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Review

Food Plastic Packaging Transition towards Circular Bioeconomy: A Systematic Review of Literature

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Abstract: Advancement in packaging technology has played an essential role in reducing food waste and losses; however, most of this technology relies mostly on the use of plastics. Thus, there is an imminent need to think seriously about the transition towards a circular bioeconomy of innovative biobased materials with biodegradability potentials. This paper examines the driving forces behind the changes in food plastic packaging regimes and specifically seeks to understand how socio-technical configurations may influence niches to transition to a circular bioeconomy, particularly biobased biodegradable plastic materials. By employing a systematic review of the literature, we find that coordination with other back-end socio-technical systems that provide valorization of packaging waste is crucial to enable the transition. The literature indicates that one possible transition path is that the biobased biodegradable materials serve as "carriers of food waste". The paper contributes to the discussion on the dynamics of food packaging in the transition to a bioeconomy viewed through the lenses of a socio-technical system (niche–regime–landscape), which continues to reinforce future actions, leading to better management of packaging end-of-life.

Keywords: bioeconomy; bioplastics; biodegradable; biobased plastics; multi-level perspective; sustainable transition

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1. Introduction

Every year 1.3 billion tons of food are lost or wasted globally; this is equivalent to one-third of the food produced annually [1]. Another study claims that every year between 194–389 kg of food is lost and wasted per person globally and between 158–298 kg in the European Union (EU) [2]. Recent data estimates these wastes and losses to cost UK households on average £500 per year [3]. Concerned by the rate of consumption that drives food waste and losses, one of the UN Sustainable Development Goals (SDG 12.3) aims to reduce by half, per capita, the food waste at the retail and consumer levels, and food losses from production and the supply chain by 2030 [1]. In this respect, advancements in food packaging technologies have played an essential role in reducing food waste by extending food shelf life [4]. Nonetheless, ironically, most packaging technology that improves food freshness relies mostly on the adoption of plastics.

Each year, about 25.8 million tons of plastic waste are produced in Europe [5], where plastic packaging accounts for nearly 40% of plastic taken up by the market [6] and less than 30% of plastic waste is collected for recycling [5]. A percentage of this leaves the EU to be processed in developing countries, where different environmental requirements may apply [5]. This has led to a significant economic and environmental impact in which plastic waste continues to leak into the ocean (from sources that come from both land and sea). Globally, 5 to 13 million tons of plastic end up in the oceans every year [5].

In response to the environmental issues of plastic waste, several innovative biobased materials with biodegradability potential have emerged in the plastic packaging market, offering an alternative to meeting the demands of more environmentally friendly customers. These new types of polymer are often claimed to potentially be a substitute for traditional plastic packaging materials.

Furthermore, greater adoption of biodegradable packaging could provide economic benefits to the UK's bioeconomy of over £267 m per year by 2025 [7]. Bioeconomy is cited as one opportunity to encourage the transition towards clean growth; however, it is still in the early stages and "the economic potential of harnessing the power of bioscience, using renewable biological resources to replace fossil resources in innovative products, processes and services" [8] (p. 9), has not yet been achieved.

This paper purposefully looks at changes in food plastic packaging transitions to a circular bioeconomy, focusing on biobased biodegradable plastic materials. Extant contributions in this domain cover a varied but fragmented range of topics that have studied how the transition of the bioeconomy may evolve concerning the different sectors involved in a sustainable transition. Examples can be found in forest-based bioeconomy [9,10], bioplastics and biolubricants for the road and aviation sectors [11], value networks that can facilitate the diffusion of sustainable innovation in food packaging [12], the adaptation of business models for a biocircular economy [13–15] and co-innovation mechanisms [16].

It has been highlighted that the study of the dynamics of different biobased niches is essential to understand the dependent relationship between the various actors and socio-technical systems. However, the literature on sustainable transitions theory towards a circular bioeconomy, and its impact on the economy and society, remains poorly understood [17], particularly concerning the sustainable transition dynamics of bioplastic products in the food plastic packaging sector. Accordingly, this paper addresses the following research questions:

- How does the broader contextual development (landscape) influence the food packaging sector's transition towards a circular bioeconomy?
- What is the potential of the socio-technical configurations (niche innovations) to change the existing food plastic packaging regime towards a circular bioeconomy?

We aim to contribute to the discussion on the dynamics of food packaging on transitions to a bioeconomy, which implies a deeper and more holistic understanding of different socio-technical system levels (niche–regime–landscape), by focusing on the factors that influence the biobased biodegradable materials for food packaging and the interaction with other socio-technical regimes. We would argue that the solution is complicated since there is not just one obstacle to introducing alternative materials, such as biobased biodegradable plastics, but a whole range of factors that work against the replacement of conventional plastic packaging. Biobased biodegradable plastic innovation is not isolated; it implies interacting with a consolidated plastic packaging regime and its articulation with the landscape and other socio-technical regimes (e.g., packaging, biofuel, agri-food regimes, etc.). For this reason, we focus on the food packaging transition towards a bioeconomy through the lens of a theoretical transition framework, which sees sustainability transitions as a long-term, multidimensional and profound transformation towards sustainable modes of production and consumption [18].

The paper will proceed as follows. The next section describes one of the most well-known transition models on social-technical systems—the multilevel perspective (MLP) [19–21]—and also the bioplastic materials. Section 3 describes the methods used to conduct this study and its results; a systematic literature review (SLR) using the search strategy by the preferred reporting items for systemic reviews and meta-analyses (PRISMA) guidelines and the bibliometric analysis. In Section 4, we analyze the results through three conceptual groups to link the food packaging transition to a circular bioeconomy, coinciding with the MLP model: food packaging niches, food packaging regime, and food plastic packaging landscape. In Section 5, we discuss the main results, and finally, in Section 6, we discuss the contribution to theory, implications for practice, limitations, and future research.

2. Conceptual Background

2.1. Socio-Technical System: The Multi-Level Perspective (MLP)

The sustainability transition literature has contributed to the understanding and conceptualizing the complex and long-term transformation needed to shift from established socio-technical systems to more sustainable modes of consumption and production [18]. Socio-technical transitions have been defined as "a set of processes that lead to a fundamental shift in socio-technical systems" [18] (p. 956), including not only technology dimensions but also far-reaching dimensions, such as cultural, consumer practices, markets, supply chains, regulation and infrastructures, etc. [22,23].

One of the most well-known transition models on social-technical systems is the MLP [18–21,24–27], which has been used to explain the sustainability transitions [18]. See Figure 1. The MLP involves interactions between three groups: niche innovations, socio-technical regime and socio-technical landscape [23]. The concept of niches originates from evolutionary theories, which analyze technological evolution [27]; early conceptualization from a quasi-evolutionary perspective defines a niche as protected spaces, as "breaded spaces" in which innovation activity takes place [28]. These emerging social or technical innovations are able "to gain a foothold in particular applications, geographical areas, or markets (e.g., the military), or with the help of targeted policy support" [23] (p. 465).

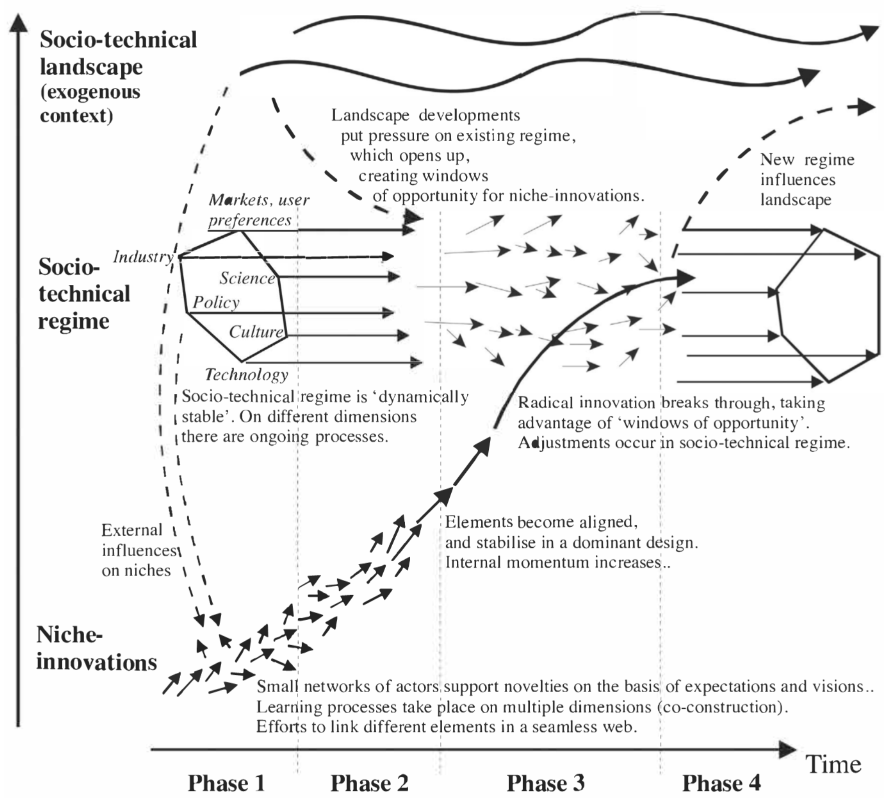

Figure 1. Multi-level perspective on socio-technical transitions. Reprinted with permission from [29]. 2018, Frank Geels.

The regimes are stable configurations of the socio-technical system; because of the stability, regimes involve mainly incremental innovations that are path-dependent on various lock-in mechanisms [21], "deeply entrenched systems around petrol cars, coal and gas-fired power plants, intensive agricultural systems and retail chains with locked-in production and consumption patterns, creating stable, path-dependent trajectories" [20]

(p. 2). Geels describes several path-dependent trajectories and lock-in mechanisms: techno-economic, social and cognitive, institutional and political [21].

The literature on the MLP defines landscape as "broader contextual developments that influence the socio-technical regime and over, which regime actors have little or no influence" [23] (p. 465). Transition developments at the landscape level can comprise slow-changing trends, such as consumer behavior and exogenous shocks, such as pandemics or war [23]. A socio-technical transition occurs through interaction within the three levels. Geels and Schot [22] explain that a transition can start when niche innovations are robust enough to build an "internal momentum" that challenges the dominant regime [22] (p. 400). Moreover, changes in the landscape create pressure for change, creating opportunities for niche innovations that disrupt the current regimes [22].

2.2. Bioplastic Materials

Bioplastics have already proved advantageous in specific applications, such as for horticultural products, disposable packaging, catering and tableware, shopping bags, clothing and cosmetic products, among other uses. Although bioplastic yields much promise, uptake is low and represents less than 1% of 360 million tons of plastic produced per year [30]. It is predicted to increase production from 2.11 million tons in 2019 to 2.43 million tons in 2024 globally [30].

Bioplastics materials can be seen as innovative and—depending on the applications—as a disruptive technology (new functions). Innovation is seen in replacing conventional plastic materials with biobased substitute products, changes to the manufacturing process and value chains, and new business models [31]. For example, a water bottle made with PLA rather than polyethylene terephthalate (PET), or applications that can use as feed-stock wastewater treatment sludge containing mixed microbial consortia and municipal secondary wastewater for polyhydroxyalkanoates (PHA) production. In addition to new customer behavior, new business models have also been innovating to shift towards a circular bioeconomy [31]; some bioplastic producers are closely linked with the catering industry, recycling and composting companies, e.g., Vegware (Vegware—plant-based compostable foodservice packaging).

According to the International Union of Pure and Applied Chemistry (IUPAC), bio-plastics are biobased polymers, i.e., derived from the biomass or issued from monomers derived from the biomass [32].

European Bioplastics association classifies bioplastic materials in three main groups, depending on their sources (fossil-based or biobased) and degradability properties [33]:

- Fossil-based plastics that can biodegrade, such as poly-(butylene adipate-co-terephthalate) (PBAT) and polycaprolactone (PCL);
- Biobased (or partially biobased) and non-biodegradable, such as bio-polyethylene (bio-PE), bio-poly-(ethylene terephthalate) (bio-PET);
- Biobased and biodegradable plastics, such as poly-(lactic acid) (PLA) and PHA.

PBAT can also be considered belonging to two categories, fossil-based polymers and partially bio-based biodegradable plastics since current developments allow that PBAT can be synthesized from a mix of fossil-based and bio-based monomers [34].

Biodegradable polymers can be divided into four main categories, according to their synthesis and sources [35,36]:

- Polymers from biomass resources (i.e., polysaccharides, proteins and lipids);
- Polymers obtained by microbial production (e.g., PHA);
- Polymers chemically synthesized using monomers obtained from agro-resources (e.g., PLA);
- Polymers are produced by chemical synthesis from fossil resources (e.g., PCL, polyester-amides (PEA), aliphatic copolyesters (PBSA)).

3. Methods

3.1. Systematic Literature Review (SLR)

An SLR was conducted, alongside an analysis with a socio-technical theory lens, to address this study's research questions. This approach was adopted for three reasons. First, an SLR exploring studies over a long time (10 years) along with the socio-technical theory, such as MLP, allows us to understand what niche innovations have been emerging in the food packaging area, particularly applications that have the potential to replace conventional plastic. Second, it enables us to describe the current food plastic packaging socio-technical regime and the broader contextual developments that influence the socio-technical regime (landscape). Third, it understands the potential changes towards a transition of food packaging to a circular bioeconomy.

We employed a search strategy using the preferred reporting items for systemic reviews and meta-analyses (PRISMA) guidelines [37] latest version, i.e., 2009 [38] (Appendix A—Table A1). The PRISMA method consists of 27 subtopics and defined sections for a systematic review, such as (1) Title; (2) Abstract; (3) Introduction; (4) Methods; (5) Result; (6) Discussion, and (7) Funding.

The literature's eligibility criteria were bound to peer-reviewed research papers in English, published from January 2011 to 6th January 2021. The information sources included in the literature searches were two widely recognized academic databases, i.e., ScienceDirect and Scopus. The next stage was the search of literature based on the keywords ("food packaging" OR ("food" AND "packaging") AND ("Europe" OR "EU" OR "UK" OR "United Kingdom" OR "England") AND ("plastic")), within the title and abstract. After this, duplicates were eliminated.

Based on these keywords and the eligibility criteria, a refinement of the selection of papers was accomplished, considering titles and abstracts, according to at least one of the following eligibility criteria, which allow the research questions to be answered:

- The study reported niche innovations (social or technical) in the food packaging system;
- The study reported stakeholder relationship within niches of food packaging;
- The study explains the transition of food packaging towards a circular bioeconomy;
- The study is interested in at least one part of the supply chain from food packaging production to consumption;
- The study describes the current plastic packaging regime;
- The study is interested in broader contextual developments (external landscape pressure) that influence the food packaging system, such as policies, regulations, environmental issues, etc.; or
- The study reviews other actors' influence (consumers, policymakers, NGOs, etc.) in the food packaging system.

Those that have no relation to the selection criteria were excluded. Furthermore, we included main reports that influenced the food packaging system from the analysis of the reference lists reported in selected documents, adopting the above-mentioned selection criteria and policy documents suggested by the authors. The process of data collection was carried out through the extraction of the paper selected. The data items process was carried out, including extracting information from the selected articles, to structure the analysis to understand the niche–regime–landscape interactions. The first author read and coded all the chosen articles. To check for consistency, the second author then read and coded randomly selected articles.

3.2. Results of the Systematic Literature Review

The keywords search in the Scopus and ScienceDirect databases identified 167 peer-reviewed papers (141 from Scopus and 26 from ScienceDirect). From the analysis of the reference lists reported in the selected literature review, two reports were added: the Ellen MacArthur Foundation [4] and the European Commission [5]. Besides, another seven documents (five policy documents, one market report, and one academic paper) were added by the authors to complement the policy and market literature review in the UK and included the following topics: plastics packaging tax [39], food waste collection [40], a deposit return scheme (DRS) [41], extended producer responsibility (EPR) [42], plastic market [43], plastic food and drink packaging [44] and end-of waste-life options [45]. In total, nine relevant report documents, mainly policy and market documents, were added. Among these, three were duplicated, and following a review of titles and abstracts according to the selection criteria, 73 peer-reviewed academic papers were shortlisted. Later 15 full-text articles were excluded for other reasons (e.g., the articles were not related to the topic). Therefore, in total, 58 documents were selected for the systematic review (see Figure 2). The full set of papers can be found in Appendix A (Table A2).

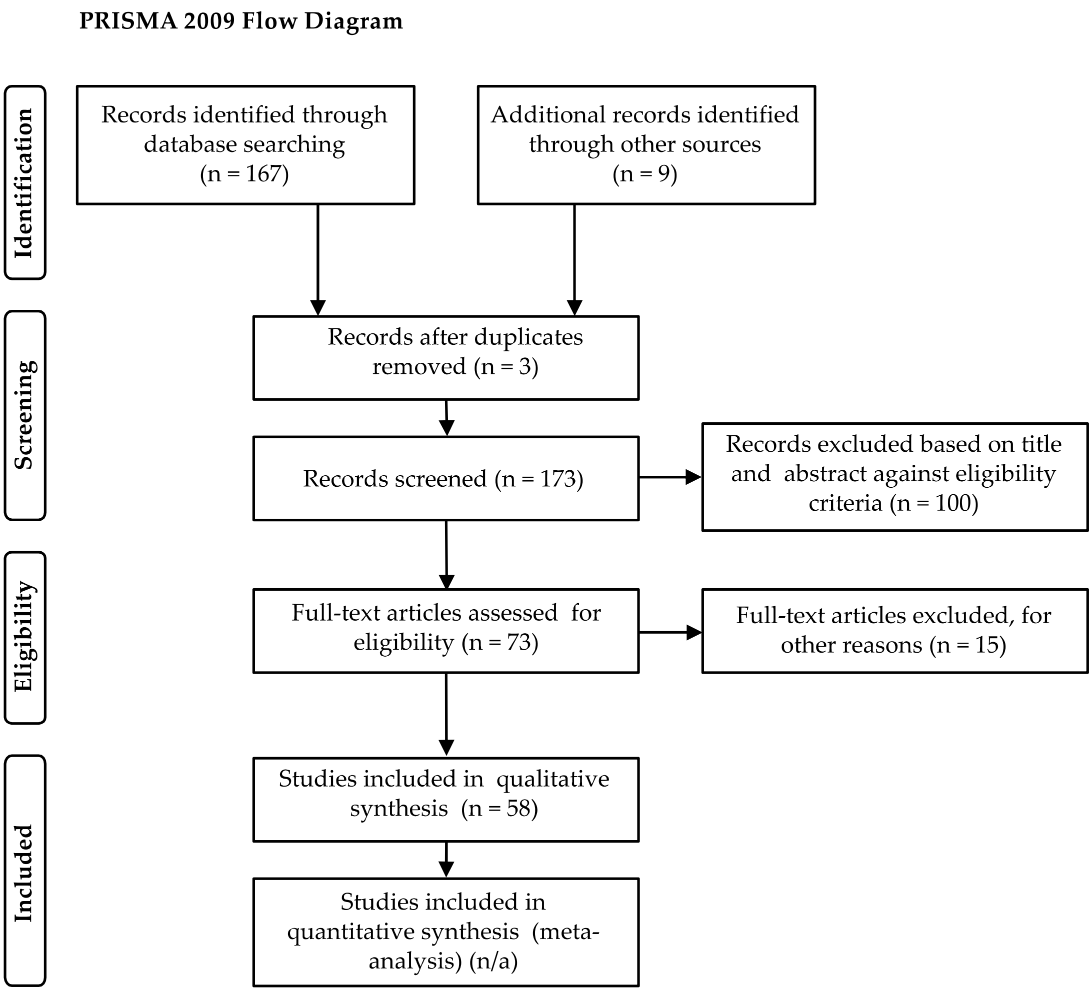

Figure 2. Preferred reporting items for systemic reviews and meta-analyses (PRISMA) flow diagram of the process and steps of the systematic literature review (SLR). Only research papers that met at least one of the following criteria were included in the SLR: (i) the study reports niche innovations (social or technical) in the food packaging system; (ii) the study reports stakeholder relationship within niches of food packaging; (iii) the study explains the transition of food packaging towards a circular bioeconomy; (iv) the study is interested at least one part of the supply chain from food packaging production to consumption; (v) the study describes the current plastic packaging regime; (vi) the study is interested in broader contextual developments (external landscape pressure) that influence food packaging systems, such as policies, regulations, environmental issues, etc., and (vii) the study reviews the influence of other actors (consumers, policymakers, NGOs, etc.) in the food packaging system.

3.3. Bibliometric Analysis

The next step was to conduct a bibliometric analysis to analyze the different topic trends emerging from 2011 to 2021 in the food packaging sector. The 50 selected journal papers were also uploaded in VOSviewer (version 1.6.16). The analysis was carried out using keyword co-occurrence. The weight attribute "Total link strength attribute" was applied [46]. Keywords from the selected papers that occurred more than five times were enrolled in the final analysis. Of the 761 keywords, 25 met the threshold. The nodes' size indicates the frequency of occurrence, and the curves between the nodes represent their co-occurrence in the same publication [46].

Figure 3 shows that two clusters emerged. The red cluster involved technical research about packaging material, biodegradable polymers, plastic products and their properties concerning packaging materials. The green cluster mainly involved the impact of food packaging products on plastic waste or water pollution and recycling. Figure 4 shows the evolution of the topics from January 2011 to January 2021, from blue to yellow. Therefore, the studies selected show how the research has been moving forward from 2011 from technical/bioplastic innovations (e.g., biodegradable polymers, biodegradable plastics, chemistry, water vapor, etc.) to environmental impact (e.g., environmental impact, plastic waste, water pollution, food waste, etc.).

This analysis also allows the visualization of the subset relationship that has emerged from 2011 to 2021. This means that, while food packaging research addresses bioplastic innovations and environmental impacts, social impacts and their actors' interaction remain under-represented. In this context, the emergence of the latest topics, such as food waste, in recent years is positive as it serves to bring connections to consumption patterns. However, a further analysis that explains the relation between the actors and their interactions is needed to understand the bioplastic packaging socio-technical system dynamics.

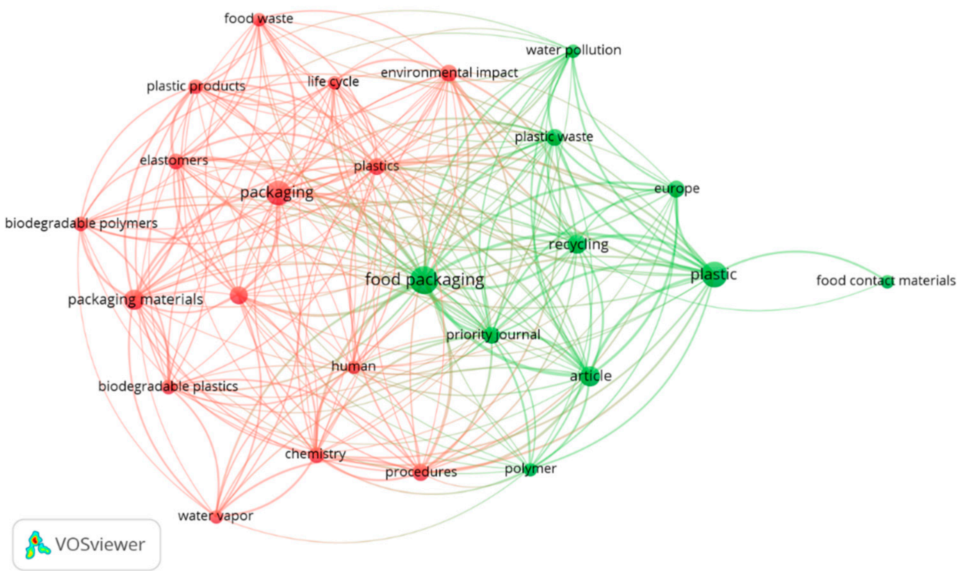

Figure 3. Bibliometric analysis. Distribution of the themes of the keywords of the selected journal articles (50). Two clusters are shown on the map. The red cluster involved technical research about packaging material, biodegradable polymers, plastic products and their properties regarding packaging materials. The green cluster mainly involved the impact of food packaging products, such as plastic waste or water pollution and recycling.

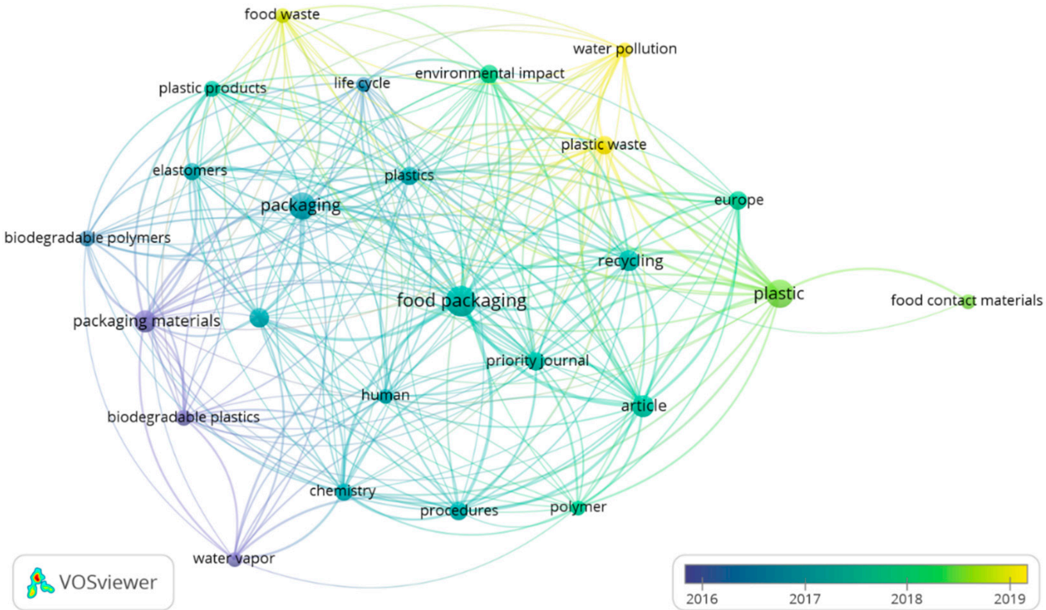

Figure 4. Bibliometric analysis. According to the keywords from the selected journal articles (50) from January 2011 to January 2021, a network map showing the trend topics from blue to yellow. The chosen studies show trends where research has been moving forward from technical innovations (bioplastics and plastic materials) to environmental impact.

4. The Conceptualization of the MLP Elements for the Food Packaging Socio-Technical System

The results are described in the following MLP model in terms of niche, regime and landscape for better understanding. This conceptualization is not aimed at strictly defining the actors, organizations, or initiatives that belong to one particular level or another because all levels interact and evolve. Instead, the aim is to structure the analysis to understand niche–regime–landscape interactions.

4.1. Food Packaging Niches

The SLR includes the description of different innovative materials that have emerged from 2011 with biodegradability potential as an alternative to conventional plastic packaging. Biodegradable materials have been recognized as an emerging alternative for the food packaging industry (e.g., compostable plastic bags) [5]. Examples of such innovations are poly (lactic acid) (PLA) (Including additives) [47–49], poly (3-hydroxybutyrate) (PHB) [50] or cellulose-based waste products [51], polymers or biopolymers that extend shelf life (active food packaging) [52,53], biodegradable edible films [54,55], other biodegradable materials [56]. See Section 2.2 for a more comprehensive description of bioplastic materials.

Biobased plastics provide advantages to reduce the dependence on dwindling fossil-based resources. However, there is concern about the broader environmental impact; for example, competition between growing crops to supply food or supply resins for the bioplastic industry (biobased biodegradable products) [57]. The biodegradability of different biopolymers in different environments also needs to be revised [57]. Biobased (and biodegradable) materials are usually more expensive than conventional plastic materials [3,4,58]; this is a market in which end-users are willing to pay more for products deemed to perform in a more environmentally friendly way. For instance, an Italian market study suggested that consumers prefer biodegradable water bottles instead of PET, and thus they are willing to pay more for these alternatives [59].

Moreover, the waste management industry's link is still weak, depending on the type of biopolymer (biobased, non-biobased, biodegradable, non-biodegradable or a combination of them) (see more information in Section 2.2). Different end-of-life waste management options for bioplastics products are potentially available, such as *mechanical recycling*, *chemical or feedstock recycling, aerobic composting, anaerobic digestion* or *energy recovery* [45]. However, from the literature review, it is not clear what the preferable end-of-life option is (from a life cycle analysis perspective) since it depends on the bio-polymer, packaging applications, and other parameters included by the authors. See for example [60,61].

In turn, these options are interconnected to waste collection and a sorting infrastructure, certification and processing capabilities (and reprocessing if applicable). However, this does not mean that all the options are readily available and well interconnected as part of a circular economy and/or biocircular economy (e.g., biobased biodegradable plastic packaging). Several examples in the selected literature show the dichotomy between technically feasible options and the infrastructure or processes needed.

For example, it is possible to implement a sorting technology to separate the biodegradable packaging waste from mixed plastic streams into separate mono streams to avoid contamination of conventional waste streams [45]. However, a report from the House of Commons in the UK pointed out that a local waste collection system's coherence is needed, including waste separation and communication with consumers [44]. Consumers could be confused because local waste management is not homogeneous: "depending on local infrastructure, consumers will need to be told to dispose of their compostable packaging with food waste only if it is sent to IVC (in-vessel composting). If their food waste is sent to anaerobic disposal, it should go in the residual bin" [44] (p. 28).

Besides, the necessary and correct environmental conditions need to be established to break out the biopolymers [5], such as humidity, ventilation and pH (Payne (2019) as cited by [6]). Also, the literature shows a gap between certification and actual biodegradation performance. Zhang, et al. [62] reviewed the anaerobic degradation of nine biodegradable plastic materials certified under EN13432; they concluded that only four showed substantial biodegradability.

Even if the right certifications and environmental conditions are in place (e.g., humidity, ventilation, pH), the industrial facilities (aerobic and anaerobic processing) and handling processes need to be available. Stagner [63] argues that anaerobic digestion is a viable and preferable option for some biodegradable plastic because the methane produced by this process can generate heat and electricity. However, with the current infrastructure in the UK, the biopolymer packaging materials are not currently processed and "operators will seek to extract it as they do with plastic contamination and send it to energy from waste (a type of incineration) or landfill" [44] (p. 28).

Finding 1: Numerous biobased biodegradable materials have emerged in the food plastic packaging market as an alternative to conventional plastics, reducing the reliance on dwindling fossil-based resources. However, some of the notable issues to fostering a sustainable transition to those materials include the high costs of the biopolymers and the end-of-life processing options (waste management) that do not seem to be readily available on an industrial scale. This has triggered the need for future research to investigate the link between feedstock production, biodegradability capability and processability of bioplastic waste (end-of-life).

4.2. Food Packaging Regime

The selected academic articles and reports help to explain the trajectory of the main actors that collaborate in the food packaging supply chain, such as packaging manufacturers (e.g., bottles), food and beverage producers (e.g., mineral water), retailers (e.g., supermarkets), consumers, and also their associated practices and challenges.

The plastic packaging market is dominant and well established [57]; in 2018, plastic production was about 359 million tons globally and 61.8 million tons in Europe [43]. Packaging by far accounts for the largest end-use market [43], and PET is one of the critical materials in the packaging sector, particularly the bottle market for beverages [64].

The plastic packaging industry has benefitted from significant innovation and research; plastic materials have properties and characteristics that could explain their success in the packaging industry, such as better protection against spoilage/breakage, diversity, costeffective, processability, lightweight, offer savings in freight costs and allow for an attractive display of products [65]. For example, PET has achieved high processability through extrusion, thermoforming and different molding techniques [64]. Although the plastic application's diversity and its characteristics are crucial to understanding its widespread success, it is also necessary to identify the social and institutional contexts along with this success.

Marty [66] studied the introduction of plastic bottled water in the French market in 1968 and its trajectory by the mineral water company Vittel. Its success was an interaction between demand for packaging, packaging product consignment (e.g., glass returnable bottles and plastic and food production innovations) [66]. The new disposable bottle was rapidly adopted by the competitors, becoming a mainstream consumer product in a context of "growing demand for packaging, significant difficulties created by the consignment of consumer products in the national market, and important innovations in the field of plastics and food production processes" [66] (p. 503).

Equally important, plastic packaging is embedded in our daily practices. It is expected, unnoticed and easily discarded [67]. The single-use products reflect these practices; for example, more than seven million single-use coffee cups are used daily in the UK [68]. Plastic packaging also has helped to reconfigure the meaning of freshness of the food "from "sealing in freshness" to extending shelf life" [67] (p. 401). Hawkins, who undertook a postwar historical review, observed the trajectory of conventional plastic packaging from a niche market to an established regime in the supermarkets, which she called the "skin of commerce" as a result of the articulation of plastic material and the market [67].

Nevertheless, the successful adoption of plastic packaging has also contributed to the current waste environmental crisis; over 90% of plastic applications rely on fossil-based plastics from the virgin feedstock, account for 6% of total oil consumption and, by 2025, are expected to account for 20% [4]. On top of that, after more than 40 years since the introduction of the first recycling symbol, only 14% of plastic packaging is collected for recycling [4]. Maye et al. state that only 1 in 400 single-use coffee cups is recycled [68].

The collection, separation of waste and recycling process has been analyzed by a number of authors [69–72], and there are many examples of the challenges for the recycling of plastic materials. From the literature, it is difficult to understand the preferable end-of-life option for conventional plastic from a life cycle analysis perspective (plastic or bioplastic material) (See [73–75]). For example, many of today's food packaging options consist of multilayer materials that pose significant challenges for mechanical recycling or, so far, cannot be cost-effectively recycled [6]. Black plastic is a particular problem because it is not generally recycled, and it contains harmful additives, which are required for black plastic production [76]. Chemically recycled plastics and the recycling process may be better suited for food packaging applications; however, the lower cost of virgin materials has created adverse incentives to use chemical recycling [6].

Some rigid and flexible plastics applications are recyclable, such as food containers, pots, tubs and trays made from various polymers, and LDPE (low-density polyethylene) film [6], and, depending on the material and recycling process, recycled plastic materials also meet the safety regulations [77,78]. Note that different authors have also researched the compliance of the safety regulations used to recycle post-consumer plastic materials into food contact materials [78–83]).

Finding 2: The plastic packaging market is dominant and well established; it also has benefited from significant innovation and research. Moreover, plastic packaging is embedded in our daily life and has helped to improve the freshness of food by extending its shelf life. Unfortunately, the food packaging regime is also responsible for some of the issues related to its environmental impacts due to its low recycling rate and dependence on virgin fossil carbon resources.

4.3. The Landscape of Food Plastic Packaging

One of the main problems for the conventional plastic packaging socio-technical system is plastic materials' environmental impact [57]. The Ellen MacArthur Foundation [4] reported that annually 8 million tons of plastic end up in the ocean, which is expected to double by 2030 and double again by 2050. Different authors have reported plastic pollution in different environments: macroplastic pollution in freshwater [84], plastic litter found on beaches [85,86], plastic on the seafloor [87], microplastics contamination of treated wastewater [88], microplastics detected in the human stool [89] and oxo-plastics [57].

A circular economy has been widely promoted to tackle environmental problems and limited non-renewable resources [4]. For example, different authors have studied the circular economy: the benefits of collaboration within the food companies supply change [90]; consumers' behavior within the circular economy [91]; and integration of the circular economy with permaculture [57]. Rhodes promotes the decentralization of the resources in which food can be produced locally, reducing the use of plastic packaging, by suggesting "a regenerative design system based on "nature as a teacher", which could help optimize the use of resources in town and city environments, while minimizing and repurposing "waste" [57] (p. 253).

Awareness of the enormous environmental damage can create opportunities for multiple niches to promote material substitution by other packaging materials [4] and new business models [4], such as novel grocery stores that renounce the use of disposable plastic packaging for their entire product range [92]. Moreover, the redesign of packaging could help to reduce the environmental impact (kg CO_2 eq.) by 36% by decreasing the plastic film thickness and reducing the package size by 10% [93].

However, implementation of the circular economy remains limited due to the high degree of cross-chain collaboration required among food systems actors [90]. Moreover, even if the supply chain is radically optimized concerning packaging design, collection, sorting, and recycling, only a net plastic packaging recycling rate of 72% can be attained [69].

In line with the circular economy, the EU has established that by 2030 all plastic packaging within the EU market must be cost-effectively recycled or reusable [5]. This can be an opportunity for innovation for niches and the regime to meet the recycling target expectations and for new materials, such as bioplastics [6]. Moreover, the plastic packaging industry in the UK may also face further legislative changes as a result of the following consultations that impact recycling rates, such as the extended producer responsibility (EPR) [42], deposit return scheme (DRS) [41] and plastic packaging tax [39].

The EPR aims to change the current producer responsibility system for packaging in 2023 [42]. Although the scheme proposal needs to be further developed, the consultation proposes that the packaging producer will manage the "full net costs" of managing packaging waste, consistent with the "polluter pays" principle [42]. EPR is closely linked with the DRS; in the latter, the producers of materials and drinks would be mandated to join the scheme via a "producer fee" and at the end-of-use stage, in order to make it easier for people to adopt this scheme, consumers should obtain their deposit refund from the return points [41].

Moreover, the UK Government has been consulting about introducing a new tax on businesses that produce or import plastic packaging (on any packaging containing less than 30% recycled content) to incentivize the use of recycled material in the production of plastic packaging [39]. However, this consultation is controversial because it includes bioplastic products as part of the tax. The UK government has also proposed legislation for collecting food waste by local authorities in 2023; all curbside properties will have access to at least a weekly separate collection service [40].

The existent literature also highlights that government initiatives are essential and also the relationship between public discourse and governance. For example, [68] argue that the factors that lead to a consumer shift in their behavior regarding disposable coffee cups depend on the environmental messages in the media and, therefore, "enable public scrutiny of current arrangements"; besides, the authors also argue for transparency in corporate social responsibility making it easier for stakeholders to confront companies regarding their actions [68] (p.311).

However, the problem is complicated because plastic packaging reduction (e.g., multi-layer) may need to consider a tradeoff when removing plastic packaging from food. It may reduce shelf life but increase food waste [6,94].

Finding 3: The main factors that have shaped the landscape of food plastic packaging are (a) plastic pollution impact on different environments; (b) circular economy; (c) government (policies or discussions), and (d) public opinion. Those factors can drive opportunities for innovating niches, such as biobased biodegradable plastics. Nevertheless, the transition is complex because reducing plastic packaging (e.g., multilayer) could also mean removing plastic packaging from food, which may reduce shelf life and increase food waste.

5. Discussion and Synthesis

Figure 5 shows the current food plastic packaging system. From the point of view of the socio-technical landscape, one could argue that (a) the environmental impacts, as part of the ever-growing accumulation of plastic in the natural environment, (b) the dwindling fossil-based resources available and (c) the increasing sustainable practices and public opinion awareness, are likely to induce further changes and discussions on the plastic packaging socio-technical regime and niche innovation. This will shape the transition of food plastic packaging towards the circular economy and/or bioeconomy. Our bibliometric analysis also confirms that the research topics have been moving forward from technical innovations (e.g., biodegradable polymers, biodegradable plastics, chemistry, water vapor, etc.) to environmental impact (see Section 3.3). Moreover, the current regulatory framework in Europe and policy discussion in the UK (i.e., EPR, DRS, plastic packaging tax, food waste collection) may facilitate the incremental improvement of the existing plastic packaging regime towards a circular economy, fostering recycling and reuse practices. However, they may not necessarily enable the disruption of the current socio-technical plastic packaging regime.

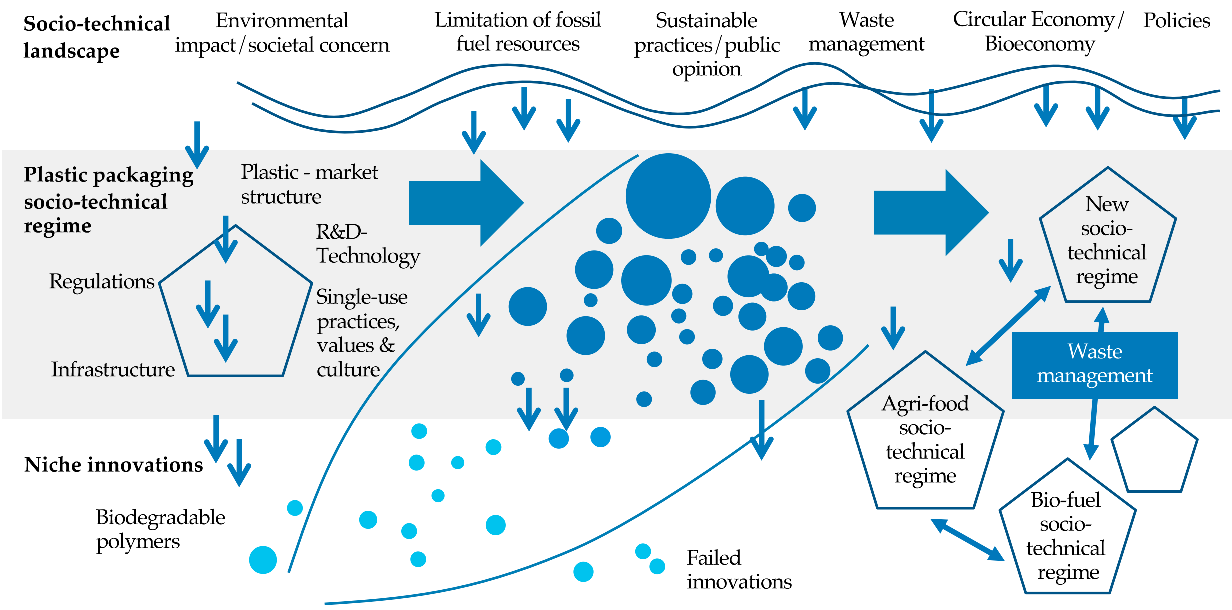

Figure 5. The multi-level perspective on food plastic packaging system.

According to the theory of sustainable transition, the landscape changes need to create pressure for change, creating opportunities for niche innovations to disrupt the existing regimes. Geels and Schot [22] suggest that niche innovations need to be robust enough to build an "internal momentum" that challenges the dominant regime. As reviewed in the niche section, the link with the waste management sector is still weak. There is no clear path implemented to process biobased biodegradable packaging waste. Similarly, waste management is one of the main problems for the current food plastic packaging regime due to its low ability to articulate a circular economy, particularly the end-of-life options. The amount of plastic packaging collected for recycling and actually recycled is still low [4].

We argue that for niche innovations, such as biobased biodegradable plastic material, the articulation of waste management (within a bioeconomy concept) can facilitate building an internal momentum. It is relevant for biobased biodegradable packaging but also for any other innovative niche in the packaging industry. In other words, even if the biobased biodegradable packaging materials are supported by the socio-technical landscape (e.g., environmental benefits, non-fossil fuel materials, sustainable practice, waste management processes, circular economy/bioeconomy, policies, etc.), this will not be enough to induce a regime shift, unless the waste management infrastructure and other socio-technical regimes (e.g., agri-food and biofuel) enable them to make the transition to a bioeconomy.

Smith and Raven [95] affirm that the dynamics of transition lie in how empowerment strategies are developed; niches can either "fit-and-conform" (by adapting to current dominant socio-technical practices) or "stretch-and-transform" (by convincing the social world that the social-technical practices need to change). For example, biobased biodegradable packaging serving as a "carrier of food waste" may be one of the "fit and conform" strategies. The legislation that may support the collection of food waste by the local authorities in 2023 in the UK is under discussion (see DEFRA [40]). In line with this strategy, the Ellen MacArthur Foundation [4] suggested that industrial compostable plastic packaging could be a viable solution for specific applications when there is a low-risk of contaminating the recycling stream (limiting recycling) and could help to put the food's nutrients back into the soil.

Therefore, this strategy may enable the biobased biodegradable industry to open the door to articulate the biodegradable packaging waste with the waste management industry. However, the back-end infrastructure to process the biobased biodegradable packing and food and the back-ends biofuel and agri-food socio-technical regimes need to enable them.

Furthermore, as other authors have suggested, the reconfiguration of a new socio-technical regime with "environmentally friendly attributes" needs to be legitimized with factors that lead consumers to shift their practices. The interaction of niche–regime–landscape has been fostered by a contemporary society that is more aware of the environmental crisis and limited non-renewable resources. In this context, the bioplastic niche sits in a market where end-users are willing to tradeoff higher costs because those materials are deemed to better meet their environmental demands [4,59]. On the other hand, the plastic packaging regime for food is legitimized by consumers and fits into their everyday practices [67]; the million single-use plastic coffee cups used every day [68] reflect these practices.

Therefore, following the practice theory [96], the reconfiguration of a new socio-technical regime needs to take into account how packing is used (e.g., people grab a cup of coffee as part of the commuting routine) and the facilitating mechanism to collect this waste (e.g., labels, dedicated bins, reusable cups, fees to pay for the collection, etc.). Consumer discussions are not about the biobased biodegradable plastic materials but rather about how the reconfiguration of practices is facilitated by niche innovation. The reduction of single-use plastic can also be supported by new ways of thinking about food packaging; for example, decentralization of the resources, so that food can be produced locally can offer some alternative visions that appear to challenge the global system's rules and, therefore, decrease food packaging use. The more contested aspects of food waste are that plastic packaging reduction may need to consider a tradeoff when being removed from vegetables or food because it might reduce shelf life and increased food waste [94].

6. Conclusions

The article has reviewed the food packaging industry's transition to a circular bioeconomy, mainly in the UK. It has situated its analysis within the transition models on social-technical systems, the MLP, particularly in biobased biodegradable plastic packaging niche transition. The article describes the current food plastic packaging system and the system's factors at different levels (niche–regime–landscape). First, the paper asks: "How does the landscape influence change in the food packaging sector towards a circular bioeconomy?" Drivers of transition towards a circular bioeconomy, such as societal concern over environmental issues, dwindling fossil fuel resources, sustainable practices, waste management and policies, and orientation towards a circular economy, have been revised as part of the food packaging landscape. Besides the different actors and legislation in Europe and current policy discussions in the UK, however, we argue that these drivers should be considered with caution because the current food packaging landscape may facilitate the incremental improvement of the existing plastic packaging regime towards a circular economy, thus fostering recycling/reuse practices. Still, they may not necessarily enable the disruption of the current food-packaging socio-technical regime with niche innovations, such as biobased biodegradable plastics or other materials, towards a circular bioeconomy transition.

What then is the potential of the socio-technical configurations (innovations) to change the existing regimes towards a circular bioeconomy? The article argues that different paths depend on the current socio-technical food packaging industry's interactions and the interaction with other back-end socio-technical systems, such as agri-food, biofuel, etc. One example explored the transition path based on the articulation of biobased biodegradable food packaging, serving as a "carrier of food waste", which can open doors for this transition. This may be supported by the current discussions on food waste collection by local authorities in the UK in 2023. However, this will depend on how well the new food packaging socio-technical system fits with the biofuel socio-technical system (e.g., anaerobic digestion industry) and/or the agri-food system (e.g., aerobic digestion/composting and farmers receiving the digestate). Moreover, enablers, such as investments in waste management (collection and processability), are needed, and a deeper understanding of how the biobased biodegradable packaging impacts the different environments.

6.1. Implications for Theory

This study provides a valuable contribution by showing how the sustainable transition theory can further develop the field of food packaging transitions to the circular bioeconomy. It attempts to understand the biobased biodegradable plastics materials (niche innovation) system dynamic that interacts with an established plastic packaging regime and the various actors that configure the plastic packaging landscape. Moreover, our investigation reveals interdependencies with other socio-technological systems; further theoretical elaboration of these interactions could significantly contribute to the MLP models' use.

6.2. Implications for Practice

In practice, this paper identifies a plausible transition path that may open a door for a new socio-technical regime in which biobased biodegradable packaging serves as a "carrier of food waste". However, the further transition also depends on the interaction with other socio-technical systems, investment enablers and the potential environmental impact (e.g., feedstock and biodegradability in different environments). Moreover, this paper emphasizes that the discussion with the consumers is not about the biobased biodegradable packaging materials, but rather about how this niche innovation facilitates the reconfiguration of practices; a new socio-technical regime needs to take into account how packing is used (e.g., people grab a coffee as part of the commuting routine) and the facilitating mechanism to collect this waste (e.g., labels, dedicated bins, reusable cups, fees to pay for the collection, etc.).

6.3. Limitations and Future Work

Despite its contribution to understanding the sustainable food packaging transition, this study has several limitations. The systematic literature methodology adopted in this paper has limitations related to the selected publications, as they become the starting point of the analysis. Examples of such limitations were the authors' documents included to understand the regime landscape (e.g., policies, market reports and waste-management-related papers). The nine documents added were neither part of the search in Scopus nor ScienceDirect. Second, although the analysis is based on a ten-year SLR, and innovation trends can be observed, it cannot predict entirely radical new approaches, processes, and business models that have not been documented in the academic literature. Finally, most of the papers emphasize niche innovation materials (from a technical perspective) or plastic materials rather than the actors and processes involved in this socio-technical system and its landscape.

Further empirical case studies are recommended to reveal different path transitions and the relationship with other socio-technical systems, such as agri-food, biofuel and packaging. Moreover, further elaboration of interactions with other socio-technical systems could significantly contribute to using the MLP models of [19,21]. Finally, the transition process can create opportunities for multiple different niches promoting material substitution by other packaging new materials. Further research is needed to understand how other niche innovations can replace conventional plastic packaging depending on the various applications.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. PRISMA v2009 [38].

Section/Topic	#	Checklist Item	Reported on Section
		Title	
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Title
		Abstract	
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	Abstract

Table A1. *Cont.*

Section/Topic	#	Checklist Item	Reported on Section
		Introduction	
Rationale	3	Describe the rationale for the review in the context of what is already known.	1
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	1
		Methods	
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	3
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	3
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	3
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	3
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	3
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	3
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	3
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	3
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	N/A
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I2) for each meta-analysis.	N/A
Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	3
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	N/A
		Results	
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	3.2
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Appendix A. Table A2

Table A1. *Cont.*

Section/Topic	#	Checklist Item	Reported on Section
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	N/A
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	N/A
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	N/A
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	N/A
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
		Discussion	
Summary of evidence	24	Summarise the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	5
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	6.3
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	6
		Funding	
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	N/A

Table A2. Studies included in the review.

ID	Item Type	Year	Author	Title	Journal/Publisher	Source
1	Book	2011	[65]	Industrial end-use applications	SpringerBriefs in Applied Sciences and Technology	Scopus
2	Journal article	2012	[77]	Going through the barrier	Food Science and Technology (London)	Scopus
3	Journal article	2013	[73]	An extended life cycle analysis of packaging systems for fruit and vegetable transport in Europe	International Journal of Life Cycle Assessment	Scopus
4	Journal article	2013	[78]	Is PET bottle-to-bottle recycling safe? Evaluation of post-consumer recycling processes according to the EFSA guidelines	Resources, Conservation and Recycling	Scopus
5	Journal article	2014	[52]	Extruded polymer films for optimal enzyme-catalysed oxygen scavenging	Chemical Engineering Science	Scopus
6	Journal article	2015	[55]	Effect of protein and glycerol concentration on the mechanical, optical, and water vapor barrier properties of canola protein isolate-based edible films	Food Science and Technology International	Scopus
7	Report	2015	COST	A position paper from the cost action FP1003 Biomatpack	Cellulose Chemistry and Technology	Scopus
8	Journal article	2015	[82]	Scientific opinion on the safety assessment of the process 'PET-M' used to recycle post-consumer PET into food contact materials	EFSA Journal	Scopus

Table A2. *Cont.*

ID	Item Type	Year	Author	Title	Journal/Publisher	Source
9	Journal article	2015	[60]	Life cycle assessment of end-of-life options for two biodegradable packaging materials: Sound application of the European waste hierarchy	Journal of Cleaner Production	Scopus
10	Journal article	2015	[54]	Characterisation of multilayered and composite edible films from chitosan and beeswax	Food Science and Technology International	Scopus
11	Journal article	2016	[74]	Comparative Life Cycle Assessment of Packaging Systems for Extended Shelf Life Milk	Packaging Technology and Science	Scopus
12	Journal article	2016	[70]	Updating and testing of a Finnish method for mixed municipal solid waste composition studies	Waste Management	ScienceDirect
13	Journal article	2016	[49]	Palm oil deodoriser distillate as toughening agent in polylactide packaging films	Polymer International	Scopus
14	Journal article	2016	[63]	Methane generation from anaerobic digestion of biodegradable plastics—a review	International Journal of Environmental Studies	Scopus
15	Journal article	2017	[53]	Recent advances in food packaging with a focus on nanotechnology	Recent Patents on Engineering	Scopus
16	Journal article	2017	[92]	The prospects of zero-packaging grocery stores to improve the social and environmental impacts of the food supply chain	Journal of Cleaner Production	Scopus
17	Journal article	2017	[50]	Post-processing optimisation of electrospun submicron poly(3-hydroxybutyrate) fibers to obtain continuous films of interest in food packaging applications	Food Additives and Contaminants—Part A Chemistry, Analysis, Control, Exposure and Risk Assessment	Scopus
18	Journal article	2017	[72]	Separate collection of plastic waste, better than technical sorting from municipal solid waste?	Waste Management and Research	Scopus
19	Journal article	2017	[48]	Performance properties, lactic acid specific migration and swelling by simulant of biodegradable poly(lactic acid)/nanoclay multilayer films for food packaging	Food Additives and Contaminants—Part A Chemistry, Analysis, Control, Exposure and Risk Assessment	Scopus
20	Journal article	2017	[47]	New PLA/ZnO:Cu/Ag bionanocomposites for food packaging	Express Polymer Letters	Scopus
21	Journal article	2018	[75]	Improving the environmental sustainability of reusable food containers in Europe	Science of the Total Environment	Scopus
22	Journal article	2018	[67]	The skin of commerce: governing through plastic food packaging	Journal of Cultural Economy	Scopus
23	Journal article	2018	[93]	Greenhouse gas emission reduction in frozen food packaging	Environmental Engineering and Management Journal	Scopus
24	Journal article	2018	[57]	Plastic pollution and potential solutions	Science progress	Scopus
25	Journal article	2018	[81]	Safety assessment of the process 'Concept Plastic Packaging', based on Starlinger Decon technology, used to recycle post-consumer PET into food contact materials	EFSA Journal	Scopus

Table A2. *Cont.*

ID	Item Type	Year	Author	Title	Journal/Publisher	Source
26	Journal article	2018	[85]	Beach litter along various sand dune habitats in the southern Adriatic (E Mediterranean)	Marine Pollution Bulletin	ScienceDirect
27	Journal article	2018	[76]	Black plastics: Linear and circular economies, hazardous additives and marine pollution	Environment International	Scopus
28	Journal article	2018	[62]	Degradation of some EN13432 compliant plastics in simulated mesophilic anaerobic digestion of food waste	Polymer Degradation and Stability	Scopus
29	Journal article	2019	[45]	End-of-waste life: Inventory of alternative end-of-use recirculation routes of bio-based plastics in the European Union context	Technology Analysis & Strategic Management	Author
30	Journal article	2019	[87]	A harmonised and coordinated assessment of the abundance and composition of seafloor litter in the Adriatic-Ionian macroregion (Mediterranean Sea)	Marine Pollution Bulletin	Scopus
31	Journal article	2019	[61]	A comparative life cycle assessment of meat trays made of various packaging materials	Sustainability (Switzerland)	Scopus
32	Journal article	2019	[68]	Ethics and responsibilisation in agri-food governance: the single-use plastics debate and strategies to introduce reusable coffee cups in UK retail chains	Agriculture and Human Values	Scopus
33	Journal article	2019	[86]	Baseline and power analyses for the assessment of beach litter reductions in the European OSPAR region	Environmental Pollution	Scopus
34	Journal article	2019	[89]	Detection of various microplastics in human stool: A prospective case series	Annals of Internal Medicine	Scopus
35	Journal article	2019	[80]	Safety assessment of the process Quinn Packaging, based on Erema Basic technology, used to recycle post-consumer PET into food contact materials	EFSA Journal	Scopus
36	Journal article	2020	[83]	Risk Assessment of Food Contact Materials	EFSA Journal	Scopus
37	Journal article	2020	[56]	Reinforced non-conventional material composites: a comprehensive review	Advances in Materials and Processing Technologies	Scopus
38	Journal article	2020	[69]	Technical limits in circularity for plastic packages	Sustainability (Switzerland)	Scopus
39	Journal article	2020	[91]	Incorporating consumer insights into the UK food packaging supply chain in the transition to a circular economy	Sustainability (Switzerland)	Scopus
40	Journal article	2020	[88]	Efficiency of wastewater treatment plants (Wwtps) for microplastic removal: A systematic review	International Journal of Environmental Research and Public Health	Scopus
41	Journal article	2020	[59]	Plastic packaging goes sustainable: An analysis of consumer preferences for plastic water bottles	Environmental Science & Policy	ScienceDirect
42	Journal article	2020	[66]	The true revolution of 1968: Mineral water trade and the early proliferation of plastic, 1960s–1970s	Business History Review	Scopus
43	Journal article	2020	[64]	Polyethylene terephthalate (PET) in the packaging industry	Polymer Testing	ScienceDirect

Table A2. *Cont.*

ID	Item Type	Year	Author	Title	Journal/Publisher	Source
44	Journal article	2020	[51]	Sustainable tetra pak recycled cellulose/Poly(Butylene succinate) based woody-like composites for a circular economy	Journal of Cleaner Production	ScienceDirect
45	Journal article	2020	[79]	Safety assessment of the process Veolia URRC used to recycle post-consumer PET into food contact materials	EFSA Journal	Scopus
46	Journal article	2020	[94]	Removing plastic packaging from fresh produce—what's the impact?	Nutrition Bulletin	Scopus
47	Journal article	2020	[84]	Macroplastic pollution in freshwater environments: Focusing public and policy action	Science of the Total Environment	Scopus
48	Journal article	2021	[90]	Collaborations for circular food packaging: The set-up and partner selection process	Sustainable Production and Consumption	ScienceDirect
49	Journal article	2021	[6]	A review on European Union's strategy for plastics in a circular economy and its impact on food safety	Journal of Cleaner Production	Scopus
50	Journal article	2021	[71]	Lead in plastics—Recycling of legacy material and appropriateness of current regulations	Journal of Hazardous Materials	Scopus
51	Report	2016	Ellen MacArthur Foundation	The New Plastics Economy, Rethinking the Future of Plastics	Ellen MacArthur Foundation	Reference
52	Report	2018	European Commission	A European Strategy for Plastics in a Circular Economy. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.	European Commission	Reference
53	Report	2019	Plastic Europe	Plastics—the Facts 2019. An analysis of European plastics production, demand and waste data	PlasticEurope	Author
54	Report	2019	DEFRA	Consultation on reforming the UK packaging producer responsibility system. Summary of consultation responses and next steps. July 2019	Department of Environment Food and Rural Affairs	Author
55	Report	2019	DEFRA	Consultation on introducing a Deposit Return Scheme in England, Wales and Northern Ireland. Summary of responses. July 2019	Department of Environment Food and Rural Affairs	Author
56	Report	2019	DEFRA	Consultation on consistency in household and business recycling collections in England. Part 1: analysis of responses from members of the public and householders. July 2019	Department of Environment Food and Rural Affairs	Author
57	Report	2019	House of Commons	Plastic Food and Drink Packaging. Sixteenth Report of Session 2017–19. Printed 9th September 2019	Stationery Office	Author
58	Report	2020	HMRC	Plastic Packaging Tax: Summary of Responses to the Policy Design Consultation. November 2020	HM Revenue & Customs	Author

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