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Food packaging business models as drivers for sustainability in the food packaging industry

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The global food packaging industry faces severe environmental challenges due to its reliance on plastics and the growing demand for convenience. In Europe, food packaging alone accounts for 40.5% of all plastic production, yet only 35% of this waste is recycled. The purpose of this study is to examine business models, technological innovations (like AI, IoT, and blockchain) and the relation with customers to support the transition to a circular economy in food packaging. The research focuses on models such as Safe and Sustainable by Design (SSbD) and reusable and returnable packaging systems, evaluating their potential to minimize environmental impact. A key aspect of the investigation is consumer behavior. While consumers express a preference for sustainable options, actual purchasing decisions often prioritize cost and convenience. The study explores how emerging technologies are transforming packaging design by enhancing product safety and improving supply chain transparency. Additionally, regulatory frameworks, particularly within the European Union, such as the Single-Use Plastics Directive (SUPD) and the Circular Economy Action Plan (CEAP), are driving industry-wide changes toward sustainability. However, disparities in adoption and regulatory compliance on a global scale present significant challenges to implementation. The outcome of this study is a set of strategic recommendations aimed at policymakers, industry leaders, and researchers. These recommendations emphasize the importance of harmonizing global regulations to support sustainable packaging practices, increasing investment in innovation and infrastructure, and balancing the relation between industry and consumers to bridge the gap between intention or preferences and action or behavior.

KEYWORDS

sustainable packaging, circular economy, consumer behavior, food packaging business models, environmental sustainability, regulatory compliance, emerging technologies

1 Introduction

The rapid expansion of industrialization and consumerism has led to a significant increase in plastic production, with food packaging being one of the largest contributors to plastic waste (Geyer et al., 2017). According to the Ellen MacArthur Foundation, approximately 40% of global plastic production is used for packaging, with a substantial portion dedicated to food products (The New Plastics Economy Rethinking the Future of Plastics, 2024). This growing dependence on plastic for food safety and convenience has had profound environmental consequences, particularly in the form of plastic pollution.

Packaging serves as a critical interface between food products and consumers, encompassing aspects of product safety, preservation, branding, and environmental impact (Yan et al., 2022). Plastic pollution has become a global crisis, with plastic debris infiltrating oceans, rivers, and even the atmosphere. The United Nations Environment Programme (UNEP) reported that over 8 million metric tons of plastic enter the ocean each year, with an estimated 150 million metric tons of plastic waste currently circulating in marine environments (Un Environment, 2019). This pervasive pollution impacts marine life, human health, and contributes to climate change (Rochman et al., 2016).

In the European context, efforts are being made to reduce plastic waste, but challenges persist. As Europe shifts to a bio-based circular economy, a plethora of new packaging restrictions have emerged. The European Union has implemented various directives aimed at reducing single-use plastics, such as the Single-Use Plastics Directive (SUPD), which came into effect in 2021 (European Parliament and Council, 2019). Policies and laws on packaging seek to improve packaging effectiveness, sustainability, efficient usage, end-of-life (reuse and recycling), and innovative business practices in EU food systems through revolutionary strategies shaped for the ecological transition required by the European Green Deal and EU 2030 climate target plan. Despite these efforts, Europe remains a significant contributor to plastic pollution, with over 30% of its plastic waste being landfilled and only about 42% being recycled (Eurostat, 2024). This indicates a considerable amount of plastic waste that could end up in the environment.

Plastic pollution is characterized by a vast range of figures that illustrate its scope and impact. A study estimated that the global production of plastics reached 368 million metric tons in 2019, with approximately half of it being discarded after a single use (Lebreton and Andrady, 2019). Furthermore, only about 9% of plastic is recycled globally, indicating a massive accumulation of plastic waste (Geyer et al., 2017). In addition, the World Economic Forum has predicted that by 2050, the weight of plastic in the oceans could surpass that of fish (World Economic Forum, 2016). Research has revealed that microplastics are now found in every corner of the world's oceans, from the deepest trenches to the Arctic Sea ice (Cole et al., 2011).

The ingestion of microplastics by marine organisms poses significant risks. Studies show that microplastics can accumulate in the tissues of marine organisms, leading to potential toxicity and disruption of biological processes (GESAMP, 2015). These microplastics can also enter the human food chain through seafood consumption, raising concerns about their impact on human health (Un Environment, 2019).

At the centre of all these issues are business models and value chains since, pondered by the different weight of actors, they are the hinge between business, consumers demands and regulations. Consequently, understanding the various business strategies and innovations employed within the packaging sector is essential for optimizing supply chain management, meeting regulatory requirements, addressing consumer preferences, and achieving strategic business objectives (Beltran et al., 2021).

In this context, business strategies become essential tools for adapting to regulations while guiding companies involved in the food packaging value chain toward optimal performance. The objective of business strategies in the food sector is to improve the competitive position of a company's products and services within a certain industry or market segment (consumers) (Phelan et al., 2022). An improved business strategy can also help a company to develop new ideas and to test different approaches for breaking into new and existing markets. This will contribute to become market leaders by putting long-term plans and goals into action.

In order to survive and adapt to environmental restrictions as well as economic fluctuations, several companies from the food sector have been forced to re-evaluate what contributes to their competitive edge as a result of the growing internationalisation and globalisation of business. This review is part of the EU funded initiative MAGNO (CONQUERING NEW STRATEGIES TO PREVENT AND REDUCE PACKAGING POLLUTION). Within this framework, MAGNO needs to consider all the circular business paths existing in the food system packaging sector to ponder on best practices, innovative business approaches and unique value propositions. All together could reignite the environmental value of the overall value chain as it materialized in this review. For doing so, it reveals necessary to review the state of play on business approaches applied to the packaging sector in the food systems to update on current scenarios and current trends for plastic packaging. This is a pivotal task for the success and outcomes of any project aimed at enhancing sustainability, efficiency, and competitiveness in the food industry.

This review contributes to the MAGNO project with knowledge that enables informed decision-making and the formulation of effective strategies for product development, marketing, and distribution. Moreover, this review would facilitate the identification of opportunities for innovation, collaboration, and sustainable practices that can drive positive outcomes for both businesses, consumers and the broader food system (Cruz et al., 2024) around the MAGNO results and beyond. Finally, the overview will also contribute to a better understanding on how these business approaches in the packaging sector have an impact on consumers attitudes and behavior so new dynamics can be developed.

1.1 Contextualization of the importance of food packaging in the supply chain, from packers to consumers

In the food packaging the supply chain perspective plays a critical role ensuring the safety, quality, and efficiency of food products. It serves multiple functions, such as protecting food from contamination, facilitating transportation, and providing necessary information to consumers. The strategic value of packaging is evident in its ability to improve supply chain effectiveness and efficiency through practices like packaging postponement, which reduces obsolescence and enhances logistics efficiency by enabling bulk transport with higher fill rates (Pålsson and Sandberg, 2021).

The innovation in food packaging is driven by the need to balance different stakeholder requirements, including environmental, economic, and social considerations. For instance, sustainable packaging innovations, such as the use of bioplastics, necessitate changes at the firm, network, and macro levels to ensure successful diffusion and adoption across the value chain (Ruippo et al., 2023; Rokka and Uusitalo, 2008).This involves collaboration among different actors within the ecosystem, from manufacturers to retailers, to address the challenges and opportunities presented by new packaging materials and technologies.

Moreover, consumer perceptions play a significant role in shaping food packaging innovations. Consumers increasingly prioritize environmental sustainability alongside traditional factors like price and quality (Camilleri et al., 2023). However, there is often a gap between consumer preferences and their understanding of sustainable packaging, highlighting the need for better communication and education about the environmental impact of packaging choices (Ruippo et al., 2023).

Overall, the importance of food packaging in the supply chain is multifaceted. It ensures product protection, enhances logistics efficiency, supports sustainability goals, and meets consumer expectations. The ongoing innovation in packaging materials and designs is crucial for addressing global challenges such as food waste and environmental sustainability.

1.2 Theoretical framework

The transition toward sustainable food packaging business models is shaped by technological innovations, regulatory frameworks, and evolving consumer behavior. Understanding how these elements interact within the food packaging value chain is critical for designing policies and innovations that support sustainability and market competitiveness, with business models as critical enabler.

Specifically, sustainable business models in the food packaging industry are increasingly guided by holistic frameworks that integrate environmental, social, and economic considerations. The Triple Bottom Line (TBL) (Elkington, 1997), emphasizes the need for businesses to balance economic viability, social equity, and environmental responsibility. This approach is particularly relevant in food packaging, where reducing waste and optimizing resource use are key sustainability objectives (Moshood et al., 2022). Complementing TBL, the Circular Economy (CE) framework shifts away from the traditional linear "take-make-dispose" model, advocating for resource efficiency, closed-loop systems, and sustainable materials (Elroi et al., 2023; Geissdoerfer et al., 2017). Circular business models, such as Reusable and Returnable Packaging Systems (RRPS), align with CE principles by reducing material waste and extending product lifecycles (Geissdoerfer et al., 2020). Additionally, Life Cycle Assessment (LCA) is widely applied to assess the environmental impacts of packaging materials from production to disposal (Klüppel, 2005). LCA-based analyses support decision-making in sustainable packaging design by identifying opportunities to minimize carbon footprints and energy consumption (Xu et al., 2025).

Regulatory frameworks, such as the EU Circular Economy Action Plan (CEAP) and the Single-Use Plastics Directive (SUPD), reinforce these sustainability paradigms by setting stringent guidelines on material use and recycling whilst at the same time helps Safe and Sustainable by Design (SSbD) principles in gaining prominence in the industry as companies seek to align with these regulations (European Commission, 2024a).

These regulations also promote biodegradable, compostable, and reusable packaging solutions while encouraging investment in innovative business models as well as in advancements in blockchain, AI, and IoT technologies, transforming packaging by enhancing transparency, supply chain efficiency, and waste reduction (Boz et al., 2020; Khan et al., 2021).

Consumer behavior studies indicate a rising preference for sustainable packaging; however, there remains a gap between consumers' stated preferences and their purchasing decisions, which are still influenced by cost and convenience (Brennan et al., 2023; Herbes et al., 2018). This discrepancy highlights the importance of industry-driven initiatives that integrate sustainability, digitalization, and consumer engagement in order to create a viable transition toward eco-friendly packaging business models (Boz et al., 2020).

Understanding how these crosscutting domains frameworks interact with business models is essential for fostering a transition toward sustainable packaging in the food sector.

2 Materials and methods

The primary goal of this review is to identify and summarize the business models research associated with the food packaging sector and, among these, highlight those that contribute to greater sustainability/circularity and the relevant aspects associated with these models, particularly considering the relevant actors in the value chain to contribute to reinforce the transtion toward sustainable policy and research discussions on business models.

It is important to contextualize this review with one of the main goals of the project, this is Specific Objective (SO) number 2 of MAGNO, aimed to *develop and validate a series of innovative business strategies.* Considering this context, these goals will be delivered by providing three blocks of analysis: Sustainable Business Practices (Thapliyal et al., 2024), Consumer Preferences (European Commission, 2023a), and Innovation in food packaging (Branca et al., 2024).

2.1 Methodological approach

The methodology approach followed in this study was based on reviewing recently published literature addressing business strategies in food packaging, distinguishing the following phases (Versino et al., 2023; Morashti et al., 2022) and criteria as stated in Table 1:

i Selection of information sources, defining explicit criteria for inclusion and exclusion.
ii Searching the available literature using defined field related search terms
iii Analyzing the collected literature
iv Synthesizing the collected literature to extract results.

Based on a preliminary search using this methodology, the total number of articles reached roughly 1,100 articles and after manual screening for relevance and exclusion of outdated or overly technical studies, the final number of articles was reduced to nearly 200 and were selected prioritizing (Boz et al., 2020):

2.2 Methods for synthesizing and analyzing information from selected literature

Once the relevant studies are identified and prioritized, the process implies two steps involving (a) extracting the necessary data and (b) synthesizing the information from the identified literature.

TABLE 1 Scope, inclusion and exclusion criteria.

Scope criteria	
Geographic scope:	Food packaging sector of the EU food systems, encompassing member states and regulatory frameworks established by EU institutions and agencies.
Industry sectors scope	Food packaging value chain, such as food manufacturers, packaging suppliers, retailers, and logistics companies operating within the EU market.
Time frame	From January 2008 to Nov 2024 both included to ensure relevance and currency of insights, covering advancements, trends, and challenges with a sufficient consistency.
Methodological approach	The review will employ a narrative literature review methodology, including database searches, keyword analysis, and selection criteria based on relevance, credibility, and methodological rigor of the retrieved sources to reinforce its value and avoid biases (see section 3).
Inclusion criteria	
Language	English
Type of studies	Research papers and articles, peer reviewed. Including primary and secondary research (reviews, meta-analyses).
Grey literature	Dissertations, research and committee reports, policy papers, proceedings, government reports, reports from government agencies, non-governmental organizations (NGOs), and industry white papers, that are not peer-reviewed but are useful to provide unique insights and data not found in peer-reviewed literature, reduce publication bias and increase reviews' comprehensiveness and timeliness fostering a balanced picture of available evidence (European Commission, 2024a).
Topics	Studies on consumer perceptions, preferences, and behaviors regarding food packaging
	On business strategies and approaches specifically within the packaging sector of food system.
	On innovations, trends, challenges, and opportunities related to food packaging.
	Studies exploring sustainability aspects such as recyclability, biodegradability, and eco-friendly packaging material.
	Case studies highlighting successful business models, partnerships, or collaborations within the food packaging industry.
	Discussing the role of technology, supply chain management, and logistics in enhancing packaging efficiency and effectiveness.
Exclusión criteria	
Business	Literature not directly related to business approaches in the packaging sector of the food system.
Technicality	Publications focusing solely on technical aspects of packaging design or engineering without considering business implications.
Food packaging:	Articles unrelated to the food industry or packaging sector.
Time frame	Outdated or irrelevant studies that do not contribute to current understanding or discourse on the topic.
Credibility	Publications from sources lacking credibility or fundamental trust (Brennan et al., 2023).

Concerning the extraction of key information from each source, the fields analyzed included relevant aspects such as authors, publication date, study objectives, methodology, findings, and conclusions. This key information will enable to frame the data on thematic areas such as business strategies, innovations, sustainability, consumer behavior, and technology in food packaging aids in organizing the information.

The synthesis process involves integrating and summarizing the publication data to identify existing findings, trends and gaps in the literature. Grouping the studies into thematic categories and summarizing the findings for each theme helps in understanding the various aspects of food packaging and the different business approaches being adopted. Comparing and contrasting findings from different studies to identify commonalities and differences is also crucial (Tables 2–10).

3 Results and discussions: on business models

3.1 Food packaging sector overview

The global food packaging market is a rapidly growing sector since in a moment of innovation the global markets are abandoning traditional food packaging and are moving toward more innovative solutions. It is valued at approximately USD 362.9 billion in 2022, with an expected compound annual growth rate (CAGR) of 5.7% from 2023 to 2030. The demand for packaged food is driven by changing consumer habits, increased urbanization, and the growing need for convenient and longer-lasting food products. Key packaging materials include plastics, paper, and bioplastics, each contributing to the market's expansion in different ways (Grand View Research, 2024).

Europe, in particular, is a significant player in the global food packaging industry, characterized by stringent regulations and a strong focus on sustainability which the EU uses not only to protect their citizens but also to shape supply chains through trade agreements with third countries. The European Green Deal and the Circular Economy Action Plan emphasize reducing plastic waste and promoting recyclable materials. This regulatory environment fosters innovation in sustainable packaging solutions, such as biodegradable and compostable materials, aiming to reduce the environmental impact of food packaging (European Commission, 2024b) policy that influences the global value chain since the EU imposes its negotiation power and consumers purchase potential. Each actor plays a crucial role in the value chain. It can be depicted as follows.

TABLE 2 Results priorities.

Scientific value	
Relevance	Sources are evaluated for their direct relevance to business approaches and strategies in the food packaging sector.
Credibility and academic rigor	Peer-reviewed articles, books from reputable publishers, and industry reports from well-known firms are prioritized to ensure the credibility of the information.
Contribution to current understanding	Recent publications are prioritized to ensure the inclusion of the latest developments, trends, and insights in the field, and contribution to current discourses.

Credibility and publication type	
Peer-reviewed articles and reviews	These sources are considered highly reliable and provide up-to-date insights into business strategies, innovations, sustainability, consumer behavior, and technology in food packaging.
Industry reports	These reports often contain valuable information that complements academic research by offering real-world examples and case studies.
Case studies	On successful business models, partnerships, or collaborations within the food packaging industry are selected to illustrate practical applications of theoretical concepts
Policy papers	Often published as part of R&D projects can contribute to understanding policy making decisions and the role of business in environmental policies.

TABLE 3 Food packaging value chain actors analysis.

Key actors	Roles	Challenges	Opportunities
Raw material suppliers	Provide materials like plastics, paper, and bioplastics used in packaging.	Ensuring sustainable raw materials.	Innovations in sustainable material sourcing.
Packaging manufacturers	Develop and produce packaging solutions compliant with regulatory standards.	Adapting to new regulations and material costs.	Developing smart and recyclable packaging.
Food producers	Select packaging that ensures safety, quality, and sustainability.	Balancing cost with sustainable practices.	Adopting advanced and biodegradable packaging.
Retailers	Influence packaging through demands for shelf-life extension and appeal.	Meeting consumer preferences for sustainability.	Promoting eco-friendly and reusable packaging.
Consumers	Drive demand for sustainable and convenient packaging through choices.	Limited access to sustainable options.	Increasing awareness and preference for eco-friendly solutions.

TABLE 4 Challenges for the food packaging value chain actors.

Challenges	Target	Obstacles	Opportunities
Environmental impact	Reducing plastic waste and pollution.	Traditional non-biodegradable plastics contribute to pollution.	Bioplastics, compostable materials, and circular economy models.
Regulatory compliance	Ensure adherence to packaging and waste regulations.	Frequent updates to laws and standards.	Driving innovation to meet compliance while improving sustainability.
Cost management	Manage costs of sustainable packaging solutions.	High expenses for developing and implementing solutions.	Affordable innovation in materials and processes.
Supply chain disruptions	Ensure material availability despite disruptions.	COVID-19 and global logistics challenges.	Strengthening local sourcing and resilience strategies.

Effective collaboration among these stakeholders is essential for developing innovative packaging solutions that meet challenging market demands and regulatory requirements (Keränen et al., 2021).

Currently, the food packaging sector faces several challenges related to the aforementioned. These challenges can be grouped into four categories, including (Sand, 2022).

Despite these challenges, the food packaging sector also presents numerous opportunities for growth and innovation that can be seized by market actors that can be subject of promotion on behalf the regulators.

At a glance, this is a picture of the food packaging sector as a dynamic and essential component of the global food supply chain involving a complex network of stakeholders with a number of challenges, particularly related to sustainability and regulatory compliance. However, it also offers significant opportunities for growth and innovation, driven by advances in materials science and technology, as well as increasing consumer demand for sustainable solutions. In the following chapters we expect to offer a more detailed view of all those perspectives (Figures 1–4).

TABLE 5 Opportunities for the food packaging value chain actors.

Opportunities	Defined as	Obstacle	Benefit
Sustainable materials	The development and adoption of biodegradable and compostable materials to promote environmental sustainability.	High production costs and limited scalability of biodegradable and compostable materials compared to conventional plastics.	Reduces environmental impact and aligns with consumer preferences for eco-friendly solutions.
Smart packaging	Use technologies to enhance safety and shelf-life.	Integrating active and intelligent systems can be costly.	Providing real-time quality and condition data to consumers.
Circular economy	Adoption of principles that focus on recycling and reusing packaging materials to minimize waste and improve sustainability.	Establishing efficient systems for recycling and reuse can be resource-intensive and requires significant collaboration across the supply chain.	Reduces waste, conserves resources, and supports long-term environmental goals.
Consumer awareness	Growing consumer demand for sustainable packaging solutions driven by increased awareness of environmental issues.	Educating and convincing a wider audience of the benefits of sustainable packaging while overcoming the perception of higher costs.	Encourages industry innovation and accelerates the adoption of eco-friendly packaging practices (Drago et al., 2020).

TABLE 6 Linear food packaging business models.

Business model	Short definition
Single-use packaging	Food Packaging designed for one-time use, typically disposable.
Bulk packaging	Large-scale packaging for transportation, discarded after one use.
Non-recyclable packaging	Packaging materials not designed for recycling, e.g., mixed plastics or laminates.
Brand-specific packaging	Custom packaging unique to a brand, often hard to recycle.
Disposable packaging	Single-use items like cutlery, plates, and straws.

3.2 Analysis of the prevailing business models in the food packaging sector

The choice of business model significantly shapes this value chain and the impact in the world at many levels, influencing not only the economic outcomes but also the environmental and social impacts associated with it.

It ranges from traditional linear (Geyer et al., 2017; Ocean Conservancy, 2019) approaches to more innovative circular economy practices (European Commission, 2024a). Understanding the economic impacts, cost–benefit analyses, investment trends, and successful case studies of these business models is crucial for stakeholders across the food packaging value chain to find inspiration, mutual consent and operation according to the best environmental principles. A summary can be seen along the sections where models are break down and comparable for a better understanding. This analysis explores the various business models, highlighting their implications and potential for fostering a sustainable and economically viable packaging industry.

3.2.1 Linear food packaging business models

In a linear business model, food packaging follows a 'take, make, dispose' approach. Resources are extracted to produce packaging, used once, and discarded as waste. These models rely heavily on finite materials, contributing to environmental challenges like pollution and landfill overflow. The ones identified in this review are.

3.2.1.1 Single-use packaging

This model involves packaging designed for one-time use, often made from plastics, aluminum, or other disposable materials. This approach has been criticized for contributing to environmental pollution due to its disposable nature (Geyer et al., 2017).

On the cost–benefit analysis, lower immediate costs but higher long-term environmental costs due to waste management and pollution (Geyer et al., 2017; United Nations, 2017). As for the Economic impacts, this model contributes to high waste management costs and potential regulatory compliance costs (European Commission, 2024b). This fact, make investors shift to sustainable alternatives (BlackRock Investment Institute, 2020).

As a key Case study, it can be mentioned the traditional plastic bottle usage in beverage industries. Despite lower costs, the environmental burden and increasing regulations are pushing companies to explore alternatives (The Coca-Cola Company, 2022).

3.2.1.2 Bulk packaging

This business model uses large-scale packaging for transportation and distribution, which is typically discarded once products are moved to retail packaging. Bulk packaging often results in significant waste (Ritchie et al., 2023).

Economical for producers as its logistically optimal but generates significant waste disposal costs (Ritchie et al., 2023). It increases the economic impacts since increased waste leads to higher disposal and environmental remediation costs (Bhosale et al., 2022). In the same line as the previous business model, the investment trends are moving toward more sustainable bulk packaging solutions (Global Commitment, 2024).

A typical case study can be bulk grain transportation using large plastic sacks, which are discarded after one use. Alternatives like reusable bulk containers are being explored to reduce waste (Hofmann et al., 2023).

3.2.1.3 Non-recyclable packaging

Some packaging materials are not designed for recycling, such as certain mixed plastics or laminated materials. This non-recyclability poses significant environmental challenges (Geueke et al., 2018).

Initial cost savings are offset by long-term environmental and disposal costs making the cost-effective dimension non desirable in the current regulatory context (Geueke et al., 2018) since they may

have huge economic impacts as significant environmental clean-up costs and/or potential regulatory fines (OECD, 2022). Due to these issues, investment trends are decreasing as regulatory pressures and consumer demand shift toward recyclability (Global Commitment, 2024).

One of the cases that took this direction was the Multi-layered snack packaging, which is difficult to recycle. Companies are researching recyclable alternatives to meet regulatory requirements and consumer preferences (Affandi and Ramadini, 2023).

3.2.1.4 Brand-specific packaging

This model involves custom-designed packaging unique to a brand. It can be difficult to recycle or reuse due to proprietary designs, leading to more waste in the long run (Velis and Vrancken, 2015).

On the financial cost–benefit analysis it has high marketing value but poor recyclability. Increased waste management costs and potential loss of eco-conscious consumers make the economic impact balance negative. Thus, companies are increasingly looking to invest in design unique yet recyclable packaging (Lacy et al., 2020).

As case study, custom perfume bottles that are not recyclable. Brands are now moving toward using recyclable materials without compromising on uniqueness (L'Oréal, 2022).

3.2.1.5 Disposable packaging

This model includes items like plastic cutlery, plates, and straws, designed to be discarded after use. Disposable packaging is associated with significant environmental degradation due to its single-use nature (Schmaltz et al., 2020).

Attending to a cost benefit analysis it possesses low initial cost but high environmental impact and waste management costs impacting negatively economically speaking with high waste management costs and potential regulatory restrictions (Schmaltz et al., 2020; OECD, 2022). Investors are on the run of this business model since bans on single-use plastics become more common (European Parliament and Council, 2019).

Plastic straws, as stereotypical case study, are being replaced by paper or reusable alternatives due to environmental concerns and regulatory bans (European Parliament and Council, 2019).

3.2.2 Circular food packaging business models

A circular business model in food packaging focuses on sustainability through resource efficiency. Food packaging is designed to be reusable, recyclable, or compostable, ensuring materials stay in use longer. This approach minimizes waste, reduces resource consumption, and fosters a closed-loop system. These are the models identified that better represent this paradigm.

3.2.2.1 Reusable packaging

In this business model, packaging is designed to be reused multiple times, reducing waste and promoting sustainability (Stahel, 2016; Cooper and Gutowski, 2017).

Speaking about the cost–benefit analysis of circular food packaging, this model as a main trend for all, faces one of the greatest cost benefit advantages. Despite the fact that offers upfront costs also offers significant savings over time through reuse (Stahel, 2016); While initial costs are higher due to durable materials and logistics for returns and cleaning, the long-term savings through repeated use and significant waste reduction make it highly cost-effective and sustainable. Companies adopting reusable packaging often benefit from operational efficiencies and reduced environmental compliance costs, which positively impact their bottom line, increasing investment as sustainability becomes a key market driver (Ellen MacArthur Foundation, 2024a).

A paramount case study can be the Loop platform by TerraCycle. Loop offers products in durable, reusable packaging. Customers return the packaging to be cleaned and reused, creating a closed-loop system that significantly reduces waste (Bukowski and Rok, 2018; Ellen MacArthur Foundation, 2024b).

TABLE 7 Food packaging circular business models.

Business models	Short definitions
Reusable packaging	Packaging designed for multiple uses, reducing waste and promoting sustainability.
Refillable packaging	Customers refill their own containers, reducing single-use packaging.
Compostable packaging	Biodegradable materials designed to be composted after use.
Recyclable packaging	Packaging made from materials that can be recycled into new products.
Returnable packaging	Packaging returned to producers for reuse, reducing waste.
Eco-friendly packaging	Packaging using sustainable materials and designs to minimize environmental impact.
Packaging as a service	Packaging provided as a leased service, reducing waste through shared systems.
Closed-loop packaging	Packaging collected, processed, and reused by the same company in a closed cycle.
Zero waste packaging	Minimalist packaging that aims to reduce waste to zero through reuse and recycling.
Collaborative packaging	Companies share packaging resources or design standards to reduce waste and improve sustainability.
Safe and sustainable by design (SSbD)	Packaging designed with safety and sustainability integrated into every stage of the design process.

3.2.2.2 Refillable packaging

This approach involves packaging systems where customers can refill their own containers, reducing the need for single-use packaging (Leal Filho et al., 2018).

The Refillable Packaging business model is moderately cost-effective over time and environmentally beneficial (Leal Filho et al., 2018; Coelho et al., 2020). While environmentally friendly and reducing single-use materials, refillable systems require significant investment in refilling infrastructure, which can be costly depending on scale. On the impact side, it contributes to decrease the need for new packaging production, reducing costs and waste. Definitely this contributes to an increasing interest from investors especially in the personal care and household products sectors (Mahmoudi and Parviziomran, 2020).

The Body Shop's refill stations represent a clear case study, since it allows customers to refill their products, reducing the need for new

TABLE 8 Resume of business models analyzed in the rewiew.

Linear business models	Environmental burden	Short/medium term costs	Long term costs	Investment trend	Impacts
Single use	Very high	Low	Very high	Decreasing	High waste management and regulatory compliance costs. Pollution.
Bulk	Very high	Low	Very high	Decreasing	High waste management and regulatory compliance costs. Pollution.
Non recyclable	Very high	Low	Very high	Decreasing	High waste management and regulatory compliance costs. Pollution.
Brand specific	Very high	Low	Very high	Decreasing	High marketing value and high waste management and regulatory compliance costs. Low recyclability. Pollution.
Disposable	Very high	Low	Very high	Decreasing	High waste management and regulatory compliance costs. Pollution.
Circular business models	**Environmental burden**	**Short/medium term costs**	**Long term costs**	**Investment trend**	**Impacts**
Reuse	Low	Moderate	Low. Reduces more with time.	High	Waste reduction
Refill	Low	High	Moderate	Moderate	Need investment on reffilable systems. Waste Reduction
Compostable	Low	High	Moderate	Moderate/High	Reduces landfill waste and contributes to soil health
Recyclable	Moderate	Moderate	Moderate	Moderate/High	Dependency on infrastructure
Returnable	Low	Low/Moderate	Low	Moderate	Investment in logistic on companies. Cost savings and improves supply chain efficiency
Eco-friendly	Moderate	Moderate	Moderate	Low	Situational
PaaS	Low	Low	High	Low	Very depending on the scale
Closed loop	Low	High	Low	High	Circular autonomy. costly but high impact in the long term.
Zero waste	Low	Low	Low	Moderate	Situational
Collaborative	Low	Moderate	Moderate	Low	Strategical but not systematic
SSbD	Low	Moderate	Low	Moderate/High	Extended environmental, economic and health savings.

plastic packaging and promoting sustainability (Affandi and Ramadini, 2023).

3.2.2.3 Compostable packaging

It uses biodegradable materials designed to be composted after use. It aligns with circular economy principles by minimizing waste (Cristóbal et al., 2023).

In terms of cost–benefit analysis, compostable packaging reduces landfill waste and contributes to soil health, offering environmental benefits. However, higher production costs and the need for specific composting facilities limit its overall cost-effectiveness. On the impact side, it reduces landfill use and potential for nutrient recovery through composting. On investment, compostable packaging is growing, especially in the food and beverage sectors where the need for sustainable, single-use alternatives is high. However, the higher costs and the need for specific composting infrastructure limit the pace of investment compared to other circular models (Rujnić-Sokele and Pilipović, 2017).

Case study: Tetra Pak has developed fully renewable and compostable cartons, enhancing resource efficiency and reducing environmental impact (Platnieks et al., 2020).

3.2.2.4 Recyclable packaging

Packaging designed with materials that can be recycled into new products. This approach helps reduce waste and supports resource recovery (Ibrahim et al., 2023).

This business model heavily depends on the availability of recycling infrastructure. This fact not only conditions the cost–benefit analysis but also its economic impact by this limitation by the efficiency and availability of infrastructure. Companies may also face variable costs associated with ensuring their packaging is recyclable under different market conditions. Thus, while recyclable packaging continues to receive steady investment, particularly as global recycling

TABLE 9 Key takeaways on consumers, society and business models.

Topic	Key insights
The influence of packaging on purchasing decisions	• Packaging impacts consumer perception and purchasing through visual appeal, functionality, and communication. • Sustainable packaging (e.g., recyclable, eco-friendly) attracts eco-conscious buyers. • Social media and unboxing trends amplify brand visibility.
Consumer attitudes and behaviors	• Preference for sustainable, recyclable, or biodegradable packaging, especially among Millennials and Gen Z. • Key drivers: affordability, convenience, and transparency. • Challenges include price sensitivity and avoiding greenwashing claims.
Implications for policymakers	• Need for supportive regulations (e.g., Circular Economy Action Plan). • Tax incentives and penalties to promote sustainability. • Enhance consumer education and address economic barriers to compliance.
Implications for industry	• Focus on sustainable innovations like biodegradable materials and reusable packaging. • Transparent communication to build trust. • Align business models with consumer sustainability expectations for competitive advantage.
Implications for researchers	• Explore business models promoting sustainable practices. • Assess lifecycle impacts of materials and circular economy potential. • Interdisciplinary studies linking behavioral science, materials engineering, and economics.

infrastructure improves, the trend is somewhat moderated by the challenges of ensuring packaging is fully recyclable across various markets (Ibrahim et al., 2023).

As a Case study, for the good but also for the bad, is the Coca-Cola's commitment to use 50% recycled material in its bottles by 2030, aiming to boost recyclability and reduce plastic waste but also being subject of criticising due to the politics of delay implemented by the company (Vandenberg, 2024).

3.2.2.5 Returnable packaging

This model involves systems where customers return packaging to the producer for reuse. This approach has been found to reduce waste and encourage consumer participation in recycling (Zaman, 2016).

Returnable packaging systems offer moderate to high cost–benefit, reducing the need for new packaging production and lowering waste disposal costs. However, they require investment in logistics and infrastructure to manage the return process. Overall, the economic impact is positive, particularly in sectors where return logistics are traditionally easier to manage as beverages. This model supports cost savings and improves supply chain efficiency, contributing to stronger economic outcomes. However, Investment in returnable packaging is still moderate. The need for robust logistics infrastructure can be a barrier to widespread adoption, which tempers investment growth compared to other models (Zaman, 2016; Coelho et al., 2020).

TABLE 10 Key takeaways on trends and innovation influencing current food packaging business models.

Topic	Key insights
Sustainable innovation in food packaging	• Critical for environmental conservation, resource efficiency, and public health. • Reduces plastic waste, carbon emissions, and ecological footprint. • Supports the transition to a circular economy and aligns with consumer preferences and regulatory demands.
Impact of social media and marketing	• Social media influences packaging trends through visual appeal and "Instagrammable" designs. • Drives demand for sustainable solutions and greater transparency. • Encourages smart packaging integration with QR codes and NFC for consumer interaction.
Functional design innovations	• Includes user-friendly features like easy-open packaging and resealable zippers. • Active packaging (e.g., oxygen scavengers) and smart packaging (e.g., freshness sensors) enhance safety and reduce waste. • Emerging technologies like edible films offer dual benefits.
Emerging technologies in packaging	• AI optimizes design, reduces waste, and enhances quality control. • IoT provides real-time product condition monitoring and improves supply chain management. • Blockchain ensures traceability and compliance, supporting sustainable practices.
Startups and CSR in packaging	• Startups drive innovation with compostable materials and novel models like "packaging as a service." • CSR promotes sustainable practices, community engagement, and transparent reporting (e.g., GRI standards). • Key to meeting consumer and regulatory demands.

3.2.2.6 Eco-friendly packaging

This approach focuses on reducing environmental impact through the use of sustainable materials and minimalistic designs (Leal Filho et al., 2018).

Eco-friendly packaging may not be top tier when it comes to cost–benefit, depending on the specific materials and designs used. While it can reduce production costs and environmental impact, the benefits are often more incremental and depend heavily on market positioning and consumer preferences. Also, the economic impact of eco-friendly packaging is generally lower compared to other circular models, as the benefits are more situational. However, it can enhance brand reputation and appeal to environmentally conscious consumers, contributing to market differentiation.

As a general trend, investment in eco-friendly packaging is growing as per other circular models, however, remains lower due to the broad and sometimes vague definition of what constitutes "eco-friendly." Investors tend to focus on more clearly defined sustainability metrics and outcomes (Leal Filho et al., 2018; Duarte et al., 2024).

FIGURE 1
Food packaging value chain.

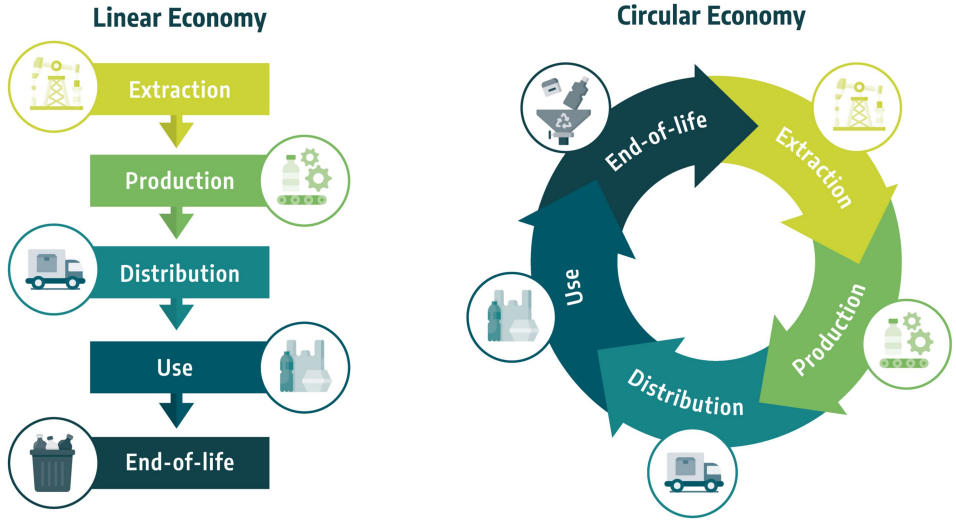

FIGURE 2
Circular economy cycle.

A case study, between business model, marketing and CSR is the IKEA's use of minimalistic, recyclable packaging materials that reduce waste and environmental impact (IKEA, 2021).

3.2.2.7 Packaging as a service (PaaS)

In this model, packaging is provided as a service, allowing businesses to reduce waste through shared or leased packaging systems (Coelho et al., 2020).

From a cost-effective perspective, it reduces the need for continuous packaging production and waste management costs. However, PaaS models often include circular elements, such as the reuse and recycling of packaging, which can further reduce costs and environmental impact over time. However, the cost-effectiveness of PaaS can vary depending on the scale of operations and the specific terms of the service agreements (Heyes et al., 2018). This way, the economic impact of Packaging as a Service can be substantial, particularly for companies that face high variability in demand for packaging materials. This model is especially beneficial in industries with high packaging turnover, such as e-commerce and food delivery. Thus, on investment, the model is still emerging, and investment trends reflect this early stage of adoption. Its potential for growth is significant, especially as more industries seek flexible and sustainable packaging solutions (Vermunt et al., 2019).

As case study, Loop from TerraCycle, where customers remand the packaging services, then pay a deposit for the packaging, which is refunded when the packaging is returned. The returned packaging is cleaned, sanitized, and refilled for reuse, creating a *defacto* closed-loop system.

3.2.2.8 Closed-loop packaging

This approach creates a closed-loop cycle by collecting, processing, and reusing packaging by the same company, reducing waste and promoting sustainability (Lacy and Rutqvist, 2015).

Closed-loop packaging systems provide high cost–benefit by enabling companies to reuse and recycle materials within their own operations. While the initial setup can be costly, the

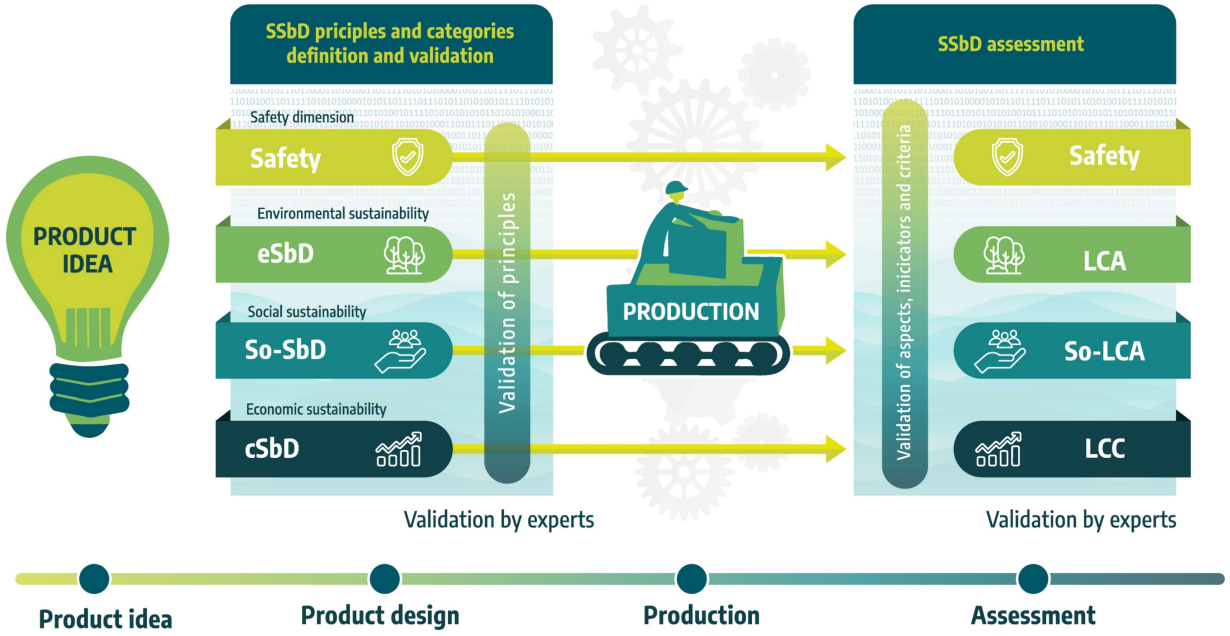

FIGURE 3
SSbD functioning scheme.

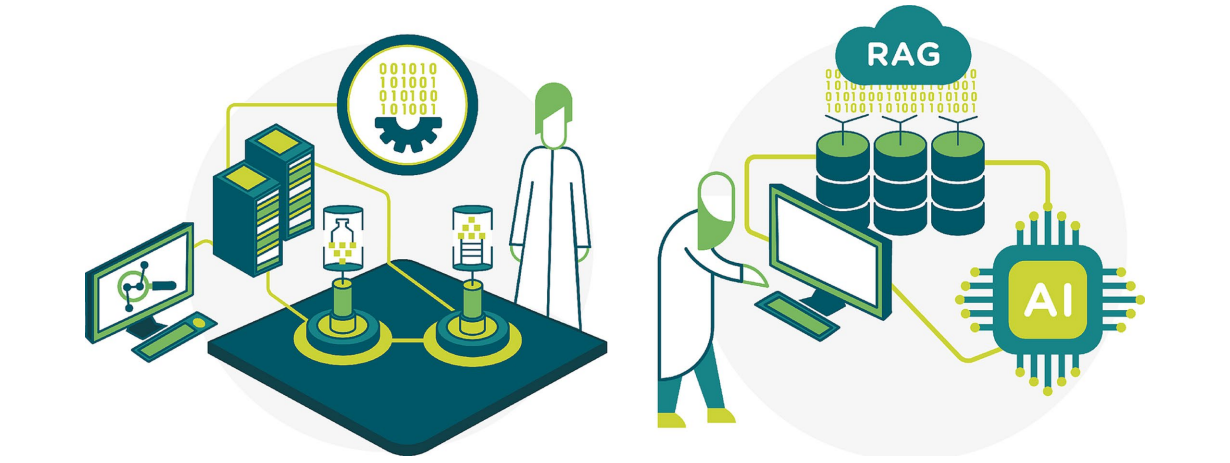

FIGURE 4
Artificial intelligence working scheme.

long-term savings in raw material costs and waste disposal are substantial, making it a highly efficient model. It reduces dependency on virgin materials and lowers waste management expenses. This model supports circular economy principles, enhancing a company's economic resilience and sustainability also showcasing a moderate level of impact. This makes the investment in closed-loop systems strong, driven by their alignment with circular economy strategies. Companies that implement these systems are seen as leaders in sustainability, making them attractive to investors focused on long-term value creation (Lacy and Rutqvist, 2015).

For example, outside the food packaging sector a paragon case is the Patagonia's closed-loop recycling program for its clothing, where old garments are collected, recycled, and turned into new products (Robertson, 2016) In food packaging, Tetra Pak, has implemented a closed-loop recycling system for its cartons, widely used in packaging liquids such as milk and juice. This system aims to address the challenge of recycling multi-layered packaging materials, which traditionally involve a combination of paperboard, plastic, and aluminium (Ozsevim, 2022).

3.2.2.9 Zero waste packaging

This model focuses on reducing waste to zero, emphasizing minimal packaging, and encouraging reuse and recycling (Novakovic et al., 2023).

The cost–benefit analysis of Zero Waste Packaging may vary. However, the long-term benefits are significant, including reduced waste disposal costs, lower environmental impact, and potential

savings from the reuse of materials (Guillard et al., 2018). The economic impact of Zero Waste Packaging is also substantial, especially in industries where waste management costs are a significant part of the budget. By reducing or eliminating packaging waste, companies can lower these costs and improve their overall economic efficiency. Additionally, adopting Zero Waste practices can lead to enhanced brand reputation, attracting eco-conscious consumers and opening new market opportunities. However, the success of Zero Waste Packaging economically depends on the scalability of the systems and the willingness of consumers to adopt such practices. Investors are drawn to companies that can demonstrate a clear commitment to reducing their environmental footprint, and Zero Waste initiatives are a strong indicator of such a commitment. However, similar to eco-friendly packaging, the investment trend can be moderated by the challenges of defining and measuring "zero waste" in a consistent and meaningful way (Guillard et al., 2018).

On case study, LUSH Cosmetics' commitment to zero waste, using minimal packaging and encouraging customers to return containers for recycling also, as previously said, enhancing brand reputation on ecological awareness whilst attracting customer in the segment (Mondello et al., 2024; Varshney and Ahmed, 2023).

3.2.2.10 Collaborative packaging

Companies work together to share packaging resources or design standards to reduce waste and improve recyclability (Jäger and Piscicelli, 2021).

Collaborative packaging offers a moderate cost–benefit and economic impact, primarily through shared resources and reduced production costs, although the effectiveness depends on the collaboration's structure and goals. Economically, it enhances supply chain efficiency and aligns with circular economy principles, which can improve market position and profitability. Investment in collaborative packaging is growing, driven by its potential for cost savings and sustainability, though it remains lower compared to more straightforward models like reusable packaging due to the complexities involved in managing partnerships (Drago et al., 2020).

A paramount example of collaborative packaging is the Sustainable Packaging Coalition (SPC), where members from various industries collaborate to develop innovative and sustainable packaging solutions. This coalition fosters a shared commitment to environmental responsibility by pooling resources, sharing best practices, and setting industry standards. The SPC's collaborative approach has led to significant advancements in sustainable packaging, making it a leading model for how companies can work together to achieve greater sustainability and economic efficiency (Sustainable Packaging Coalition, 2025).

3.2.2.11 Safe and sustainable by design (SSbD)

This model integrates safety and sustainability into every stage of the packaging design process, ensuring that materials and processes are safe for both consumers and the environment. It also ensures that the materials and processes used are not only effective in preserving product quality but also safe for consumers and the environment. The emphasis on both safety and sustainability helps companies mitigate risks, enhance brand reputation, and meet stringent environmental standards (European Commission, 2022).

The SSbD model balances higher initial design and development costs with significant long-term benefits, including reduced environmental damage, lower regulatory risks, and enhanced consumer trust. By prioritizing safety and sustainability from the outset, SSbD mitigates long-term liabilities and aligns with increasing regulatory demands, leading to substantial overall savings. SSbD has a strong economic impact by reducing risks associated with harmful substances in packaging and improving public health outcomes. Companies adopting SSbD are better positioned to comply with evolving regulations and meet consumer demand for sustainable products, thereby enhancing brand reputation and market share. There is a growing investment trend toward SSbD, driven by regulatory pressures and the increasing importance of sustainability in consumer choices. Investors view companies that adopt SSbD principles as resilient and future-proof, making this model an attractive area for capital allocation (Cassee et al., 2024; European Commission, 2022).

Despite public statements by some multinationals to Safe and Sustainable by Design principles, only one full case study has been developed by the European Commission JRC in 2023 (European Commission, 2023b). This case study still does not address the socio-economic aspects of sustainability in Safe and Sustainable by Design (SSbD) yet. Currently there are some projects being developed that will start giving results by 2025 and 2026 (IRISS, 2024; PINK Project Consortium, 2025; MOZART Project Consortium, 2025).

3.2.3 Wrap up

The analysis of various circular packaging modelsreveals a spectrum of benefits and challenges that each model brings to the field. Among these, followed by Reusable packaging and returnable packaging, SSbD stands out as the most ambitious, comprehensive and strategically advantageous, yet it is essential to see how this approach develops and understand the significant contributions and considerations of other models as well.

3.3 Business models comparison on overall effectiveness

Among the analyzed models, SSbD seems to stand out as the most optimal approach even though still road ahead also because its build on older business models incorporating lessons learned and best practice. It is the most effective in terms of long-term sustainability, economic viability, and regulatory alignment. SSbD stands out as the most comprehensive approach, integrating safety and environmental sustainability at the design stage, thus minimizing long-term risks and aligning with evolving regulatory frameworks. Effectiveness can be achieved by operating on multiple levels, including the use of recycled raw materials, renewable resources, and eco-design strategies to reduce environmental impact (Dörnyei et al., 2023).

It not only addresses immediate cost and economic challenges but also positions companies for long-term success in an increasingly regulated and consumer-driven market. By integrating safety and sustainability from the outset, SSbD reduces risks, enhances brand loyalty, and aligns with the global movement toward sustainable practices. The contributions of other models such as Reusable, Closed-loop, and Recyclable Packaging are also significant and should be considered as part of a broader strategy to enhance sustainability and economic performance in the food packaging industry.

Secondly, in a decreasing ranking, Reusable Packaging, and similarly closed loop, appears below SSbD. It demonstrates strong cost-effectiveness over time, reducing waste generation and material use, though it requires upfront investment in logistics and consumer participation. Similarly, Closed-Loop Packaging excels in minimizing raw material dependency by reintroducing materials into the production cycle, making it highly effective for resource efficiency (Noëth et al., 2024).

Thirdly, Compostable and Recyclable Packaging aim to reduce waste through materials that can be composted or recycled. However, their effectiveness is often limited by the availability and efficiency of local composting and recycling infrastructures. While compostable and recyclable packaging options are available, their sustainability benefits are contingent upon proper waste management systems (Dörnyei et al., 2023).

In fourth position, packaging as a Service (PaaS) and Collaborative Packaging involves shared use of packaging resources to enhance efficiency and sustainability. However, empirical data on their effectiveness is currently limited, indicating a need for further research to assess their practical impact as well as the lack of interest of industry and academia, due to the limited number of studies.

Lastly, Eco-friendly packaging and Zero Waste Packaging seems to have limitations that put them far away from being the most effective models. On the early, "eco-friendly" packaging can be used with strategies that may not be necessarily effective, CSR or in the best-case scenario lack of empirical data. On the later, the Zero Waste ideal aims to eliminate waste entirely through design and process innovations. While conceptually appealing, practical implementation faces significant challenges, particularly in scaling such models across diverse markets and consumer bases (Dörnyei et al., 2023).

In conclusion, while each circular packaging model offers unique benefits and challenges, SSbD represents the most comprehensive approach, combining cost-effectiveness, economic resilience, and strong investment appeal. While still in its initial steps, it is expected that companies that adopt SSbD principles are better positioned to navigate the complexities of modern markets, meet consumer expectations, and achieve long-term sustainability goals. However, it is worth to mention that SSbD approach applies when packaging options are created and/or developed, and it is hardly applicable in already existing packaging solutions.

4 Results on: consumers, society and business models

Understanding the relations between consumers, society, and business models in the food packaging industry is crucial, as these elements collectively shape market dynamics and sustainability practices. Consumers' preferences and behaviors drive demand for innovative and sustainable packaging solutions, while societal trends influence regulatory frameworks and environmental standards. Business models must adapt to these changing demands and expectations, ensuring that packaging not only meets functional requirements but also aligns with broader societal goals of sustainability and ethical responsibility. Addressing these interlinkages is key to fostering a resilient and future-ready food packaging industry. Therefore, in this review we will examine the following topics.

4.1 The influence of packaging on purchasing decisions

Packaging plays a critical role in shaping consumer purchasing decisions, serving not only as a protective barrier for food but also as a powerful tool for marketing and communication. In the highly competitive food industry, packaging often serves as the first point of interaction between the consumer and the product (Shukla et al., 2022). This can significantly influence a consumer's perception of the product and, ultimately, their purchasing decision.

Studies have consistently shown that consumers are drawn to packaging that is aesthetically pleasing, with color, design, and typography playing crucial roles in capturing attention. Bright colors and bold graphics tend to attract more attention, while minimalist designs may appeal to consumers seeking simplicity and elegance (Wyrwa and Barska, 2017). The visual elements of packaging can convey the quality, value, and even the intended audience for the product. For instance, premium products often feature sophisticated, elegant packaging, while products aimed at children may use vibrant colors and playful designs (Su and Wang, 2024).

Luxury packaging, a hallmark of premium markets, emphasizes exclusivity through sophisticated designs and materials, often at significant environmental cost. However, luxury brands are increasingly adopting sustainable practices, such as sustainable materials and circular economy principles, to address consumer demand for sustainability (Sousa et al., 2020). Case studies on Giorgio Armani and Helena Rubinstein highlight efforts to reduce environmental impact, while research suggests minimalist designs can effectively communicate ecological commitment (Ding et al., 2024; Drobac et al., 2020).

Beyond aesthetics, packaging also communicates essential information that can influence purchasing decisions. Nutritional information, ingredient lists, and certifications (such as organic or non-GMO) are critical for health-conscious consumers (Cavaliere et al., 2017). The transparency of packaging, both literal (as in clear packaging that allows consumers to see the product) and figurative (providing clear, honest information), can build trust and encourage purchase. Additionally, packaging that emphasizes sustainability, such as using recyclable materials or highlighting sustainable practices, can attract environmentally conscious consumers (Mudgal et al., 2024; Crié, 2015). This trend has become increasingly important as more consumers prioritize sustainability in their purchasing decisions.

The functionality of packaging also plays a big role in influencing purchasing behavior. Packaging that is easy to open, resealable, or offers convenience features like portability can enhance the consumer experience and increase the likelihood of repeat purchases (Ahmed, 2014). For example, innovative packaging solutions that extend shelf life or improve product safety, or extend information through QRs, can also sway consumer decisions, especially in categories like fresh produce or dairy products (Rundh, 2016).

Brand identity and loyalty are closely tied to packaging as well. Packaging that consistently reflects a brand's identity helps reinforce consumer recognition and trust. Iconic packaging, such as the distinctive shape of a Coca-Cola bottle can create strong brand associations and loyalty (Akbar et al., 2023; Mensah et al., 2022). For brands, maintaining a consistent packaging design across products

can create a unified brand image that resonates with consumers and fosters repeat purchases (Veeranagandla and Anitha, 2023).

Furthermore, the role of packaging in the consumer's decision-making process extends to the growing influence of social media and unboxing experiences. Attractive packaging that is well-designed and visually appealing can encourage consumers to share their purchases on social platforms, providing free word-of-mouth marketing and enhancing brand visibility (Ali Abbasi et al., 2022). This phenomenon has given rise to the "Instagrammable" packaging trend, where brands design their packaging with social media aesthetics in mind to attract digital-savvy consumers (Yang et al., 2021).

Thus, packaging is far more than just a container for a product; it is a crucial element in the marketing mix that can significantly influence consumer purchasing decisions. From visual appeal and functionality to the communication of brand values and sustainability efforts, or information provision for educated consumers, packaging affects how consumers perceive a product and whether they choose to buy it. As consumer preferences continue to evolve, particularly toward greater sustainability and convenience, the role of packaging in influencing purchasing decisions will only become more pronounced.

4.2 Insights on consumer attitudes and behaviors relevant for food packaging business models

To provide a comprehensive analysis, it is essential to examine consumer attitudes and behaviors toward food packaging. This is an essential factor for developing effective and sustainable food packaging business models. Over the past decade, consumer preferences have increasingly shifted toward sustainability, driven by growing environmental awareness and concerns about health and safety. This shift has profound implications for how food packaging is designed, marketed, and utilized within the food supply chain.

Regarding consumer preferences, recent studies have highlighted a growing preference among consumers for packaging that aligns with environmental sustainability goals. Consumers are increasingly favoring packaging that is recyclable, biodegradable, or made from renewable resources (Aschemann-Witzel et al., 2013; García-de-Frutos et al., 2018). This trend is particularly strong among younger demographics, such as Millennials and Generation Z, who are more likely to prioritize sustainability in their purchasing decisions (White et al., 2019). These consumers often perceive sustainable packaging as a reflection of a brand's commitment to environmental responsibility, which can significantly influence brand loyalty and purchasing behavior (García-de-Frutos et al., 2018).

However, there remains a notable gap between consumer attitudes and actual purchasing behavior. While many consumers express a preference for sustainable packaging, their purchasing decisions are still heavily influenced by other factors such as affordability, price, convenience, and brand familiarity (De Canio, 2023; Crié, 2015). Thus, within those material constraints, consumer usage patterns are also evolving in ways that are reshaping the food packaging industry. There has been a significant increase in demand for packaging that supports convenience and ease of use, such as resealable packaging, single-serve portions, and packaging that extends product shelf life (Lindh et al., 2016). These features are particularly valued in urban areas, where busy lifestyles drive the demand for convenient food options. Moreover, the rise of e-commerce has introduced new challenges and opportunities for food packaging as a need for packaging that not only protects the product during shipping but also offers an unboxing experience that reflects the brand's values (Sastre et al., 2022). This has led to innovations in packaging design that emphasize durability, sustainability, and aesthetics, further influencing consumer behavior and expectations.

Taking all of these features into account suggests that packaging design can significantly influence perceptions of quality, value, and brand identity (Nyadzayo and Khajehzadeh, 2016). Studies have shown that consumers often associate attributes of the packaging with the attributes of the product itself, making packaging design a critical component of marketing strategy (Wang and Chang, 2022). Beyond this, in recent years, the role of packaging in conveying sustainability credentials has also become increasingly important. Clear labeling regarding recyclability, material origins, and environmental impact can enhance consumer trust and encourage purchase decisions (Crié, 2015). Packaging that transparently communicates its environmental benefits can thus differentiate a product in a competitive marketplace, appealing to the growing segment of eco-conscious consumers. This suggests that while there is a clear demand for sustainable packaging, its adoption is contingent upon the packaging also meeting other key consumer needs and material limits. Also, the negative effect that greenwashing exerts on the markets undermining legitimacy of the commercial claims toward sustainability is presenting an unexpected obstacle to an increasement of demand (Bernini and La Rosa, 2024; Liu et al., 2023).

4.3 Potential implications for policymakers, industry, and researchers

These interactions between consumers and business models in the food packaging sector have significant implications for policymakers, industry stakeholders, and researchers. As consumer awareness and demand for sustainable practices grow, these interactions drive changes across the entire value chain, necessitating adjustments in policy, industry practices, and research priorities.

4.3.1 Implications for policymakers

Policymakers must address growing consumer demand for sustainability by implementing regulations that encourage sustainable packaging while ensuring business competitiveness. Examples include the EU's Circular Economy Action Plan and Single-Use Plastics Directive, which aim to reduce plastic waste and promote recyclable or biodegradable materials (European Commission, 2024a). As consumers continue to prioritize sustainability, stricter regulations, tax breaks for sustainable innovation, and penalties for failing to meet recycling targets may be necessary (European Commission, 2024c). However, financial constraints often hinder compliance with sustainability goals, and imposing penalties without addressing these barriers could be counterproductive. Research identifies cost as a key obstacle, with structural or economic challenges often causing misalignment with sustainability objectives rather than a lack of intent (Agyabeng-Mensah et al., 2020). Supportive policies and financial incentives could ease this transition. Additionally, consumer behavior data, such as insights from the MAGNO project, can guide educational campaigns to improve public understanding and recycling practices (Crié, 2015).

4.3.2 Implications for industry

For the industry, consumer interaction drives the need for innovation in packaging design and materials. Companies that fail to meet consumer expectations risk losing market share. To remain competitive, industry must invest in sustainable solutions, including biodegradable materials, reusable systems, and innovations that reduce environmental impact. Adopting sustainable business models meets consumer demand and enhances Corporate Social Responsibility (CSR), increases brand loyalty and provides a competitive edge in an eco-conscious market (Lim, 2017). Furthermore, the industry must engage in transparent communication with consumers about the sustainability of their products to build trust and promote informed purchasing decisions (Papista et al., 2018).

4.3.3 Implications for researchers

The evolving interaction between consumers and business models offers opportunities for researchers to evaluate the effectiveness of various approaches in promoting sustainability. Studies could focus on the impact of consumer income, education on recycling, the lifecycle of new packaging materials, and the economic implications of adopting circular economy models. Researchers also play a key role in assessing the environmental impact of packaging options and creating metrics to guide industry practices and policymaker decisions. Interdisciplinary research combining behavioral science, materials engineering, and economics is essential to develop comprehensive solutions for sustainable packaging (Steenis et al., 2018). As consumer expectations evolve, researchers must continue to investigate how these expectations shape and are shaped by industry practices, ensuring that the food packaging sector can meet sustainability goals while maintaining economic viability.

5 Results on: relevant trends and innovation influencing current food packaging business models

As the global population and consumption rates rise, the need to reduce plastic waste, lower carbon emissions, and minimize the ecological footprint of packaging becomes increasingly urgent. By embracing innovating sustainable practices or applying socially innovative features involving social media or CSR, the food packaging industry can play a pivotal role in driving the transition toward a circular economy, ensuring that packaging not only protects products but also preserves the planet for future generations. Moreover, sustainable innovation fosters economic resilience by aligning with evolving consumer preferences and regulatory demands, making it a critical area of focus for industry leaders. This review is addressing also this topic about reviewing the following sections.

5.1 The impact of social media and marketing on packaging trends

In recent years, social media and marketing strategies have played a transformative role in shaping food packaging trends, significantly influencing consumer behavior and driving innovation in the industry.

One of the most significant impacts of social media on food packaging is the shift toward more aesthetically pleasing and shareable designs which is a global trend for communication (Li, 2022). Consumers are increasingly motivated by the desire to share their experiences online, and food packaging that is visually appealing is more likely to be featured in social media posts. This trend has led to the rise of "Instagrammable" packaging—designs that are not only functional but also visually striking, creating a strong brand presence online (Wansink, 2012). The packaging serves as a marketing tool in itself, with its design elements, such as colors, shapes, and textures, tailored to evoke emotional responses and encourage sharing on social media platforms (Wyrwa and Barska, 2017).

Moreover, social media has heightened consumer awareness and demand for sustainability, pushing brands to adopt more sustainable packaging solutions. The widespread dissemination of information regarding environmental issues, facilitated by social media, has led consumers to become more conscious of the environmental impact of their purchases (White et al., 2019). Brands that demonstrate a commitment to sustainability are often favored in social media conversations. As a result, companies are increasingly adopting sustainable packaging practices not just to meet regulatory requirements but also to enhance their social media image and appeal to a more environmentally conscious demographic (Steenis et al., 2017). Consequently, brands are increasingly incorporating sustainable materials and highlighting these efforts in their marketing campaigns to align with consumer values. The rise of social media has empowered consumers to voice their opinions more widely and effectively, creating a demand for greater transparency from brands, especially in terms of packaging and environmental practices. This shift has compelled companies to adopt more transparent approaches to packaging, to generate trust by giving consumers the information they require, reflecting the increasing consumer demand for sustainability and ethical business practices (Buerke et al., 2017).

Marketing on social media has also influenced the adoption of smart packaging solutions. With the rise of e-commerce and digital marketing, brands are exploring innovative ways to connect with consumers through packaging that integrates technology, such as QR codes or NFC tags, allowing consumers to access additional product information, promotional content, or interactive experiences (Mukhtar et al., 2023; Pillai et al., 2021). This integration of digital and physical elements in packaging not only enhances the consumer experience but also provides valuable data for brands to refine their marketing strategies.

Furthermore, social media enables brands to leverage user-generated content as a marketing tool. Consumers who share photos or videos of their packaged products contribute to brand visibility and credibility, often leading to viral marketing effects. This consumer-driven content can amplify brand messaging and create a sense of community around the product, further solidifying brand loyalty (Tuten, 2015). As a result, brands are increasingly designing packaging that encourages user interaction and content creation, such as limited-edition designs or personalized packaging options.

The influence of postmodernism culture and social media on consumer behavior has forced brands to innovate and adapt their packaging strategies to meet the evolving demands of the digital age. As social media continues to be a dominant force in consumer marketing, its role in shaping food packaging trends will likely continue to grow, further integrating packaging design with brand storytelling and consumer engagement.

5.2 Overview of recent innovations in functional design, such as user-friendly features and product protection

Recent years have witnessed significant innovations in the functional design of food packaging, driven by the dual goals of enhancing user experience and improving product protection whilst keeping the business models optimal. One key area of innovation is the development of easy-open packaging. Traditionally, food packaging has been challenging to open, especially for the elderly and those with disabilities. Recent designs have addressed these issues by incorporating features such as tear notches, peelable seals, and resealable zippers between many others in several forms to remove obstacles to consumers that may find difficulties to use such applications (Wagle et al., 2021).

Another significant innovation in functional design is active packaging, which interacts with the food product to extend its shelf life and ensure safety. Active packaging technologies include oxygen scavengers, moisture absorbers, and antimicrobial films. These features are embedded within the packaging material and actively work to control the internal environment, thus protecting the food from spoilage and contamination. Vanderroost et al. (2014) described how oxygen scavengers have become increasingly common in packaging for high-fat foods, where oxidation can lead to rancidity. These innovations are particularly beneficial in reducing food waste and enhancing food safety, aligning with broader sustainability goals in the food packaging industry (Vanderroost et al., 2014).

Smart packaging is an innovative frontier in the food industry, incorporating sensors, indicators, and digital technologies to monitor the condition of food products in real-time. Time–temperature indicators (TTIs) and freshness sensors are critical in ensuring the quality of perishable goods. These technologies help reduce food waste by providing precise information on product freshness, allowing consumers to make better decisions. Additionally, smart packaging often includes RFID tags and QR codes, which enhance traceability and provide detailed product information, improving transparency and consumer trust. This approach not only improves food safety and quality but also offers significant benefits in supply chain management by providing real-time data on environmental conditions, enabling more efficient and informed decision-making (Salgado et al., 2021; Madhusudan et al., 2018; Thirupathi Vasuki et al., 2023).

Edible packaging is another emerging innovation that offers both functional and environmental benefits. This type of packaging is designed to be consumed along with the product, thereby eliminating waste. As discussed previously, it is being studied the use of edible films made from natural polymers such as chitosan and alginate, which not only provide a protective barrier but also offer additional nutritional benefits (Akalin et al., 2022). Further, a study (Cheng et al., 2022) highlighted the development of carrageenan-based films. While still in the early stages of commercialization, edible packaging represents a promising solution to the problem of packaging waste, particularly in the context of single-use plastics (Oztuna Taner et al., 2023).

Finally, nanotechnology has been instrumental in advancing the protective functions of food packaging. Nanocomposites, which incorporate nanoparticles into packaging materials, have been shown to improve barrier properties, making packaging more resistant to gases, moisture, and UV light. Other studies (Shankar et al., 2024) highlighted how nanoclays and nanosilver have been effectively used to create films that are not only stronger and more durable but also possess antimicrobial properties, thus extending the shelf life of packaged foods.

As consumer expectations and regulatory pressures continue to evolve, the integration of user-friendly features and advanced protective technologies will likely become even more central to packaging design strategies.

5.3 The potential impact of emerging technologies (e.g., AI, IoT, blockchain and others) on packaging

Revolutionary technologies are appearing. Artificial Intelligence (AI), the Internet of Things (IoT), and Blockchain to revolutionize operations, improve sustainability, and enhance consumer engagement also in the field of food packaging. These technologies are not only transforming how packaging is designed (Wang et al., 2024), produced, and recycled but also how it interacts with consumers and the broader supply chain.

Artificial Intelligence (AI) plays a crucial role in optimizing packaging design and manufacturing processes. AI algorithms can analyze large datasets to identify patterns and trends, enabling companies to develop packaging that meets consumer preferences while minimizing material usage and waste. AI-driven predictive models are also being used to forecast demand, which helps in reducing overproduction and associated packaging waste. Furthermore, AI is being employed in quality control, where machine learning models detect defects in packaging materials or print quality, ensuring that only products meeting the highest standards reach consumers (Abass et al., 2024). As an example, dairy processing can enhance production efficiency by 20 to 40%. Applying similar Digital Twins or AI-driven optimization across the food packaging value chain can lead to significant improvements in operational efficiency, sustainability, and product quality (Taner and Çolak, 2024).

The Internet of Things (IoT) enhances packaging by embedding sensors and connectivity into packaging materials, transforming them into smart packaging. IoT-enabled packaging can provide real-time information on product conditions, such as temperature, humidity, and freshness, which is particularly valuable in the food and pharmaceutical industries. This real-time monitoring not only ensures product safety but also extends shelf life by optimizing storage and transportation conditions (Beliatis et al., 2019). Additionally, IoT can facilitate more efficient supply chain management by tracking the movement of goods and packaging throughout the logistics network, reducing losses and ensuring timely delivery (Rad et al., 2022).

Blockchain technology offers significant potential for improving transparency and traceability in the packaging supply chain. By providing an immutable and decentralized ledger, blockchain can verify the origin and journey of packaging materials, ensuring they are sourced sustainably and processed according to environmental standards. This transparency is particularly important for consumers who are increasingly demanding sustainable and ethically sourced products (Kamilaris et al., 2019). Moreover, blockchain can streamline regulatory compliance by providing auditable records that demonstrate adherence to packaging regulations and standards (Kouhizadeh et al., 2021).

In addition to these technologies, 3D printing is gaining traction in the packaging industry, enabling the production of customized and complex packaging designs with reduced waste. 3D printing allows for

rapid prototyping, which accelerates the design process and enables companies to respond quickly to market trends. This technology also supports localized production, reducing the carbon footprint associated with transportation (Attaran, 2017).

The integration of these technologies into the packaging industry not only drives efficiency and innovation but also supports the transition to a circular economy and even brings a touch of creativity mixing traceability, optimizing resource use, and improving recyclability As these technologies continue to evolve, their impact on packaging is expected to grow, making them essential tools for achieving sustainability and meeting the demands of modern consumers.

5.4 Startups CSR and other strategical innovations shaping new business models

Startups have become a driving force in the transformation of the food packaging value chain, bringing innovative solutions that challenge traditional business models and push the industry toward greater sustainability and efficiency. These pioneering companies often leverage cutting-edge technologies, novel materials, and creative business approaches to address the complex demands of the modern food packaging sector, including environmental concerns, regulatory pressures, and changing consumer preferences. For instance, startups have been at the forefront of developing biodegradable and compostable packaging materials, which offer a viable alternative to conventional plastics. These materials not only reduce the environmental impact of packaging waste but also align with the principles of the circular economy, which seeks to minimize waste and maximize resource efficiency (Ritchie et al., 2023). As an example, companies like TIPA, a startup that produces fully compostable flexible packaging, exemplify how innovation in material science can disrupt traditional packaging paradigms and lead to new business models focused on sustainability (TIPA Corp, 2025).

Also, the agility of startups allows them to experiment with and adopt new business models more rapidly than established companies. For example, the previously mentioned "packaging as a service" model, where packaging is offered on a subscription basis rather than as a product, has gained traction through startup initiatives. This model reduces the need for single-use packaging and supports a circular economy by enabling the reuse and recycling of packaging materials (Stahel, 2016). Startups like Loop, which provides reusable packaging for everyday products, are leading this charge by collaborating with major brands and retailers to reduce packaging waste and promote sustainability (LOOP Circular Economy Ecosystem, 2025).

On CSR, even though that its arguable that regulations are more effective that voluntary schemes for companies (Vandenbergh and Gilligan, 2017), CSR in the food packaging industry is increasingly recognized as a strategic approach that not only addresses environmental sustainability but also enhances social value. As consumers become more environmentally conscious, companies are compelled to adopt initiatives that align with these expectations, particularly in the context of sustainable food packaging.

One of its key aspects is the reduction of environmental footprints through sustainable packaging solutions. Companies are increasingly focusing on minimizing the use of single-use plastics, promoting recyclable or compostable materials, and investing in circular economy models. These efforts not only reduce the environmental impact but also resonate with consumers' growing demand for eco-friendly products. For instance, Vanapalli (Vanapalli et al., 2021) highlights how companies in the sector are shifting toward biodegradable materials and recyclable packaging as part of their CSR strategies, which helps mitigate the long-term ecological impact of plastic waste.

In addition to environmental concerns, CSR in food packaging also involves addressing social equity and community engagement. Companies are now more aware of their social responsibilities, which include ensuring fair labor practices, supporting local communities, and contributing to social welfare. Further, CSR initiatives in the food packaging industry also involve transparent reporting and stakeholder engagement. Companies are increasingly expected to disclose their environmental and social performance through sustainability reports. These reports provide stakeholders with information on how companies are addressing packaging-related challenges and their progress toward achieving sustainability goals. The Global Reporting Initiative (GRI) standards, for example, have become a benchmark for reporting on environmental and social impacts, including those related to food packaging (Global Reporting Initiative, 2025; OECD, 2020).

6 Discussion

The literature reviewed provides a comprehensive overview of the current state of the food packaging sector, particularly focusing on the growing need for sustainability in food packaging practices and business models. This work could be linked to Sustainable development goals as Goal 2: Zero Hunger; Goal 12: Responsible Consumption and Production; Goal 13: Climate Action; Goal 15: Life on Land (Krannich and Reiser, 2023). A significant portion of the literature discusses the environmental impacts of traditional packaging materials, particularly plastics, which are widely used but contribute to significant pollution and waste management challenges (World Economic Forum, 2016).

The review also takes a successful look toward the business models that enables the shift toward sustainable materials, including bioplastics and compostable packaging, is a recurring theme in the reviewed literature. These materials align with the principles of the circular economy, aiming to minimize waste and resource use throughout the packaging lifecycle, incorporating new regulations also product of changes in consumers' behaviors. This way, being characterized by enhancing a high percentage of conscious consumers, the European Union (EU) is at the forefront of this movement, with regulations such as the Single-Use Plastics Directive (SUPD) and the Circular Economy Action Plan (CEAP) promoting the use of recyclable and biodegradable materials in food packaging (European Parliament and Council, 2019).

These models include, reusable, refillable, compostable, and recyclable packaging solutions, each offering unique benefits and challenges (Shankar et al., 2024). Also, the study highlights the benefits of SSbD, Reuse or returnable packaging as the best models taking into consideration their cost-effectiveness, economic impact and investment possibilities. Moreover, as previously stated, consumer preferences play a crucial role in shaping the food packaging industry.

The literature indicates a growing demand for sustainable packaging options, driven by increased environmental awareness among consumers, particularly younger demographics. However, there remains a gap between consumer attitudes and actual purchasing behaviors, suggesting that while sustainability is valued, other factors such as convenience and cost also significantly influence consumer choices (Vanapalli et al., 2021).

Taking this into account the aforementioned the literature on food packaging reveals a substantial body of knowledge regarding sustainable practices, regulatory frameworks, and consumer behavior. However, several gaps and limitations require further investigation to enhance the understanding and application of this sustainable food packaging solutions.

One of the critical gaps identified in the literature is the inconsistent adoption of sustainable packaging practices across different regions and sectors. While the EU has made significant steps in promoting sustainability through regulations like the SUPD and CEAP, other global regions lag behind, often due to weaker regulatory frameworks, power, infrastructure or limited consumer demand. This disparity highlights the need for more globalized efforts and the harmonization of standards to ensure widespread adoption of sustainable practices.

The literature also points to a need for more empirical research on consumer behavior concerning sustainable packaging. While there is a general consensus that consumers are increasingly aware of and interested in sustainable packaging, the disconnect between attitudes and actual purchasing behaviors suggests that more research is needed to understand the underlying factors influencing consumer choices, taking into account the current scenario where income is more limited at regular consumer level (Sandberg, 2022). Beyond this main factor, examining the role of education, marketing, and product availability in shaping consumer behavior also seems key to have a better understanding (Vanapalli et al., 2021).

Thus, while the existing literature provides a solid foundation for understanding the trends and challenges in the food packaging sector, further research is necessary to explore the global adoption of sustainable practices, the economic impacts of circular business models, the factors influencing consumer behavior, and the role of emerging technologies in shaping the future of food packaging.

6.1 Comparability and research gaps

It is also necessary to compare our results with recent studies published. For the sake of a offer an up-to-date study, our results have been compared with similar studies from 2022 onwards. This section compares key thematic areas, including consumer purchasing behavior, regulatory frameworks, technological advancements, and industry investment trends, to identify consistencies and deviations between the review's findings and contemporary research. Additionally, it highlights critical research gaps. By integrating insights from well-known recent academic literature, this comparative review aims to enhance the depth and validity of this study while providing a roadmap for future research and policy discussions in sustainable food packaging.

6.1.1 Sustainable packaging business models

The review identifies both linear (e.g., single-use, bulk, and disposable) and circular (e.g., reusable, returnable, and Safe and Sustainable by Design—SSbD) models. Recent studies reinforce the dominance of circular models, particularly in regulatory discussions. Research from Frontiers in Sustainable Food Systems incorporated to our study (Taner and Çolak, 2024) highlights the growing adoption of compostable, biodegradable, and recyclable packaging, aligning with the review's conclusions. However, one notable gap in the review is the absence of a detailed discussion on regional adoption disparities and the economic feasibility of each model in different sectors.

6.1.2 Consumer willingness to pay for sustainable packaging

Our review notes that while consumers express a preference for sustainability, cost and convenience often dictate actual purchasing decisions. However, contrasting evidence from a 2024 PwC (PwC, 2024) study indicates that European consumers are still willingness, but not actual data on purchasing, to spend an average of 9.7% more on sustainable packaging, despite economic pressures. The review does include a temporal tracking of pre and post-pandemic behavioral shifts, so its arguable to think that this is an ongoing trend. While price remains a factor for taking action, consumer demand for sustainability is still increasing, particularly among the younger population.

6.1.3 Regulatory frameworks and policy comparisons

Our review discusses latest regulation developments at eU level: EU policies such as the Circular Economy Action Plan (CEAP) and the Single-Use Plastics Directive (SUPD), emphasizing their role in pushing businesses toward sustainable models. This is consistent with recent regulatory developments, such as France's Anti-Waste & Circular Economy Law (Scantrust, 2022), which mandates reusable packaging. However, others studies (Pantazi, 2024; Thorens et al., 2025) highlight that the U.S. remains behind the EU in implementing legally binding sustainability policies, instead relying on voluntary corporate commitments. After reviewing other articles, we think this review accurately notes regulatory disparities but, maybe due to the proprietary nature of the review study, lacks own quantitative comparisons of compliance rates between EU and non-EU markets.

6.1.4 Technology in sustainable packaging

The review mentions the role of AI, IoT, and blockchain in improving transparency and efficiency in the packaging industry. Recent research provides concrete evidence of AI-driven improvements (Taner and Çolak, 2024) found that AI-driven material optimization has increased efficiency by 20–40% in certain food sectors, such as dairy. Additionally, studies (Da Costa et al., 2023) highlight that while IoT sensors are being integrated into packaging for real-time freshness tracking, adoption remains limited due to high costs.

6.1.5 Material innovations and circular economy strategies

The review highlights bioplastics, compostable packaging, and smart packaging trends, aligning with MDPI (2023) findings on material advancements. However, newer studies emphasize emerging trends such as edible packaging, particularly seaweed-based films, which remain niche but are gaining traction. One major research gap

in the review is the cost–benefit analysis of biodegradable alternatives versus traditional plastics—a crucial factor for industry decision-makers.

6.1.6 Industry barriers to adoption and investment trends

The review correctly identifies cost, logistics, and regulatory challenges as primary barriers to sustainable packaging adoption. However, recent reports from Feber et al. (2023) and PwC (2024) indicate that investment in sustainable packaging is rising, with large retailers pressuring suppliers to adopt eco-friendly solutions. The review does not explore how major companies are funding sustainability efforts, a crucial aspect for understanding the feasibility of transitioning to sustainable business models.

6.1.7 Research gaps and areas for further study

The review acknowledge has been unable to identify empirical data on consumer spending behaviors from 2022 onwards, particularly in relation to sustainability preferences across different demographics. Recent studies indicate regional and generational variations in willingness to pay, which should be addressed but not in actual spending.

A quantitative analysis comparing the profitability and cost-effectiveness of models like SSbD, reusable, and compostable packaging would strengthen the review's argument. However, this cannot be found within the review results and more time would be needed to receive or visibilize this data among the scientific community.

While the EU is extensively covered, Asia and the U.S. have implemented varied regulatory approaches that should be analyzed. There is evidence that the EU is a major global driver, for such policies, but the focus of the article limited this comparisons.

On technology, the review relies on external sources for case studies on how technologies as AI and blockchain are actively improving supply chain efficiencies in food sustainable packaging. Future studies should delve into these case studies where more abundant.

A deeper look into corporate sustainability commitments, venture capital investments, and financial feasibility would provide a more comprehensive picture of business model transitions. However, due to trade secret nature of companies' business models this is not always transparent nor accessible for researchers.

7 Conclusion

Firstly, the global food packaging market is expanding rapidly, driven by urbanization, changing consumer habits, and the demand for longer shelf life of food products. However, this growth has also led to significant environmental challenges, primarily due to the widespread use of plastics. The literature highlights the urgent need to facilitate the ongoing transition to sustainable materials such as bioplastics, compostable packaging, and other sustainable alternatives that align with circular economy principles.

Secondly, business models within the food packaging sector are evolving from traditional linear approaches to more innovative circular models. These circular models focus on reducing waste and resource use, with strategies such as reusable, refillable, and recyclable packaging gaining traction. The literature finds that while these models offer environmental benefits, their adoption is uneven across regions and industries, pointing to the need for more harmonized global efforts (Shankar et al., 2024). SSbD, Reuse and Returnable packaging stand out over the rest of current business models. Packaging as a Service is also on the rise.

Thirdly, consumer behavior plays a critical role in shaping the food packaging industry. There is a growing demand for sustainable packaging options, particularly among younger consumers who prioritize environmental responsibility. However, the literature identifies a gap between consumer attitudes and actual purchasing behaviors, suggesting that other factors, such as cost, income, and convenience, continue to influence decisions. This finding highlights the importance of educating consumers and providing clear information on the benefits of sustainable packaging (Vanapalli et al., 2021).

With this in mind, the future of the food packaging sector lies in its ability to balance sustainability with economic viability, consumer preferences, and regulatory requirements. There are still considerable gaps in the global adoption of sustainable practices. Regional disparities in regulatory frameworks, economic challenges associated with transitioning to circular models, income and cost and the complex nature of consumer behavior all pose significant hurdles. Addressing these challenges will require concerted efforts from all stakeholders, including policymakers, industry leaders, researchers, and consumers (Vanapalli et al., 2021).

Emerging technologies offer promising solutions to many of these challenges, providing tools for more efficient packaging design, better supply chain management, and enhanced consumer engagement. However, the practical implementation of these technologies in the food packaging sector remains in its early stages, necessitating further research and development (Shankar et al., 2024).

Looking ahead, the food packaging sector must continue to innovate and adapt to the evolving demands of sustainability since it cannot help by themselves unlocking sufficient income to consumers to make them embrace all the sustainability option. Thus, the sector must adapt and involve not only new materials and technologies but also rethinking business models and consumer education strategies. The shift toward a more sustainable food packaging system is not just an environmental imperative but also a strategic opportunity for businesses to align with consumer values and regulatory trends (Unilever, 2024).

Author contributions

JP: Conceptualization, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. MF: Writing – original draft, Writing – review & editing. VM: Data curation, Writing – original draft. LO: Data curation, Validation, Visualization, Writing – review & editing. LC: Validation, Writing – review & editing. PR: Data curation, Validation, Writing – review & editing. WH: Supervision, Validation, Writing – review & editing.

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Generative AI statement

The authors declare that Gen AI was used in the creation of this manuscript. AI was used to find sources when encountering knowledge gaps. Aprox 5% of the source were found through this methodology. No other use of generative AI tools.

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