

AESOP4Food Sustainable Food Planning Seminar

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Circular Economy in Food Retail Alternative Food Packaging

1. Research subject and theoretical framework

As population growth, increasing economic activity, and rapid urbanization drive changes in global consumption and production patterns, the result is heightened resource exploitation and exponential waste generation (Schroeder et al., 2019). Consequently, modern systems demand more sustainable solutions. The concept of the circular economy (CE) was initially introduced by British environmental economists Pearce et al. (1990), who posited that the Earth should be viewed as a closed economic system. They built on Boulding's (1966) idea that the interactions between the economy and the environment are circular, not linear. Geissdoerfer et al. (2017) expand on this by explaining that CE represents a new paradigm focused on sustainability and is based on the idea of a regenerative system. Kirchherr et al. (2017) define CE as "an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling, and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks), and macro level (city, region, nation, and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity, and social equity, to the benefit of current and future generations."

In recent years, the CE has attracted interest from the public, companies, and local authorities (Urbinati et al., 2017), who see it as crucial for sustainable development (Kirchherr et al., 2017) and as a strategy to anchor economic activities locally and promote responsible consumption (Bourdin et al., 2023). The CE model has been implemented in a wide variety of fields, including urban food systems (Fassio and Minotti, 2019; Hamam et al., 2021; Lever and Sonnino, 2022), due to the growing unsustainability of modern food systems. In fact, a report issued by the FAO estimated that approximately one-third of global food production is wasted or lost, equating to an annual aggregate of 1.3 billion metric tonnes, and that food systems contribute to nearly one-third of global greenhouse gas (GHG) emissions (FAO, 2011).

In line with the scientific debate surrounding the food circular economy, another emerging concept is the "circular bioeconomy." This concept is promoted by the FAO (e.g., the webinar "Overcoming barriers to building the Circular Bioeconomy," part of the CRFS Knowledge Exchange Series in partnership with RUAF) and other national and international agencies (Hetemäki et al., 2017). The circular bioeconomy paradigm is presented as a mechanism focused on utilizing biological resources from waste streams to create valuable products such as organic fertilizers, bioenergy, and alternative proteins.

The application of CE principles to food packaging is particularly pertinent given the significant environmental impact of traditional packaging materials. The need to develop sustainable packaging solutions is critical in reducing the overall footprint of food systems. Alternative packaging solutions include biodegradable materials, recyclable materials, and innovations that reduce packaging waste. These alternatives aim to mitigate the adverse effects of packaging on the environment by incorporating materials that either decompose naturally or can be reused multiple times within the food chain.

By applying the CE framework to food packaging, the research explores how alternative packaging solutions can contribute to a more sustainable food system. This involves assessing the life cycle of packaging materials, their environmental impact, and their potential for integration into a circular economy. The transition to sustainable packaging not only aligns with environmental goals but also addresses economic and social dimensions by promoting resource efficiency, reducing waste, and enhancing consumer awareness about sustainable practices.

In conclusion, the circular economy and circular bioeconomy frameworks offer a comprehensive approach to addressing the sustainability challenges in the food packaging sector. By focusing on reducing waste, reusing materials, and recycling resources, these frameworks support the development of innovative packaging solutions that can significantly reduce the environmental impact of food systems. The integration of these principles into

food retail can lead to a more sustainable and resilient food supply chain, benefiting both current and future generations

2. Research aims

The aim of this research is to explore and analyse possible alternative solutions for food packaging in the food chain, at the retail level, to reduce the impact of packaging and increase the sustainability of the food chain. The concept of a circular economy involves creating a closed-loop system where resources are reused, recycled, and minimized to reduce waste and environmental impact. However, despite its relative simplicity, achieving circular loops in the food sector remains challenging. The difficulties arise from various factors, particularly the complexities of global food supply chains.

To address these challenges, I worked within the specific dynamics of the Madrid Living Lab. This initiative is based on the premise that shorter food supply chains and more direct relationships between production and consumption could facilitate a shift towards circularity. The Living Lab is envisioned as a collaborative space for generating applied knowledge, involving the cooperative supermarket LA OSA and supported by the International Center for Circular Economy (CIEC) of the Municipality of Madrid.

The primary goal of this research is to enhance circular economy mechanisms within the food retail sector, focusing on reducing both packaging and food waste and promoting the recovery and reuse of packaging materials. This initiative aligns with the interests expressed by the cooperative and its members, some of whom have already attempted to establish a working group on these issues.

To achieve its objectives, the research begins with a central question: How can food packaging be reduced in the food chain from a perspective of circularity and sustainability? Addressing this question requires exploring and analysing alternative solutions for food packaging at the retail level. The goal is to reduce the environmental impact of packaging and enhance the overall sustainability of the food chain. Through this research, the aim is to identify practical and scalable strategies that can be implemented within food retail environments to foster a more sustainable and circular economy.

3. Methodology

The objective of this research is to explore and assess alternative packaging solutions in the food chain, with a focus on sustainability and recent developments. Achieving this objective requires a thorough examination of current packaging methods and materials that contribute to creating a sustainable food system aligned with circular economy principles.

To accomplish this, a comprehensive literature review was conducted using the Scopus search engine. Scopus was chosen for its extensive database of academic papers and publications, which ensures access to a wide range of scientifically relevant contributions. The literature search was guided by specific keywords, including: food, packaging, sustainability, circular economy, circular bioeconomy, biodegradable, food chain, and sustainable food system. These keywords were selected to cover the broad scope of sustainable food packaging and to capture the latest advancements in this field.

The research process began with an in-depth study of the theoretical framework surrounding alternative packaging solutions. This initial phase aimed to build a comprehensive understanding of the existing literature on sustainable packaging within the food chain. By delving into various theoretical perspectives, models, and concepts, the research sought to identify the fundamental principles and criteria that define sustainable packaging solutions. This foundational knowledge was crucial for setting the context and guiding the subsequent phases of the study.

Following the establishment of the theoretical framework, the research moved to a more focused analysis of the state of the art in sustainable packaging. This involved the identification and detailed examination of ten key papers that represent the latest advancements and trends in the field. These papers were selected based on their relevance, contribution to the topic, and the innovative solutions they presented. The selection process ensured that a diverse range of perspectives and approaches to sustainable packaging were considered, providing a holistic view of the current landscape.

Each of the ten key papers was analysed to evaluate their contributions to the field of sustainable food packaging. The analysis aimed to uncover the most promising alternative packaging solutions, assess their feasibility, and understand their potential impact on the food chain. This phase of the research was instrumental in highlighting

both the strengths and limitations of various packaging methods and materials, thereby identifying areas where further innovation and improvement are needed. By integrating the findings from both the theoretical framework and the detailed analysis of key papers, the research aimed to provide a comprehensive assessment of the current state of sustainable food packaging. The insights gained from this literature review form the basis for proposing practical and scalable strategies that can be implemented within food retail environments. These strategies are designed to reduce the environmental impact of packaging and enhance the overall sustainability of the food chain, thereby contributing to the broader goal of fostering a circular economy in the food retail sector.

4. Results

The examination of alternative food packaging innovations reveals a dynamic and promising landscape poised to revolutionize the food industry with a strong emphasis on sustainability. Key advancements, including biodegradable polymers, composites, metals and alloys, nanomaterials, and edible films and coatings, collectively offer multifaceted solutions aimed at minimizing environmental impact and enhancing the sustainability of the food chain.

- Biodegradable polymers have emerged as a significant innovation, largely due to their potential to mitigate the pervasive issue of plastic waste. Derived from renewable resources such as corn starch, potatoes, or sugarcane, these polymers decompose naturally into benign components. This not only reduces landfill waste but also ensures effective protection of food products from environmental factors like moisture and oxygen. The ability of biodegradable polymers to maintain food integrity while being environmentally benign underscores their importance in the quest for sustainable packaging solutions.
- Biomaterials-based recyclable and biodegradable packaging materials, derived from renewable resources like algae, cellulose, or plant-based starches, offer a viable alternative to traditional single-use plastics. These materials are biodegradable and less dependent on fossil fuels, aligning with the principles of a circular economy. Their development and adoption are crucial for reducing waste and the consumption of new resources.
- Composites, which combine various biomaterials, represent another crucial advancement. While they offer robust packaging solutions by leveraging the distinct properties of different materials, their recycling complexity due to material heterogeneity and limited temperature tolerance presents challenges. Despite these limitations, the innovation in composite materials reflects a significant step towards creating more sustainable packaging options that can be tailored to specific needs within the food industry.
- Nanomaterials, including nanocomposites and graphene-based materials, offer enhanced mechanical strength, barrier properties, and thermal stability. Their application in food packaging, such as silver nanoparticles with antibacterial properties, reduces the risk of foodborne infections. However, the potential health and environmental impacts of nanoparticles remain a critical area for further research.
- Edible films and coatings present much potential as an innovative approach to sustainable packaging by offering solutions that can be consumed along with the food, thus eliminating packaging waste. These materials not only preserve and enhance the quality of food products but also extend their shelf life. For instance, strawberries coated with yam starch exhibit reduced deterioration and increased firmness. Similarly, gum arabic and almond gum coatings offer multiple benefits for various fruits. The dual functionality of edible films and coatings—preserving food and reducing waste—demonstrates a significant advancement in sustainable packaging.

The exploration of agro-food waste as a source of bio-based materials for packaging further exemplifies the innovative potential within the industry. Companies like NatureWorks, Corbion, and Futerro are pioneering technologies to utilize greenhouse gases, food waste, and industrial waste streams for packaging solutions.

5. Conclusions and reflections

The journey of researching and implementing alternative packaging for food unveils a varied landscape where innovation meets practicality, and sustainability intertwines with economic feasibility. At its core, this process demands a delicate balance between cost-effectiveness and environmental impact. As researchers delve into materials ranging from biodegradable polymers to recycled alternatives, they navigate a terrain where commercial scalability and cost considerations often dictate feasibility. The quest is not merely about finding eco-friendly substitutes but ensuring they meet stringent safety standards for consumer well-being.

Central to this exploration is the regulatory framework that governs packaging materials. Safety evaluations are crucial checkpoints, ensuring that these alternatives do not compromise food quality or pose health risks. As researchers and policymakers collaborate, a clear need emerges for consistent policies that not only regulate but also promote and incentivize sustainable practices. Such policies are pivotal in fostering a supportive ecosystem where businesses are encouraged to adopt greener solutions. Moreover, the journey highlights the necessity for behavioral change among consumers. Awareness and education play pivotal roles in shaping consumer preferences towards sustainable packaging. Efforts to inform the public about the environmental impact of packaging choices can catalyze shifts in consumer behavior, reinforcing the demand for eco-friendly options and driving market forces towards sustainability.

The implementation of alternative packaging also underscores the importance of multi-actor synergies. Collaboration among academia, industry, and the public sector proves indispensable in advancing research, scaling up innovations, and navigating regulatory landscapes. Academia contributes through pioneering research and development of new materials, while industry brings practical insights into scalability and market dynamics. The public sector, encompassing regulatory bodies and policymakers, provides the necessary frameworks and incentives to drive systemic change. Successful endeavors in alternative packaging exemplify how these synergies can yield transformative results. From biodegradable plastics derived from agricultural waste to innovative packaging designs that reduce material usage, each advancement is a testament to collaborative efforts across sectors. These efforts not only address immediate environmental concerns but also pave the way for a more sustainable future.

In conclusion, reflection on the research process and implementation of alternative food packaging reveals a dynamic interplay of innovation, regulation, and societal change. It underscores the imperative of balancing economic viability with environmental responsibility, navigating regulatory landscapes, and fostering collaborative synergies across academia, industry, and the public sector. As stakeholders continue to forge ahead, driven by the shared goal of sustainability, the evolution towards greener packaging solutions promises a brighter, more resilient future for food packaging and beyond.

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