SUSTAINABLE PACKAGING IN THE CONTEXT OF CIRCULATION AND SUSTAINABILITY

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Abstract
Sustainable packaging is a relatively new concept and lacks a definite and complete definition. However, it is possible to explain this by evaluating and combining the definition of packaging and sustainability. Most often, sustainable packaging is defined as the development of packaging materials that have as little impact on the environment as possible without compromising the quality of the packaged product. The lack of clarity in the terms of sustainable packaging creates additional difficulties for both consumers and manufacturers when trying to distinguish sustainable packaging from less sustainable alternatives. This study aims to identify parameters that can be used for characterizing and recognizing sustainable packaging. By using monographic analysis methods and secondary data analysis methods in this study, authors have identified main circular economy principles in packaging and have developed concept for sustainable and circular food packaging model. The authors conclude that no single type of packaging - plastic, glass, metal, cardboard or paper - has all the characteristics of sustainable packaging. All of these materials have advantages and costs that vary depending on their application, regional standards, and other factors. Based on the above, the author offers a definition of sustainable packaging that refers to materials and designs used in the packaging of products that prioritize environmental responsibility throughout their entire lifecycle. It encompasses various key elements, including sustainability, recyclability, food protection, and adherence to the principles of the circular economy.
Keywords: sustainable, food packaging, life cycle model.

Introduction

The Ministry of Smart Administration and Regional Development Republic of Latvia explains the packaging as a set of products attached to goods and products, which are used to protect, contain, deliver, store, conveniently use, sell the product - raw materials and finished goods - and present it throughout the packaging cycle from producer to consumer. The packaging is removed from the product before or during consumption (VARAM, 2021). On the other hand, a broader definition of packaging can be found in the Packaging Law (Packaging Law, 2002). That states that the aim of packaging is to ensure the development of packaging production, the introduction of advanced packaging technologies and the creation of rationally used packaging management systems in the country, thereby reducing the negative impact of used packaging on the environment.

According to Meredith Leahy (Leahy, 2020) sustainable packaging is any packaging that reduces environmental impact by using less sustainable options. Although sustainable and environmentally friendly packaging are not the same, using sustainable materials to create new packaging options is believed to positively impact the environment.

On the other hand, a simplified definition of sustainable packaging is packaging produced from sustainable materials using energy from renewable sources. The packaging must be safe and effective throughout its life cycle, after which its components must be fully recyclable, thus creating a closed cycle of production and use. Truly sustainable packaging must be able to meet business market requirements in terms of cost, performance and safety. In other words, you will ensure that the packaging is designed, manufactured and processed in such a way that it requires a minimum number of raw materials to produce and can be reused or recycled at the end of its useful life (Netherlands Institute for Sustainable Packaging, 2022).

In this way, combining these explanations, the authors conclude that sustainable packaging must encompass all its inherent properties, and should be made from materials that do not threaten the climate, reduce the impact on the environment and do not affect the future development of future generations, at the same time ensuring economically profitable markets basic principles.

According to recent studies (Leahy, 2020), sustainable packaging must meet four key variables:

- Costs (economic size);
- Sustainability (recyclable, compostable and reusable);
- Performance (does this new, more sustainable packaging protect and preserve the products it was intended to transport as effectively as the previous packaging, which had potentially less sustainable packaging options);
- Sorting or waste management (whether this packaging can be correctly and appropriately sorted into waste material containers and whether this material has an end market once it has been recycled).

Companies are challenged to combine all four of these variables simultaneously; however, progress in this area is relatively slow due to both additional costs and problems with waste management. For this reason, the countries are more and more actively trying to draw the attention of both businessmen and consumers to this issue. One option is to use policy approaches such as extended producer responsibility, which holds companies accountable for producing packaging that

is difficult to recycle, to incentivize the production and use of more environmentally friendly packaging (Brown et al., 2023). The author points out that all these variables listed above can be defined as the main factors when choosing sustainable packaging. And they have a huge impact on the further development and operation of companies in the future.

Thus, sustainable packaging is packaging that is defined as packaging that (Kachook, 2024) uses SMART design; promotes the use of recycled and/or sustainably sourced materials, renewable raw materials; are intended for reuse, recycling or compostability and are labelled with appropriate instructions for use.

Companies working on sustainable packaging should also work to ensure that their product bundles the system: works with reuse and refill models; investing in the growth of recycling and composting infrastructure.

It is also important to remember that not all recyclable packaging is sustainable packaging and vice versa, because currently packaging is actively promoted as sustainable; however, they neither have been tested for the reaction of the added materials to recycling, nor for being recyclable in general.

Such situation analysis and considerations have set the aim of this research to find out what parameters could be used to characterize sustainable packaging and identifies how to recognize it, as well as authors of this study offer original definition of sustainable packaging. Specific objectives of this study were to identify main circular economy principles in packaging and develop circulation model of packaging.

Materials and Methods

In this research, the authors applied the monographic method and secondary data analysis to explore the concept of sustainable packaging. The study was structured in the following stages: (1) a systematic literature review to identify key characteristics of sustainable packaging; and (2) the development of a classification framework and articulation of the authors' original definition of sustainable packaging.

This study provides a conceptual foundation for further research on sustainability-related issues in packaging. The monographic method facilitated a comprehensive examination of primary literature sources. Relevant publications were identified based on a set of defined keywords and a specific publication period. The literature was sourced from scientific databases such as ScienceDirect, ResearchGate, the Ellen MacArthur Foundation, EU regulatory documentation, and other relevant repositories, using search terms: 'sustainable packaging', 'sustainable food packaging', 'circular economy', and 'sustainability'.

The collected publications were subsequently analyzed to synthesize current findings and investigate the interrelationships between various factors and sustainable packaging indicators. The literature analysis was conducted during the time frame of 2021 to 2025.

Results and Discussion

Circular economy principles in packaging

British economist Kate Raworth (Raworth, 2017) states that it is necessary to take nature as a model (seeing life cycle processes), measuring instrument (finding out ecological standards to move towards a sustainable life) and mentor (learning from its 3.8 billion years of experiments).

Sustainable packaging, similar to the concepts of circular economy and sustainability, lacks a definite and complete definition. Sustainable packaging refers to the design, manufacture, the use of packaging materials and systems that reduce environmental impact, conserve resources and promote social responsibility throughout the product's life cycle. Sustainable packaging aims to reduce the impact of packaging on the environment, taking into account factors such as material extraction, energy consumption, waste generation and disposal or recycling.

Summarizing latest understandings (Kachook, 2024; World Packaging Organization, 2023; Herbes et al., 2020) criteria for sustainable packaging may include:

1. Choice of materials and properties: sustainable packaging is most often associated with renewable, biodegradable, and recyclable materials such as paper, cardboard, glass, metal or bio-plastic packaging. However, different interpretations exist.
2. Resource efficiency: Sustainable packaging aims to optimize the use of materials and reduce resource consumption through reduced weight, source reduction and efficient packaging design. This helps the generation of waste throughout the life cycle of the packaging.
3. Recyclability and reuse (circularity): Packaging should be designed for easy recycling or reuse to reduce the amount of waste sent to landfills. This includes the use of materials that are widely accepted by refineries and the development of packaging structures that are suitable for existing recycling processes. The material must be clearly marked on the packaging to facilitate sorting.
4. Biodegradability and compostability: Sustainable packaging can contain biodegradable or compostable materials that break down naturally in the environment, reducing the impact of packaging waste on ecosystems. However, it is important to ensure that biodegradable materials are properly managed to avoid contaminating recycling streams. Also, there must be confidence that they will not negatively affect people's health.
5. Performance and Functionality; Life Cycle Assessment (LCA): Sustainable packaging considers the environmental impact of packaging materials and systems throughout their life cycle, from raw material extraction and production to distribution, use and end-

of-life disposal. Life cycle assessment (LCA) methodologies help assess overall environmental impact and inform decision-making.

1. Design and structure. Packaging colour is one of the most important packaging features that determines product purchasing decisions, as it attracts attention and can also signal naturalness and sustainability.
2. Social and Environmental responsibility: sustainable packaging takes into account social factors such as worker safety, labour rights and impact on society. Packaging must be produced under fair working conditions, support the local economy and make a positive contribution to social well-being. Packaging manufacturing processes must reduce energy consumption and greenhouse gas emissions through energy-efficient technologies, renewable energy sources, and efficient transportation and distribution practices.
3. Innovation, communications and continuous improvement: Sustainable packaging encourages innovation and continuous improvement in packaging design, materials and processes. This includes investing in research and development to identify new technologies, materials and approaches that further improve the sustainability of packaging solutions.
4. Expenses and economic factors. For example, transportation and location - sustainable packaging must correspond to the shortest possible transport distance from the packaging manufacturer to the customer; packaging must be low-cost product and easily to be obtained.
5. Health and safety: Packaging must protect food and must not increase health problems.

Following these criteria, sustainable packaging aims to reduce environmental impact, save resources and promote responsible consumption and production practices in the packaging industry.

Packaging and its circulation model

Packaging is considered one of the most important activities in the food supply chain. Although it plays a vital role in both supply chain management and the manufacturing industry, the knowledge base for the implementation of extended producer responsibility for packaging is largely ignored and inadequate. Thus, it is important to identify and analyze the challenges of circular food packaging in relation to food waste reduction and a sustainable food supply chain (Ada et al., 2023). Challenges for circular food packaging are Circular resources utilization.

Food packaging plays a critical role in terms of sustainability in the global food distribution system. The packaging material depends on the type of product to be packaged, its chemical and physical properties, the desired packaging life, customer preferences, costs, etc.

The circular economy paradigm is considered a viable solution to create a cyclical use of packaging materials to preserve their value in the long term. The packaging industry can use circular economy concepts (Zhang et al., 2022) and packaging is seen as an essential element of sustainable food consumption and a great way to reduce food waste, keeping food fit for human consumption and also viable reducing the carbon footprint (Guillard et al., 2018).

Plastic packaging competes with paper packaging. These two materials, the most widely used in the packaging industry, will dominate the future due to their sustainability features. Defining the structure that underpins packaging involves serving the sustainability philosophy of packaging produced using sustainable materials, as consumers increasingly demand circular products and solutions. Therefore, integrating recycled materials into packaging products in chemical processes will also increase recyclability level. It is therefore necessary to promote the circular economy by promoting energy and water efficiency and use more sustainable packaging solutions.

Indicators of importance for customers' wishes for food packaging - the criterion with the highest degree of importance was determined as 'Product identification' (Kazancoglu et al., 2023).

Plastic packaging has encouraged companies to export their products to different countries, and packaging has also helped to maintain a longer shelf life of the product (Rijal, 2019).

It is important to take into account that the circular economy also plays an important role in this process. It is a concept that was developed in 1989, trying to preserve the value of products, their parts and materials as much as possible (Pearce & Turner, 1989). The key to the circular economy is transparency in almost all processes. The key to the Butterfly economy, on the other hand, is to consider all materials as belonging to one of two nutrient cycles: either biological nutrients, such as soil, plants, and animals, or technical nutrients, such as plastics, synthetics, and metals. Materials are never 'used up' and thrown away, but are utilized repeatedly through cycles of reuse and renewal (Raworth, 2017).

The circulation model of sustainable packaging is closely related to the circulation economy model. It is depicted differently in various studies and literature sources, taking into account the understanding of sustainability of each involved party and its need to develop it further in a specific direction.

The model of sustainable packaging already combines several important factors. The Dutch institute offers a 5-perspective KIDV model (Netherlands Institute for sustainable Packaging, 2022). This model depicts 5 main factors influencing packaging, starting from raw materials, packaging materials, the packaged product, which goes on to be consumed, and finally goes to waste or recycling. Such a model is clearly understandable, but very simple and incomplete, as it does not show all the involved circulation factors. Therefore, the original model is supplemented with a packaging system, process and logistics.

When planning a sustainable combination of products and packaging, it is important to consider the various components of the packaging process, because in

addition to the material itself, sustainability is affected by the packaging process. In this model, the impact of logistics on the circulation process is already more widely revealed, which shows that it is also possible to evaluate the principles of sustainability in this activity and implement them in order to promote a more efficient circulation system.

Inbound logistics is explained by package delivery. In this process, it is important to evaluate how the package is delivered, including the type of transport packaging, whether returnable containers are used, and if the cargo assembly is adequately planned.

Next, the product is packed in a package and sent to the packaging system, which further transfers it to external logistics, which delivers the product to sales points and to manufacturers or customers. It should be emphasized that when developing packaging materials, the main focus is often on only part of the packaging chain (indicated by green arrows). This part of the chain goes from the production of the material to the moment when the packaging material is disposed of. For organizations aiming to make their packaging materials more sustainable, this is the most knowledgeable part of the chain. Corporations often work well with suppliers of their packaging materials and with buyers and retailers responsible for sales. However, state institutions must also be involved in this process, which can further regulate the end-of-cycle processes - waste management. These processes can only be optimized when all involved members of the cycle cooperate.

Although the goal of sustainable packaging is to remain in the circulation cycle as long as possible and to leave something unusable as little as possible, waste management is inevitable and the final phase of the cycle, yet one of the most important is waste sorting flow.

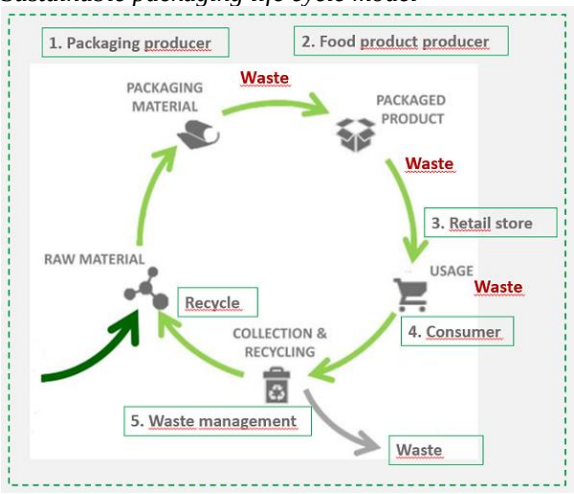
Considering the proposed cycle for sustainable packaging, the authors present a sustainable packaging cycle model. This model identifies interested parties and internal customers, while also highlighting the stages of waste generation within the various phases of the circular economy. The authors emphasize that this ultimately moves back to the manufacturer, who then uses these recycled or renewed packages for his products ‘Figure 1’.

Also at this stage, waste occurs, both defective products and surplus materials, when adjusting production systems and lines. Various incidents are possible during the delivery process, where goods and packages are also damaged, similarly it can also happen in retail stores. A relatively large producer of waste is the final consumer, as not only packaging risks can arise at this stage, but also food risks. Additionally, the final consumer may not be aware of the sorting options, thus sending the waste to disposal instead of recycling.

The circular economy is based on 3 basic principles. These principles are defined differently in different sources - environmental benefits, economic benefits and business benefits (Rijal, 2019) or developed waste management, preserved used products and materials, restored natural systems (Ellen Macarthur Foundation, 2024).

Figure 1

Sustainable packaging life cycle model



Considering the above, it is important to increasingly choose sustainable and clean packaging. Kate Raworth (Raworth, 2017) explains that in a degenerative industrial economy, value is monetary and is created in the pursuit of ever-lower and ever-higher product sales: the typical result has been an intensive flow of materials. In a regenerative economy, this material is transformed into a circular flow, but the real transformation comes from a new understanding of value. In essence, this means that it is necessary to focus and evaluate the roundness of the packaging when choosing products.

Packaging technology trends

Packaging is divided into short-term product storage and retail, and long-term product storage (Payne et al., 1998). Preservation technologies such as vacuum packaging or modified atmosphere packaging are increasingly being applied to product distribution and retailing to extend shelf life. The purpose of packaging is to maintain the quality and safety of the product packaged in it from the time it is manufactured until the consumer starts using it. In addition to protecting the product, the packaging should improve product sales and be environmentally friendly (Bhat Z. F. & Bhat H., 2011).

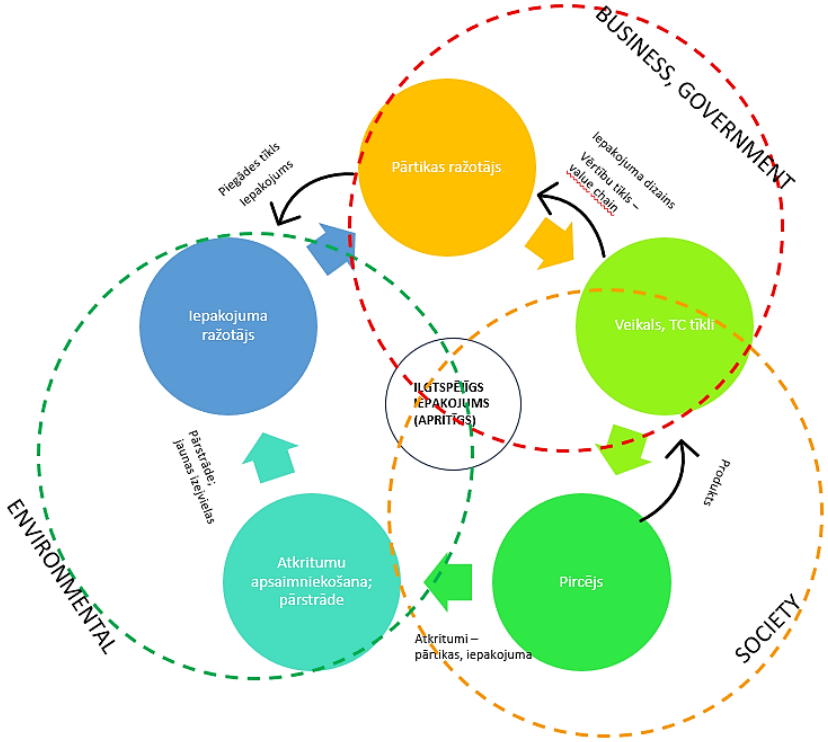
The functions of the food packaging system can be divided into four areas (Bhat Z. F. & Bhat H., 2011):

- limitation (product packaging, separation);
- information (marketing and corporate communication);
- convenience (feature of packaging convenience);
- and protection (the most important function of packaging, protecting the product from microorganisms, rodents, dust, external contaminants, moisture, light and oxygen).

Fake sustainable packaging is a current problem that is developing in the world right now. Therefore, when

choosing sustainable packaging, the following essential criteria must be taken into account:
1. Material source – plastic or bio-degradable packaging, which itself degrades in the environment over the years; mono material packaging that can be recycled later and whether the packaging has already been recycled;
2. The production process – how environmentally friendly it is and what resources are consumed; transparent - less paint is used, and it is much easier to recycle such packaging;
3. Product quality and shelf life;
4. Recyclability of packaging;
5. Logistics and delivery network;
6. The manufacturer's attitude towards a sustainable environment.
It is essential to find a packaging design that satisfies consumers, sales channels, supply networks, manufacturers, and waste managers. This proves that all food packaging is connected to both pillars of sustainability and the cycle of the circular economy. Therefore, the author has created and developed her own model, which explains the connection of packaging design with other factors, see 'Figure 2'.
The model shows the interaction of sustainable packaging with the circular economy and sustainability development goals, proving that not only packaging, but also sustainability and the circular economy are closely related. The black lines indicate the reverse cycle action, starting from the consumer, further to the retail networks, which affects the food producer and the packaging designer, explaining the author's assertion in the previous chapters that the main creators of the packaging design are consumers and retailers, further setting their demands on the food manufacturers and for packaging manufacturers.
Finding a balance in the amount of packaging is important, as underpackaged foods can compromise product safety, while overpacking creates a huge environmental footprint due to waste (Boye & Arcand, 2013). A balance must be maintained between energy and material costs, environmental impact, awareness, pollution, and food protection (Marsh & Bugusu, 2007).

Figure 2
Sustainable packaging model



Thus, greener options that use recyclable materials should be used without losing the integrity of the outer packaging. A three-dimensional analysis of circular food packaging encompasses circular economy principles, materials and food packaging subsectors. Bold, innovative thinking, understanding the entire supply chain, and sound analysis and design are critical to the development of sustainable packaging (Kieselbach, 2020).

Conclusions
1. According to the authors' findings, concepts such as sustainability, sustainable packaging, and individuals' attitudes toward the future should be viewed as dynamic and interrelated processes, continuously evolving in response to climatic and ecological changes. Only a systematically planned and well-oriented approach to packaging production, material

selection, and end-of-life recycling can ensure a positive environmental impact for future generations.

2. The relevance of sustainable packaging is increasing globally. A growing number of packaging producers, food manufacturers, retailers, and consumers are recognizing the environmental implications of packaging and prioritizing sustainability in their decisions. This shift underscores the necessity to establish clear guidelines that define appropriate material usage for different product categories, specify recycling requirements, and promote collaborative innovation among packaging designers and suppliers. The goal is to develop packaging solutions that comply with sustainable packaging criteria.

3. It is essential to recognize that no single packaging material - whether plastic, glass, metal, cardboard, or paper - can independently fulfil all the requirements of sustainable packaging. Each material type offers specific advantages and limitations, which are context-dependent and influenced by regional policies, product requirements, and supply chain factors.

4. Building on these insights, the author proposes a comprehensive definition of sustainable packaging. It refers to the use of materials and designs that prioritize environmental responsibility across the entire packaging lifecycle. Core components of this definition include ecological sustainability, recyclability, food protection, and alignment with circular economy principles.

5. Sustainable packaging entails resource utilization that satisfies present needs while safeguarding the needs of future generations. This involves assessing environmental, social, and economic impacts associated with packaging production, use, and disposal. Recyclability plays a central role, focusing on the ability of materials to be collected, processed, and transformed into new packaging or products. Materials such as paper, cardboard, glass, aluminum, and selected plastics are favored for their ease of recycling and lower environmental burden.

6. Equally crucial is the protection of food products, ensuring their safety, quality, and longevity throughout the supply chain. Sustainable packaging solutions must mitigate contamination, spoilage, and mechanical damage, thereby contributing to reduced food waste and supporting broader food security objectives.

7. The concept of the circular economy is fundamental to sustainable packaging. It promotes the design of packaging systems that retain resources in use for as long as possible through reuse, recycling, and composting strategies. By minimizing waste and encouraging resource efficiency, the circular economy helps reduce the environmental footprint of packaging systems.

8. Importantly, sustainable packaging does not solely imply the use of fewer or recyclable materials. Rather, it encompasses the optimization of the entire packaging system from design to disposal to ensure minimal resource consumption and environmental impact.

In conclusion, sustainable packaging represents a comprehensive and systemic approach that integrates environmental responsibility, material recyclability, effective product protection, and circular economy principles. It seeks to balance ecological imperatives with the functional needs of consumers and businesses, offering a viable pathway toward long-term sustainability in the packaging industry.

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