for packaging alternatives that are not only sustainable but also safe for health.

4. Knowledge economy – a prerequisite for the rapid entry of the food industry into the circular economy

The knowledge economy can play an important role in improving environmental friendliness in the food industry.

This principle is essential as it can contribute to the implementation of intelligent systems that reduce the risk of environmental problems. Instead of limiting ourselves to unsatisfactory plastic resources, it is important to develop innovative packaging solutions and apply new technologies.

Packages of natural ingredients: Made from materials such as rice or potato starch, this packaging demonstrates good barrier properties against oxygen.

"Oxygen barrier. Much of food deterioration is due to the oxidation of lipids and food ingredients, discolouration of myoglobin in fresh meat cuts, or enzymatic browning of fresh-cut produce. Using edible packaging with low oxygen permeability (OP) preserves the quality and extends the shelf life of O2-sensitive foods while reducing the usage of expensive nonrecyclable O2-barrier plastics" (Janjarasskul & Krochta, 2010).

Consumer acceptance of the new materials, despite the higher production costs, offers significant environmental advantages, making the mass production of these solutions increasingly achievable. The application of the principles of the knowledge economy can play an important role in process optimization, through cost-cutting innovations and technologies. In this context, smart warehouse management systems represent a powerful tool for optimizing resources and improving packaging management, which can lead to significant economic and environmental benefits.

Optimization of packaging regarding the orders: Intelligent systems can analyse and forecast future orders and packaging needs. This allows companies to choose the optimal type and size of packaging for each specific delivery, reducing the unnecessary use of materials and resources. Improving environmental sustainability: By reducing excess packaging size and optimizing the space used in virtual planning, intelligent systems help to reduce the volume of waste and carbon emissions. This improves the environmental footprint of warehouse operations and supplies. Competitive advantage through efficiency and speed: Optimizing storage space and improved goods management allow companies to increase the efficiency of their logistics. This leads to faster and more accurate deliveries, which improves customer service and the company's competitive position in the market. Smart inventory management: Systems can offer accurate demand forecasts and ensure optimal stock management, which prevents unnecessary inventory and shortages. This reduces financial losses and improves the overall sustainability of the business.

5. Conclusion

The study highlights the importance of the sustainable management of plastic packaging in the food industry, even replacing it with other types of innovative packaging. Plastic, while providing exceptional functionality and economy, also poses a serious challenge to the environment and human health, especially due to pollution issues and the presence of chemicals in recycled materials.

The EU with its new regulations on the use of recycled plastic in beverage packaging is a step in the right direction to reduce adverse environmental impacts. However, further innovation and efforts are needed in the field of recycling and alternative materials to offer more sustainable packaging solutions.

The Knowledge economy plays a key role in this context, promoting innovation and education programmes to increase awareness of sustainable resource use and improve recycling processes. At the same time, the industry must work to reduce the chemicals in recycled materials and ensure the safety of food offered to consumers. The effective implementation of regulations and cooperation between governments, industry, and scientific institutions is key to the success of sustainable practices. Strict standards and controls will ensure the safety and quality of recycled materials.

The recommendations for the future of innovative packaging highlight several key aspects related to improving their efficiency and reducing the ecological footprint. The first major factor is **investment in research and development (R&D)**. While this packaging offers great environmental benefits, issues such as insufficient knowledge of chemical migration and material resilience persist. This requires additional investment in **developing the perfect packaging** that is completely safe for human health and the environment. Additional studies can optimize its structure and barrier properties, leading to increased efficiency in preserving the qualities of food products.

Also, one of the key challenges is the high cost of this packaging, especially **edible and biopolymer solutions**. **Intelligent warehouse and resource management systems** could play a key role in optimising these processes, helping to reduce production costs over the long term. Over time, automation and technological advances can solve the problem of higher initial investment by creating **more affordable solutions for mass production**.

In addition, there is a need **to improve the recycling infrastructure**, which needs to be adapted to new materials to ensure their maximum recovery and reuse. Public-private partnerships can provide the necessary resources and knowledge for the successful deployment of these technologies.

Finally, **education campaigns** are essential to stimulate consumer acceptance and build a culture of sustainable resource management. A public understanding of the importance of innovative packaging will help their mass adoption and support the transition to greener practices on a global scale.

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