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Consumer demand for bioplastics: an umbrella review of barriers and recommendations

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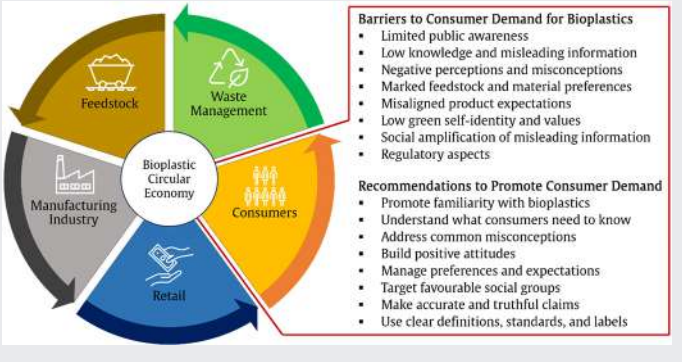
ABSTRACT

Bioplastics are emerging as an alternative to conventional plastics. These hold the promise of a more sustainable alternative that promotes the circular economy, while reducing dependency on fossil resources and negative environmental impacts of conventional plastics. Nevertheless, the success of bioplastics in replacing conventional plastics largely depends on consumers acceptance and demand. Here we conducted an umbrella review with the goal of aggregating and summarizing the findings regarding: (1) barriers to consumer acceptance and demand for bioplastics, and (2) recommendations to promote consumer acceptance and demand for bioplastics. This was accomplished thorough aggregating findings from recently published reviews in the field. Identified barriers include: (a) limited public awareness; (b) low knowledge; (c) biased perceptions and beliefs; (d) strong preferences; (e) misaligned expectations; (f) conflicting identity values; (g) social amplification of misleading information; and (h) complex regulatory landscapes. Recommendations suggest: (a) promoting interaction with bioplastics; (b) understanding what consumers know and what they still need to know; (c) addressing consumers' misconceptions; (d) building positive attitudes; (e) managing expectations; (f) targeting favourable social groups; (g) making accurate and truthful claims; and (h) developing clear standards and labels. Researchers, professionals, and policy makers can find a synthesis of the main barriers to consumer acceptance and demand for bioplastics and comprehensive summary of evidence-based recommendations.

GRAPHICAL ABSTRACT



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1. Introduction

1.1. The concept and IMPORTANCE of bioplasics

Bioplastics are emerging as a possible alternative to mitigate or even solve the negative impacts that conventional plastics have on the environment (Notaro, Lovera, and Paletto 2022a), while reducing the dependency on fossil raw materials, and promoting a shift towards circular economy and cradle-to-cradle principles (Bhagwat et al. 2020). Bioplastics can be defined as plastics that are either bio-based, biodegradable, or both bio-based and biodegradable (Atiwesh et al. 2021; Baranwal et al. 2022; European Bioplastics 2022a). On the one hand, 'bio-based' means that the feedstocks used to produce the plastic are at least partially or fully derived from biomass (e.g. plants; algae; molluscs; bacteria; insects; organic waste). On the other hand, 'biodegradable' means that the plastic, when exposed to specific conditions (e.g. temperature; humidity), can be converted by different naturally occurring organisms (e.g. microbes) into natural substances such as water, carbon dioxide and compost. When this process takes place in proper industrial composting facilities, it enables production and full recovery of valuable materials, including raw materials for bioplastics production (Atiwesh et al. 2021). In that regard, bioplastics reduces dependency on fossil resources by using renewable biomass while offering unique potential for carbon neutrality, but it should not be seen as solution for inappropriate waste management or littering (European Bioplastics 2022a).

1.2. The IMPORTANCE of consumer demand for bioplastics

The circular nature inherent to the concept of bioplastics aligns with the European Union Circular Economy Package (Briassoulis, Pikasi, and Hiskakis 2019) and is seen as an important driver to foster the European Union's transition to a circular economy (Crippa et al. 2019). This is joined with the motivation to upscale production of bioplastics, increasing resource efficiency and reducing dependency on fossil resources (Atiwesh et al. 2021). In fact, industry reports show that bioplastics production capacities are rapidly growing. For example, European Bioplastics (2022b) predicts an increase in production of bioplastics from 2.42 million tonnes in 2023 to 6.29 million tonnes in 2027, with 3.56 million tonnes representing bioplastics that are both bio-based and biodegradable. Nevertheless, for consumers bioplastics represent a novel and mostly unknown technology (Ruf, Emberger-Klein, and Menrad 2022).

While the benefits of bioplastics for the industry and the environment are becoming increasingly recognized, their success on the market critically depends on consumer acceptance (Weinrich and Herbes 2023), which has been extensively studied in relation to other novel technologies, particularly in the food sector (Siegrist and Hartmann 2020). Such research connects with bioplastic applications (e.g. food packaging and biomedical solutions), and highlights that factors such as consumer awareness, knowledge, perceptions, attitudes, and values towards new sustainable products play a significant role. For example, low familiarity, perceived risk, and misinformation associated with novel sustainable products can hinder acceptance and demand, while positive attitudes, trust, and environmental concern often enhance it.

Without consumer acceptance and demand for bioplastics there is no production growth. This is because consumer acceptance and demand are important drivers for business decision making, with impact on the potential profits of companies and on the advancement of legal regulations. Thus, and although the plastic transition to bio-based and biodegradable products is ultimately a joint project involving almost all sectors of the economy and society, the success of bioplastics in replacing conventional plastics, at least in the short term, largely depends on consumers acceptance and demand (Findrik and Meixner 2023; Weinrich and Herbes 2023), and their ability to nudge industry and policy makers towards change. Bioplastics implementation

and consolidation on the market still faces several consumer-side challenges and barriers emerging from the complex interaction with human psychosocial processes (i.e. emotional, cognitive, and behavioural). For bioplastics to succeed such challenges and barriers need to be recognized and overcome. In that regard, this umbrella review aims to identify and summarize: (1) barriers to consumer acceptance and demand for bioplastics, and (2) recommendations to promote consumer acceptance and demand for bioplastics.

3. Methods

There is an extensive body of literature on consumer research on bioplastics, including several systematic reviews published in recent years (e.g. see Findrik and Meixner 2023; Ruf, Emberger-Klein, and Menrad 2022; Weinrich and Herbes 2023). Nevertheless, information about the barriers to consumer demand for bioplastics, and the recommendations to overcome such barriers is still scattered, making it more difficult for researchers, professionals, and policy makers to have a clear and comprehensive understanding of these. In that regard, we conducted an umbrella review (Grant and Booth 2009) with the goal of compiling and summarizing findings from multiple reviews on: (1) barriers to consumer acceptance and demand for bioplastics, and (2) recommendations to promote consumer acceptance and demand for bioplastics. Umbrella reviews allow to compile evidence from multiple systematic and non-systematic reviews into one document, aggregating previously scattered findings and summarizing results in one comprehensive document.

To provide a systematized and replicable approach, we designed a search string (Supplementary Materials Annex I), based in the PICO framework (Richardson et al. 1995). More specifically we used the PIO(S) variation (for a review see Hosseini et al. 2024) to identify published literature reviews (study type) in the field of consumer (population) acceptance and demand (outcome) for bioplastics (intervention). The search string included synonymous and commonly used expressions for each PIO(S) identifier. For example, bioplastics are often referred as bio-based, biodegradable, and even as sustainable or green products, so these different ways of referring to bioplastics were also included. This search string was then used on Web of Science and SCOPUS to identify published literature reviews on the topic. Search was limited to English-language peer-reviewed papers published between 2019 and 2024. This timeframe was chosen due to the introduction of the European Green Deal in December 2019 (European Commission 2019). After removing duplicates, 264 documents remained. These were screened at title, abstract and finally at full text level. Only literature reviews mentioning barriers and/or recommendations related with consumer acceptance and demand for bioplastics were selected. Barriers and recommendations were identified by screening the full text for explicit statements describing, for example, obstacles, challenges, concerns, constraints, or limitations (barriers), and suggested actions, strategies, best-practices, drivers, or solutions (recommendations). A total of 42 literature reviews were identified after the screening, but one was excluded due to the absence of available full text source. The methodological quality of the remaining 41 literature reviews was then assessed by two independent judges using the Overview Quality Assessment Questionnaire (OQAQ; Oxman and Guyatt 1991). This is a validated checklist suitable for appraising systematic and non-systematic literature reviews. After achieving adequate inter-rater agreement ($K = 0.895$) divergencies between judges were resolved by consensus between the judges. As result of this process 5 documents were excluded from the analysis.

The list of 36 literature reviews identified and reviewed in this work can be seen in Supplementary Materials Annex II. To provide additional depth and clarity to the analysis this was further complemented with the review of context (e.g. cross-cultural differences and specific consumer segments) and product specific (e.g. packaging and consumer goods) publications connected to the literature reviews analysed. These publications were identified through title and author searches

on Google Scholar, Web of Science, and Scopus. To provide transparency, the list of the 56 publications reviewed, in addition to the reviewed literature reviews, together with a brief description and goals of the publication, can be found in Supplementary Materials Annex III.

The barriers and recommendations identified in this umbrella review were coded following categories inspired on the Hierarchy of Effects Theory which links influencing factors to consumer behaviour (e.g. see Findrik and Meixner 2023; Ketelsen, Janssen, and Hamm 2020). This model describes a series of steps a consumer undergoes while deciding to purchase a given service or product, highlighting how each step can function as a driver or barrier to purchase, and predict advertising effectiveness (Lavidge and Steiner 1961). Following this framework enabled grouping barriers and recommendations according to themes that were explicitly addressed in the literature reviews (e.g. awareness, knowledge, perceptions, attitudes, and values towards bioplastics). This enabled synthesizing key barriers influencing consumer acceptance and demand for bioplastics, linking them to evidence-based strategies, recommendations, and best practices that can guide researchers, professionals, and policymakers in effectively promoting bioplastics.

4. Results

The work enabled identifying and summarizing a set of barriers and recommendations to consumer acceptance and demand for bioplastics that were previously scattered across several existing literature reviews. These barriers and recommendations were grouped into six main categories based on the Hierarchy of Effects Theory (Lavidge and Steiner 1961), namely: (1) awareness and recognition; (2) knowledge and available information; (3) perceptions and beliefs; (4) attitudes, preferences, and expectations; (5) identity values, goals, and social influence; and (6) policy and regulatory landscapes. Whereas barriers were typically the main focus of the reviewed literature reviews, recommendations were usually a secondary outcome, often resulting in overly generic guidance. To promote a better understanding and add depth about the recommendations and its ramifications to practical applications, insights from behavioural science were included in the analysis. Next, we present each category of barriers and associated recommendations in greater detail.

4.1. Barriers factors to consumer demand for bioplastics

A summary of barriers and respective recommendations can be seen in Table 1.

4.1.1. Limited awareness and recognition

Bioplastic products still have limited availability (Bos et al. 2024; Filho et al. 2022) and are often unfamiliar to consumers (Ruf, Emberger-Klein, and Menrad 2022; Zwicker et al. 2020), particularly non-plant-based bioplastics. As seen in other fields, lack of public awareness and reluctance to new or unfamiliar technologies act as barriers to consumer acceptance (de Marchi et al. 2020; Filho et al. 2022, 2021; Scarpi et al. 2021). Consumers limited awareness about bioplastics extends to its properties, benefits, life cycle, and end-of-life options (Abrha et al. 2022). Moreover, without clear labelling, bioplastics are difficult to distinguish from conventional plastics, creating challenges for both consumer recognition and proper disposal (Dilkes-Hoffman et al. 2019; Taufik et al. 2020). Not being able to differentiate bioplastics from conventional plastics, threatens not only consumer demand but also recovery, undermining the circular economy model intended for bioplastics (Dijkstra, van Beukering, and Brouwer 2020; Morris and Hicks 2022). Altogether, low awareness and difficult recognition makes it hard for consumers to classify their interactions with bioplastics, build meaning, and use their experiences with such products to attest their quality, safety, and functionality, while building trust.

Table 1. Summary of barriers and recommendations to consumer acceptance and demand for bioplastics found in the reviewed literature.

Barriers	Recommendations
Limited awareness and recognition – Limited availability of bioplastic products (Bos et al. 2024; Filho et al. 2022) – Lack of public awareness and reluctance to new technologies (Ruf, Emberger–Klein, and Menrad 2022; Zwicker et al. 2020) – Bioplastic products are relatively new and unknown to consumers, particularly those that are not plant–based (de Marchi et al. 2020; Filho et al. 2022, 2021; Scarpi et al. 2021) – Difficulty in recognizing bioplastic products, and differentiating bioplastics from other plastic products (Dijkstra, van Beukering, and Brouwer 2020; Morris and Hicks 2022) – Absence of clear labelling systems that catch consumers' attention (Dilkes–Hoffman et al. 2019; Taufik et al. 2020)	– Promote awareness, interaction, and familiarity with bioplastic products (Findrik and Meixner 2023) – Highlight the personal benefits of bioplastics (Klein, Emberger–Klein, and Menrad 2020; Ruf, Emberger–Klein, and Menrad 2022) – Promote brand and product involvement, while delivering products that live up to marketing claims (Scarpi et al. 2021) – Use clear labelling systems that can enable quick and automatic identification of bioplastic products and their characteristics (Mehta et al. 2021) – Carefully design and test communication materials with target group consumers (Reinders, Onwezen, and Meeusen 2017; Zwicker et al. 2023)
Low knowledge and available information – Limited or low consumer knowledge and understanding about bioplastics (Bos et al. 2024; Findrik and Meixner 2023; Klein et al. 2019; Maior et al. 2022) – Complexity of bioplastic concepts and terminology (Fletcher 2022; Moshood, Nawanir, and Mahmud 2022) – Lack of clear and trustworthy information sources (Fletcher 2022; Moshood, Nawanir, and Mahmud 2022) – Low knowledge about bioplastic material sources, biodegradability, and disposal methods (Blesin, Jaspersen, and Möhring 2017; Dilkes–Hoffman et al. 2019; Sijtsema et al. 2016) – 'Simply' providing knowledge and information without following up on consumers' needs (Weinrich and Herbes 2023)	– Understand what consumers already know and what they still need to know about bioplastics to make informed decisions (Bruine de Bruin and Bostrom 2013) – Tailor knowledge dissemination and communication activities to identified knowledge and information gaps (Ruf, Emberger–Klein, and Menrad 2022; Weinrich and Herbes 2023) – Focus on what consumers still need to know rather than on the redundancy of what they already know (Bruine de Bruin and Bostrom 2013) – Diversify knowledge dissemination and information activities, tailored to different social contexts and target groups (Klein, Emberger–Klein, and Menrad 2020; Otaki and Kyono 2022; Sang, Yu, and Han 2022) – Coproduce knowledge about bioplastics joining together relevant stakeholders and consumer groups (Confente, Scarpi, and Russo 2020; Laborda et al. 2023) – Select appropriate and diversified knowledge dissemination channels, while building and maintaining consumers trust in such channels (Klein, Emberger–Klein, and Menrad 2020; Otaki and Kyono 2022; Sang, Yu, and Han 2022) – Test knowledge sharing materials and interventions, and monitor their effects on consumers knowledge (Reinders, Onwezen, and Meeusen 2017; Zwicker et al. 2023)
Biased Perceptions and beliefs – Negative and ambivalent perceptions of bioplastics (Onwezen, Reinders, and Sijtsema 2017; Zhuang, Luo, and Riaz 2021; Zwicker et al. 2020) – Perception of high cost, lower durability, and poor performance of bioplastics (Bos et al. 2024; Ketelsen, Janssen, and Hamm 2020; Marcon et al. 2022) – Beliefs and misconceptions about bio–based and biodegradable properties (Corona, Tunn, and van den Broek 2024; Ferreira–Filipe et al. 2021; Taufik et al. 2020) – Perceptions of greenwashing and feelings of deception (Findrik and Meixner 2023) – Perceptions of risk and concerns about the safety and origin of feedstock and final products (Cammarelle, Viscecchia, and Bimbo 2021; Herbes, Beuthner, and Ramme 2018; Karachaliou et al. 2017; Meeks et al. 2015)	– Assess perceptions and beliefs about bioplastics beforehand and identify problematic perceptions and misconceptions (Findrik and Meixner 2023; Onwezen, Reinders, and Sijtsema 2017) – Concisely and systematically addressed problematic perceptions and misconceptions as they are identified (Blesin, Jaspersen, and Möhring 2017; Boz, Korhonen, and Sand 2020; Filho et al. 2022; Herbes, Beuthner, and Ramme 2018; Mehta et al. 2021) – Reinforce existent positive perceptions and accurate beliefs (Rudolph 2018) – Frame communications to avoid the perception of exaggerated or false claims (Fletcher 2022) – Make accurate, relevant, and truthful, claims backed up by sound measurements based on approved and certified standards (Findrik and Meixner 2023) – Minimize the perception of losses by highlighting both the performance aspects that are personally relevant to consumers and the eco–friendliness of bioplastics (Rudolph 2018) – Test communication materials beforehand, and monitor their effects on consumers perceptions and beliefs (Reinders, Onwezen, and Meeusen 2017; Zwicker et al. 2023)

(*Continued*)

Table 1. Continued.

Marked attitudes, preferences, and expectations – Positive attitudes driven mainly by environmental friendliness alone, which often is not enough to outweigh other competing personal goals and values (Klein et al. 2019; Testa et al. 2021) – Preferences for locally produced and plant–based bioplastics, which act as a barrier to consumer demand for other types of bioplastics (Filho et al. 2022; Klein, Emberger–Klein, and Menrad 2020; Scherer, Emberger–Klein, and Menrad 2018; Sijtsema et al. 2016) – Preference for 100% bio–based, with products with lower percentages of bio–based content being perceived as greenwashing attempts (Cruz et al. 2022; Niedermeier, Emberger–Klein, and Menrad 2021; Scherer, Emberger–Klein, and Menrad 2017) – Emphasis on preference for biodegradability over bio–based content (Notaro, Lovera, and Paletto 2022a; Taufik et al. 2020) – High expectations about technical and environmental performance (Laborda et al. 2023; Mehta et al. 2021)	– Focus on bioplastics and product characteristics that align with consumers attitudes, preferences, and expectations (Bangsa and Schlegelmilch 2020; Panda et al. 2024; Zhuang, Luo, and Riaz 2021) – Assess consumers' attitudes, preferences, and expectations towards different types of bioplastics (Notaro, Lovera, and Paletto 2022a; Russo et al. 2019; Weinrich and Herbes 2023) – Build and maintain positive attitudes, and manage consumers' preferences and expectations (Confente, Scarpi, and Russo 2020) – Promote meaningful and positive interactions with different types of bioplastics, focusing on quality, safety, and environmental performance (Confente, Scarpi, and Russo 2020; Sharma, Aswal, and Paul 2023) – Implement social marketing activities across a diverse range of contexts and consumer groups (Fatemi et al. 2023; Koenig–Lewis et al. 2014; Scarpi et al. 2021) – Test communication materials and interventions, and monitor their effects on consumers attitudes, preferences, expectations, and behaviours (Reinders, Onwezen, and Meeusen 2017; Zwicker et al. 2023)
Conflicting identity values, goals, and social influence – Contexts of lower green self–identity, environmental concern, and pro–environmental values (Cao 2023; Scarpi et al. 2021; Zhang and Dong 2020) – Heightened environmental concern of specific social groups and with increase exploitation of animals and land use (Mehta et al. 2021) – Contexts of absence of social norms towards sustainability, particularly pro–environmental norms, and low social pressure to preserve the environment (Reinders, Onwezen, and Meeusen 2017) – Mass media and social media amplification of controversies and misleading or false information about bioplastics (Grebitus et al. 2020; Neves et al. 2020; Scherer, Emberger–Klein, and Menrad 2018)	– Target environmentally conscious and concerned consumers, with a green self–identity and pro–environmental values (Confente, Scarpi, and Russo 2020; Russo et al. 2019; Skoczinski et al. 2023; Zwicker et al. 2023) – Design Marketing campaigns that are transparent, interactive, and aligned with broader societal values (Bangsa and Schlegelmilch 2020; Panda et al. 2024) – Promote consumers' green self–identity and pro–environmental values (Blesin, Jaspersen, and Möhring 2017; Mehta et al. 2021) – Be aware of common pitfalls when leveraging green self–identity, pro–environmental goals and values, and social norms (Filho et al. 2022; Karachaliou et al. 2017; Lestari, Pambekti, and Annisa 2025; Zwicker et al. 2021) – Monitor how emerging environmental and social issues influence consumer responses to bioplastic products (Barbu et al. 2022; Cao 2023; Weinrich and Herbes 2023) – Build information sharing partnerships with media outlets, particular those with sections on innovative and green technologies (Cao 2023) – Strengthen online presence, and foster trustworthy online resources and online communities to coproduce knowledge (Veerabhadrappa, Fernandes, and Panda 2023) – Monitor communication, dissemination, and marketing activities effects on consumer behavioural and psychological responses (Falcone and Imbert 2018)
Complex policy and regulatory landscapes – Lack of clear and uniformized policies and regulations (Cruz et al. 2022; Karachaliou et al. 2017; Mehta et al. 2021) – Lack of policies and regulations that encourage or support consumers to purchase bioplastic products (Koenig–Lewis et al. 2014) – Inadequate labelling systems and misleading labelling, signs, and disposal instructions (Fletcher 2022) – Lack of universally accepted biodegradability standards and need for certification and labelling programs (Weinrich and Herbes 2023)	– Develop and implement shared cross–cultural definitions, that counter identified misconceptions arising from current bioplastics definition (Fletcher et al. 2021; Herbes, Beuthner, and Ramme 2018; Jha et al. 2024; Klein, Emberger–Klein, and Menrad 2020; Lettner, Schöggl, and Stern 2017) – Create uniformized, consistent, and shared certification and labelling programs ratified by government agencies from different countries (Morris and Hicks 2022; Notaro, Lovera, and Paletto 2022a) – Create visible mechanisms to ensure product compliance with policy and regulation, focusing on safety and quality assurance (Filho et al. 2022) – Regulate the use of 'attractive labelling strategies' that can mislead consumers (Bhagwat et al. 2020; Dey et al. 2024; Scherer, Emberger–Klein, and Menrad 2017) – Governments can set incentives for consumers when buying, reusing, and recycling bioplastics (Medeiros et al. 2022)

4.1.2. Low knowledge and available information

With few exceptions (e.g. Filho et al. 2022), the reviewed literature consistently suggests that consumers possess low knowledge about basic concepts, properties, and disposal methods of bioplastics, contributing to slow adoption (Bos et al. 2024; Findrik and Meixner 2023; Klein et al. 2019; Maior et al. 2022). The complexity of bioplastics terminology and the limited availability of clear and trustworthy information were identified as important barriers to consumer understanding (Fletcher 2022; Moshood, Nawanir, and Mahmud 2022). Studies point that consumers are particularly uncertain about bioplastics' environmental impacts, often holding misconceptions about the meaning of biodegradability, while not knowing how to dispose them and that they should not biodegrade outside of composting facilities (Blesin, Jaspersen, and Möhring 2017; Dilkes-Hoffman et al. 2019; Sijtsema et al. 2016). Another consistent finding reported in the literature was that consumers view bioplastics mostly as plant-based, often lacking knowledge about alternative feedstocks, such as food waste, insects, or bacteria (Blesin, Jaspersen, and Möhring 2017). Evidence suggests that simply providing information and/or attempting to 'paternalistically educate' consumers can have negative influence on consumer demand for bioplastic products (Weinrich and Herbes 2023). This is because information provision without accounting for consumers existing knowledge, beliefs, and informational needs can evoke, for example, perceptions of greenwashing, dishonesty, deception, as well as negative and ambivalent feelings (e.g. anger, revolt), hindering consumer's trust and demand for bioplastics (Fatemi et al. 2023; Findrik and Meixner 2023; Onwezen, Reinders, and Sijtsema 2017).

4.1.3. Biased perceptions and beliefs

Consumers hold several perceptions about bioplastics, influenced by misconceptions and limited knowledge, which hinder acceptance and demand (Onwezen, Reinders, and Sijtsema 2017; Zhuang, Luo, and Riaz 2021; Zwicker et al. 2020). While concerns about plastic pollution promote perceptions of bioplastics as environmentally friendly and sustainable (Boz, Korhonen, and Sand 2020; Dilkes-Hoffman et al. 2019), perceptions of lower quality, durability, performance, and high costs often undermine consumer acceptance (Bos et al. 2024; Ketelsen, Janssen, and Hamm 2020; Marcon et al. 2022). Misconceptions about 'bio' and 'biodegradability' further reduce acceptance, leading to improper disposal and scepticism (Corona, Tunn, and van den Broek 2024; Ferreira-Filipe et al. 2021; Taufik et al. 2020). Bioplastics are often perceived as greenwashing attempts due to exaggerated marketing claims, lack of transparency, and unclear labelling (Findrik and Meixner 2023). Non-plant-based bioplastics (e.g. derived from food waste, bacteria, or insects) evoke disgust, particularly for sensitive applications like food packaging, toys, or medical devices (Falcone and Imbert 2018; Laborda et al. 2023; Ruf, Emberger-Klein, and Menrad 2022; Scherer, Emberger-Klein, and Menrad 2017; Weinrich and Herbes 2023). This is often tied to fears of cross-contamination and misunderstandings about product's composition (Cammarelle, Viscecchia, and Bimbo 2021; Herbes, Beuthner, and Ramme 2018). Other sources of risk perceptions include suspicions about industry motives, perceived use of additives or toxic substances, and concerns about use of genetically modified organisms in production (Karachaliou et al. 2017; Meeks et al. 2015). The belief that bioplastics are plant-based also raises fears about food security, hindering acceptance (Blesin, Jaspersen, and Möhring 2017; Notaro, Lovera, and Paletto 2022b).

4.1.4. Marked attitudes, preferences, and expectations

Research highlights that consumers' attitudes, preferences, and expectations significantly influence bioplastics' acceptance and demand (Wijekoon and Sabri 2021). Positive attitudes are primarily driven by perceived environmental benefits (Klein et al. 2019; Testa et al. 2021). However, there are also negative attitudes and attitude-behaviour gap, often driven by competing personal goals and values (Sharma, Aswal, and Paul 2023). Aspects such as quality, price,

visual appeal, and safety tend to be more valued by consumers than environmental friendliness (Martinho et al. 2015; Shaikh, Yaqoob, and Aggarwal 2021). Consumers prefer bioplastics produced locally with local feedstocks and can hold negative attitudes towards products from physically and psychologically distant regions (Filho et al. 2022; Klein, Emberger-Klein, and Menrad 2020; Scherer, Emberger-Klein, and Menrad 2018; Sijtsema et al. 2016). Plant-based bioplastics are favoured over waste-based alternatives, with the latter promoting negative attitudes (Cammarelle, Viscecchia, and Bimbo 2021; Findrik and Meixner 2023). Consumers also prefer 100% bio-based products, associating lower percentages to greenwashing (Cruz et al. 2022; Niedermeier, Emberger-Klein, and Menrad 2021; Scherer, Emberger-Klein, and Menrad 2017). Biodegradability is more valued by consumers than bio-based content, with non-biodegradable bioplastics being less desirable than recyclable or biodegradable conventional plastics (Notaro, Lovera, and Paletto 2022a; Taufik et al. 2020). High consumer expectations about bioplastics' technical and environmental performance can also hinder acceptance, particularly when expectations clash with technical limitations (Blesin, Jaspersen, and Möhring 2017; Fletcher 2022; Lettner, Schöggl, and Stern 2017). Unmet expectations lead to negative attitudes and belief that bioplastics are no better than regular plastics (Laborda et al. 2023; Mehta et al. 2021). Consumers often overlook bioplastics' circular economy benefits, focusing instead on beginning and end-of-life characteristics (Bhagwat et al. 2020; Herbes, Beuthner, and Ramme 2018).

4.1.5. Conflicting identity values, goals, and social influence

Personal and social factors play a key role in consumer acceptance and demand for bioplastics. Individuals with strong green self-identity and values, environmental concern, and health consciousness tend to have more favourable views and higher willingness to pay for bioplastics than consumers without this profile (Cao 2023; Scarpi et al. 2021; Zhang and Dong 2020). High self-congruity with green products further enhances acceptance and value attributed to bioplastics, especially when environmental benefits are clear (Confente, Scarpi, and Russo 2020). However, consumers may not be willing to pay more if the shopping experience is less convenient or affordable (Dijkstra, van Beukering, and Brouwer 2020). Additionally, promoting non-plant-based bioplastics may not appeal to consumers with strong environmental or ethical concerns, such as vegetarians and vegans, particularly if they perceive animals are explored or killed in the production process (Mehta et al. 2021). Social norms also influence bioplastics acceptance, with pro-environmental norms nudging consumers towards these products (Cammarelle, Viscecchia, and Bimbo 2021; Notaro, Lovera, and Paletto 2022a). However, leveraging social norms requires caution; for instance, communicating unrealistic descriptive social norms or associating bioplastics with brands socially represented as 'environmentally unfriendly' may evoke greenwashing perceptions and distrust, particularly among eco-conscious consumers (Reinders, Onwezen, and Meeusen 2017). Mass media and social media also significantly shape consumer perceptions, easily amplifying misinformation and controversies, such as concerns about biodegradability or use of additives (Scherer, Emberger-Klein, and Menrad 2018). Moreover, fake or seemingly contradictory online content can confuse consumers and hinder acceptance (Grebitus et al. 2020; Neves et al. 2020). As noted by Karachaliou et al. (2017) there is the need to create trustworthy, accessible online resources tailored to consumer needs.

4.1.6. Complex policy and regulatory landscapes

Policy and regulation play a crucial role in promoting consumer demand for bioplastics. Research shows that unclear policies and inconsistent labelling, together with the lack of incentives for purchasing bioplastics hinder consumer demand (Cruz et al. 2022; Karachaliou et al. 2017; Mehta et al. 2021). Lack of trustworthy, clear, and uniformized regulations leads to misinformation, confusion, and misconceptions about bioplastics (Koenig-Lewis et al. 2014), with consumers being overwhelmed by non-transparent labels and misleading logos (Fletcher 2022). The absence

of universally accepted biodegradability standards and end-of-life regulations further complicates consumer understanding (Bhagwat et al. 2020; Klein et al. 2019). As suggested by Weinrich and Herbes (2023), governments must establish standards for bioplastic incentives, particularly for reusing and recycling, and need to establish labelling standards that clearly reflect the life cycles of bioplastics.

4.2. Recommendations to promote consumer demand for bioplastics

4.2.1. Promoting awareness and recognition

Boosting public awareness and recognition of bioplastic products, through conscious interactions, is essential for increasing consumer acceptance and demand (Findrik and Meixner 2023). Effective marketing strategies and clear labelling systems can highlight bioplastics' availability and benefits, such as being bio-based, biodegradable, and safe, while emphasizing quality and functionality (Klein, Emberger-Klein, and Menrad 2020; Ruf, Emberger-Klein, and Menrad 2022). These efforts should prioritize personal, social, and environmental benefits over technological aspects or the negatives of conventional plastics (Dey et al. 2024; Filho et al. 2022; Findrik and Meixner 2023). Brand engagement is vital for raising awareness, fostering trust and personal connection, by promoting shared values, fostering trust, and providing information on production techniques and product benefits (Scarpi et al. 2021). Engaging consumers in product design and enhancing sensory connections to bioplastics can increase visibility and interaction (Luo, Wu, and Luximon 2024). Promoting familiarity with bioplastics, combined with trust in their safety, quality, and functionality, encourages positive evaluations and a willingness to adopt circular alternatives (Barbu et al. 2022; Sang, Yu, and Han 2022; Scarpi et al. 2021). To build trust, brands must deliver products that meet marketing claims regarding safety, quality, and environmental friendliness (Klein, Emberger-Klein, and Menrad 2020; Sang, Yu, and Han 2022). Clear and visually distinct labels can promote recognition and shelf visibility, communicating eco-friendly characteristics and encouraging purchasing decisions (Barbu et al. 2022; Corrêa et al. 2022; Ketelsen, Janssen, and Hamm 2020). However, labels must be carefully designed to provide honest and accessible information without confounding consumers (Mehta et al. 2021). Testing labels beforehand ensures they effectively convey key product features and align with consumer emotions and behaviours (Reinders, Onwezen, and Meeusen 2017; Zwicker et al. 2023). Transparency and secure communication through various channels are essential for building trust and driving demand (Camilleri et al. 2023).

4.2.2. Promoting knowledge and information

Promoting consumer knowledge and providing clear, trustworthy information about bioplastics is essential for fostering acceptance and demand. Still, simply providing information is insufficient; understanding what consumers already know and need to know is critical for informed decision-making (Bruine de Bruin and Bostrom 2013). Lack of knowledge and reliable information can lead to negative attitudes, risk perceptions, misconceptions, and distrust (Albarracin and Shavitt 2018; Verbeke et al. 2015). Building awareness and interaction with bioplastics can improve consumer knowledge over time, but immediate strategies should use relatable, jargon-free language through trustworthy channels (Bruine de Bruin and Bostrom 2013; Ruf, Emberger-Klein, and Menrad 2022). Consumers need knowledge to handle and dispose of bioplastics accordingly (Morris and Hicks 2022; Rietz and Kremel 2024). This requires coordinated efforts from researchers, professionals, and policymakers to identify consumers knowledge gaps and preferred communication methods. Initial studies with smaller groups can inform broader standardized surveys to prioritize knowledge dissemination and assess its impact on consumer understanding and behaviour (Bruine de Bruin and Bostrom 2013). Tailored educational campaigns, coproduction of knowledge activities, and public-private

partnerships can be used as tools to improve general knowledge about bioplastics (Ruf, Emberger-Klein, and Menrad 2022; Weinrich and Herbes 2023). Consumers should be active participants in bioplastics development, as their insights are crucial for creating relatable and user-oriented products (Confente, Scarpi, and Russo 2020; Laborda et al. 2023). Reliable and diverse communication channels are vital for shaping consumer knowledge, building trust and avoiding pitfalls misconceptions (Klein, Emberger-Klein, and Menrad 2020; Otaki and Kyono 2022; Sang, Yu, and Han 2022). This requires development of carefully designed and tested knowledge-sharing strategies to address consumer needs, while monitoring their effects to avoid unintended consequences (Reinders, Onwezen, and Meeusen 2017; Zwicker et al. 2023).

4.2.3. Promoting positive perceptions and accurate beliefs

Promoting awareness and providing information about bioplastics alone is insufficient to ensure consumer acceptance and demand. Consumer perceptions and beliefs about bioplastics also need to be addressed. Positive perceptions (e.g. safety; reliability) and accurate beliefs promote acceptance. Negative or ambivalent perceptions and misconceptions, hinder demand delaying the transition towards sustainability (Findrik and Meixner 2023; Onwezen, Reinders, and Sijtsema 2017; Zwicker et al. 2021). Systematically identifying and addressing problematic evaluations and misconceptions while reinforcing existing positive perceptions and accurate beliefs is essential (Blesin, Jaspersen, and Möhring 2017; Boz, Korhonen, and Sand 2020; Filho et al. 2022; Herbes, Beuthner, and Ramme 2018; Mehta et al. 2021). Addressing negative perceptions requires minimizing perceived losses, such as higher costs or lower performance, while highlighting bioplastics' eco-friendliness and personally relevant benefits (Rudolph 2018). However, exaggerated or false claims, particularly about biodegradability and sustainability, must be avoided to prevent perceptions of greenwashing (Fletcher 2022). Bridging the gap between consumer beliefs and expert definitions is also important. This involves translating technical language into 'consumer-friendly' terminology, while providing accurate and truthful claims supported by certified standards (European Bioplastics 2017; Findrik and Meixner 2023). Clear, open, and trustworthy information about bioplastics' safety and benefits is crucial, especially when addressing risk perceptions (Slovic et al. 2004). This highlights again the importance of carefully designing and testing communications and marketing campaigns beforehand, and monitoring consumers affective, cognitive, and behavioural responses to such communications (Reinders, Onwezen, and Meeusen 2017; Zwicker et al. 2023).

4.2.4. Bridging attitudes, preferences, and expectations

Consumer attitudes, preferences, and expectations toward bioplastics can act as barriers or drivers of acceptance and demand (Bangsa and Schlegelmilch 2020; Panda et al. 2024; Zhuang, Luo, and Riaz 2021). Consumers generally hold positive attitudes towards bioplastics, favouring locally produced, plant-based, and biodegradable bioplastics (Klein, Emberger-Klein, and Menrad 2020, Klein et al. 2019; Testa et al. 2021; Zwicker et al. 2021). Additionally, they have high expectations for technical and environmental performance (Blesin, Jaspersen, and Möhring 2017; Falcone and Imbert 2018). These insights enable aligning product development with consumer preferences and expectations (Confente, Scarpi, and Russo 2020). However, expanding bioplastics to incorporate novel feedstocks (e.g. waste-based) and technologies requires addressing unfavourable attitudes and preferences. This requires assessing not only what are consumers' responses towards different types of bioplastics, but also how those responses can be influenced (Notaro, Lovera, and Paletto 2022a; Russo et al. 2019; Weinrich and Herbes 2023). Attitudes can be difficult to change, particularly when they are crystallised in memory or evoke strong emotional and cognitive responses (Albarracin and Shavitt 2018). Repeated meaningful and positive interactions with different types of bioplastics, emphasizing quality, safety, and environmental

performance can prompt re-evaluations contributing to change attitudes and adjusting expectations (Confente, Scarpi, and Russo 2020; Sharma, Aswal, and Paul 2023). Social marketing strategies, targeting a diverse range of contexts and consumer groups, can support this by making truthful claims emphasizing personal gains and the hedonic facet of shopping (European Bioplastics 2017; Fatemi et al. 2023; Koenig-Lewis et al. 2014; Scarpi et al. 2021). Consumer attitudes and behaviours are also influenced by evolving personal values, social relationships, cultural trends, and situations (Albarracin and Shavitt 2018). Effective communication must adapt to individual and social changes, ensuring testing of communication materials and monitorization of consumer responses to such materials.

4.2.5. Addressing identity values, goals, and social influence

Promoting consumer acceptance and demand for bioplastics requires leveraging green self-identity, pro-environmental values, and social influences while maintaining transparency. Targeting environmentally conscious and concerned consumer groups can be an effective starting strategy (Confente, Scarpi, and Russo 2020; Russo et al. 2019; Skoczinski et al. 2023; Zwicker et al. 2023). Brands can incorporate green self-identity and pro-environmental goals and values in their marketing campaigns, and on their own brand identity (Bangsa and Schlegelmilch 2020; Panda et al. 2024). However, leveraging green self-identity has challenges. Some consumers with high green self-identity and pro-environmental values may oppose bioplastics derived from animal or food-related waste due to ethical concerns (Blesin, Jaspersen, and Möhring 2017; Mehta et al. 2021). Others can oppose bioplastics if they perceive that production conflicts with land use, food security, or cultural values (Filho et al. 2022; Karachaliou et al. 2017; Lestari, Pambekti, and Annisa 2025; Zwicker et al. 2021). This points to the importance of understanding consumer profiles and how self-identity and values shape consumer choices (Fletcher et al. 2021). Social influence is another powerful driver of bioplastics demand (Barbu et al. 2022; Cao 2023; Weinrich and Herbes 2023). Communicating descriptive norms (what people do) and injunctive norms (what is expected) can be an effective strategy but must avoid false claims, particularly when communicating descriptive norms (Cao 2023; Schultz et al. 2007). Despite its potential, research on social norms in bioplastics marketing remains understudied (Weinrich and Herbes 2023). Mass and social media also play a critical role in marketing bioplastics, but as social norms this role is understudied (Veerabhadrappa, Fernandes, and Panda 2023). Companies should collaborate with media outlets and specialized journalists, engage with influencers, and create trustworthy and user-friendly online resources and communities to share information and coproduce knowledge on bioplastics (Falcone and Imbert 2018).

4.2.6. Unpacking policy and regulatory landscapes

There is a lack of clear and uniform policies and regulations regarding bioplastics, including lack of public incentives for supporting consumer purchase (Jayakumar et al. 2023). This enables proliferation of misleading labels, unclear biodegradability standards, and misinformation about bioplastics (Cruz et al. 2022; Weinrich and Herbes 2023). Shared cross-cultural definitions and consistent certification and labelling programs, supported by governments and independent agencies, are crucial to counter abusive practices, enhancing consumer trust and demand (Fletcher et al. 2021; Herbes, Beuthner, and Ramme 2018; Jha et al. 2024; Klein, Emberger-Klein, and Menrad 2020; Lettner, Schöggl, and Stern 2017). Regulations must ensure mechanisms for compliance with eco-labelling and eco-advertising standards, preventing misleading claims and misuse of labels, while protecting consumers from abusive use of terms such as 'biodegradable' or '100% renewable' (Bhagwat et al. 2020; Dey et al. 2024; Scherer, Emberger-Klein, and Menrad 2017). Clear labelling must summarize main characteristics of bioplastics (e.g. type and origin; environmental impacts; end-of-life procedures) while backing up environmental, safety, and quality claims with standards and certifications that are verifiable, recognizable, and readily available to

consumers (European Bioplastics 2017; Morris and Hicks 2022; Notaro, Lovera, and Paletto 2022a). Besides protecting consumers and companies, this transparency fosters the circular economy by promoting awareness and knowledge about bioplastics production processes, life cycle, disposal methods, and environmental footprint (Abrha et al. 2022; Klein et al. 2019; Meeks et al. 2015). Public policies can incentivize bioplastics purchase through tax reductions, refunds based on recovery, or social responsibility initiatives (Adeyanju et al. 2021; Bioplastics Europe 2021; Filho et al. 2022). Rather than penalizing consumers with taxes, governments can set consumer incentives for buying, reusing, and recycling bioplastics (Medeiros et al. 2022).

5. Discussion/conclusion

The success of bioplastics in replacing conventional plastics largely depends on consumer acceptance and demand. Strategies to promote demand include co-creating tailored marketing and educational campaigns, supported by truthful, certified and verifiable claims, involving businesses, communities, environmental organizations, and educational institutions. These campaigns should promote interaction and self-identification with bioplastics, address knowledge gaps, and reduce misconceptions by clarifying what are bioplastics, their production and end-of-life processes, and their risks and environmental benefits. Co-creation between industry and consumers fosters trust and credibility, enabling a common language and the joint identification and implementation of action strategies.

Tailored social media and digital marketing campaigns can be used to amplify these efforts by sharing success stories, case studies, and testimonials, connecting bioplastics to personal and societal values that resonate with diverse audiences. These campaigns can promote deeper engagement by resorting to collaborations with sustainability-focused influencers, using visually engaging materials, and linking bioplastics to personal lifestyles and societal trends. Highlighting bioplastics contribution to environmental sustainability and social responsibility through real-world examples and partnerships with relevant organizations can further enhance consumer demand, including integrating bioplastics awareness into curricula to foster long-term knowledge.

Consumer preferences often emphasize end-of-life characteristics of bioplastics, particularly biodegradability (Bhagwat et al. 2020; Herbes, Beuthner, and Ramme 2018). However, biodegradability alone is not synonymous of environmental problem-solving. The industry's ability to compost and reuse bioplastics is essential for shifting from a cradle-to-grave to a cradle-to-cradle production paradigm. In that regard, consumer misconceptions about bioplastics environmental impact, particularly biodegradability, must be addressed. This also requires overcoming negative perceptions and attitudes towards waste-based bioplastics, which still requires further research (Cammarelle, Viscecchia, and Bimbo 2021; Findrik and Meixner 2023; Herbes, Beuthner, and Ramme 2018; Mehta et al. 2021).

Cross-cultural studies using qualitative and mixed-method approaches are needed to better understand how psychosocial, regulatory, and economic factors influence bioplastics acceptance, trust, and demand (Weinrich and Herbes 2023). Such research should focus on actual behavioural responses, assess the effectiveness of communication materials and interventions, explore media and social media narratives about bioplastics, and leverage Big Data analysis and algorithm development. Comparative studies can further identify effective strategies across different contexts and consumer profiles, highlighting the influence of cultural and regulatory differences, and minimizing limitations of generalizing recommendations.

Clear and legally binding definitions and regulations about bioplastics, across broad regions, such as the EU, are vital for promoting consumer trust and demand. Regulatory clarity can address labelling challenges and ensure harmonized standards. Standardizing certification processes, reducing costs for small-scale manufacturers, giving incentives to consumers, and fostering collaboration among stakeholders can strengthen the regulatory landscape, promoting consumer awareness and trust.

Nevertheless, some limitations must be acknowledged when reading and interpreting the results presented in this umbrella review. First, the findings are based on studies with varying methodologies, samples, products, and consumer contexts, which may limit the generalizability of barriers and recommendations to consumer acceptance and demand for bioplastics. Second, the reviewed literature reviews often do not provide sufficiently detailed or comparable data to determine which barriers have the greatest impact or which interventions are most effective in promoting consumer acceptance and demand. These limitations must always be considered when reading and interpreting the results.

Overall, this umbrella review identifies and summarizes barriers and recommendations to consumer acceptance and demand for bioplastics. It does not assess what barriers are more impactful and what type of interventions are more effective, although it provides some insights on that regard. This result emphasizes the need for further research on the drivers of plastic transition, including the need for meta-analytic studies. Addressing barriers through targeted research and evidence-based collaborative efforts can streamline industry efforts to produce meaningful change, promoting bioplastics as viable alternatives to conventional plastics.

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