



*Mini review*

## **Is the consumer experience creating barriers for the effective uptake and disposal of bioplastics?**

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**Abstract:** Over the last decade, the European Union has developed objectives at a strategic level that seek to improve sustainability and circularity across all aspects of production and consumption. More recently, the Green Deal and Circular Economy Action Plan, have applied a specific focus on the production, use and disposal of plastics, where solutions that address the issues posed by traditional petroleum-based plastics have been sought. As a response to this strategic shift, the utilization of bioplastics (namely bio-based and/or biodegradable plastics) has been promoted as a potential solution, whereby they can substitute, or provide an alternative to, traditional petroleum-based plastics. However, successful uptake and the effective waste management of bioplastics, and products that utilize bioplastics, will be based on the consumer experience and ultimately market acceptance. This study explores three factors that may influence the consumer experience when purchasing, using, and disposing of bio-based and biodegradable plastics: consumer confusion, unrealistic expectations, and the value-action gap. Based on qualitative evidence gathered across the academic literature, this mini review suggests that all three aspects (both individually and combined) can have a marked effect on the uptake of bioplastics, and indeed other sustainable options. Indeed, when these potential impacts are considered in the broader context of a circular economy, it is suggested that feelings of cynicism and skepticism, along with unintended rebound effects may hamper the effectiveness to recirculating and maintaining resources within production and consumption systems and across multiple life cycles.

**Keywords:** circular economy; bio-based plastics; biodegradable plastics; consumer experience; market acceptance; sustainability

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## 1. Introduction

Traditional (fossil-based) plastics have become ubiquitous within modern day society; however, their use is considered to be a key contributor to unsustainable patterns of production and consumption [1,2]. Where the increased consumption and availability of new products, often with reduced lifespans, translates into the increased consumption of raw materials and energy, alongside the increased generation of waste [2]. As such, the current political agenda seeks to address the environmental and social impacts associated with the production, use and disposal of plastics. One approach being considered concerns the development of the bioeconomy, whereby traditional plastics are replaced with alternatives such as bioplastics [3]. For example, the European Union (EU) published the Bioeconomy Strategy in 2012 to address climate change, strengthen industrial competitiveness, and reduce global dependence on non-renewable resources [4]. Specifically, the Bioeconomy Strategy promotes innovative solutions, such as the deployment of bio-based and biodegradable products [4], thus contributing to overarching priorities such as sustainable development and the transition to a circular economy. More recently, the EU Green Deal was released in 2019 with overarching aims of making the EU climate neutral by 2050 and decoupling economic growth from resource use, and specific initiatives to promote clean innovation and improve product lifespan considering the 3R principles<sup>1</sup> [3]. These ambitions have been further developed by the EU in the 2020 Circular Economy Action Plan [5].

Bioplastics is an umbrella term for a range of materials that can be bio-based, biodegradable or both [6]. This paper focuses on the use of bioplastics in end-user or consumer products such as single use packaging, consumables (single use and durable) and other durable products such as toys, cutlery, fashion accessories, etc. It is noted that while bioplastics can also be used a term to describe materials that are bio-compatible such as dissolvable stitches, and other products used in surgery and drug delivery for example, consideration of such products are excluded from the scope of this study. Bio-based plastics are derived from organic feedstocks such as crops, organic wastes, and algae. Where in comparison with traditional plastics (e.g., polyethylene terephthalate, also known as polyester or PET) the only difference is the raw resource utilized in synthesis, then the bio-based alternative (e.g., bio-PET) can be referred to as a “drop-in” plastic. “Drop-in” plastics are chemically very similar, if not identical, to the petroleum counterpart and therefore can be managed in the same way (e.g., through mechanical recycling), using the same infrastructure [7,8]. Plastics marketed as biodegradable on the other hand, can be either fossil-based or bio-based, where the term “biodegradable” describes a characteristic, i.e., the material, under certain conditions and through the action of microbes and/or enzymes, can be broken down into its constituent parts: water (H<sub>2</sub>O), carbon dioxide (CO<sub>2</sub>), or methane (CH<sub>4</sub>) depending on oxygen availability, and organic matter [9].

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<sup>1</sup> The 3R concept promotes users to Reduce, Reuse and Recycle the materials and products they consume. The 3R concept is central to the circular economy and also underpins the waste hierarchy, which has been employed by the European Union as a means to reduce waste generation and increase landfill diversion.

In the context of a circular economy, the increased uptake of both bio-based and biodegradable plastic may aid the transition. Regarding bio-based plastics, their use of renewable resources as a feedstock means that they do not rely on declining material reserves, which is in stark contrast to traditional fossil-based plastics and in some instances, bio-based plastics can be shown to be more favorable with regards to carbon emissions [10,11]. With respect to biodegradable plastics, the inherent characteristic of being biodegradable opens up alternative avenues for waste management where composting<sup>2</sup> and the production of biogas via anaerobic digestion can be considered. However, a key message to note here is that not all bioplastics are created equal, where bio-based plastics may not necessarily be biodegradable (and vice versa), and not all biodegradable plastics can claim to be compostable [12]. Thus, care should be taken not to misconstrue their contribution to a circular economy when marketing new products.

While the promotion of bioplastics has been well received by industry, leading to the development and innovation of novel materials and products, successful uptake and effective waste management of bioplastics ultimately depends on market acceptance<sup>3</sup> and changes to consumer behavior. Thus, it is important for those that develop new materials and innovate new products to understand not only the desired properties for specific applications but also the key barriers to market acceptance [13]. Indeed, a range of perceived and actual barriers related to consumer attitudes and expectations have previously been highlighted for existing bioplastic products [7,13]. For example, complexity created by the different terms used to describe bioplastics has created confusion and misinterpretation for consumers and technologists alike. Where the terms bio-based plastic, biodegradable plastics, and bioplastics (i.e., plastics that can be bio-based or biodegradable or both) are often used interchangeably, even though they present different properties and characteristics [14,15]. Across the grey literature, the usage of differing terms has been highlighted as a source of consumer confusion, particularly when various aspects of biodegradation (i.e., biodegradable vs. compostable) are included [7,12]. In addition, expectations regarding technical and environmental performance may also create barriers. Falcone and Imbert [16] argue that consumers expect bioplastics to perform to, not only an equal, but to a higher standard of technical performance when compared with traditional plastics. This is in addition to the higher standard which is expected by consumers with respect to the environmental performance of bioplastics, particularly from those consumers who subscribe to eco-conscious behaviors [17]. Indeed, previous research completed by the author on the attitudes and expectations of consumers towards alternative plastics [8] has indicated potential barriers caused by consumer confusion, unrealistic expectations, and the value-action gap.

Building upon these indications, this paper delves into the literature (using bibliometric analysis) to explore the impact that consumer confusion, unrealistic expectations and the value-action gap may have on the use and disposal of bioplastics, particularly through the lens of the circular economy. To provide context, this paper will first introduce the aspects of consumer confusion, unrealistic expectations, and the value-action gap, reflecting on their potential impact to sustainable consumption and production (as a proxy for the circular economy). Next implications of consumer confusion, unrealistic expectations and the value-action gap will be discussed with respect to bioplastics and in the context of a circular economy; identifying potential barriers to future uptake

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<sup>2</sup> A specific type of biodegradation, defined by standard conditions regarding temperature, pH, O<sub>2</sub> availability, and time.

<sup>3</sup> Here, market acceptance refers to the level of satisfaction which a product or service achieves within its target market that will ultimately merit its continued or increased supply.

and developing suggestions to overcome them. Finally, the broader conclusions and wider implications of this study will be presented.

## **2. Contextual information**

Since the 1970's (most notably after the Club of Rome's acknowledgement of "limits to growth"), sustainable consumption and production has gained international prominence as a key element of achieving sustainable development [18]. In the time since, Wang et al. [18] notes that the literature concerning different aspects of sustainable consumption and production (particularly from and about developed economies) has matured to include multi-criteria evaluations, life cycle analysis (LCA), and industry-specific awareness. They also highlight the effect of purchasing behaviors and consumer awareness, where additional effort is required to translate intention to change into sustained action. This section introduces consumer confusion, unrealistic expectations, and the value-action gap, then drawing on the literature, reflects upon their potential impact to sustainable consumption and production.

### *2.1. Consumer confusion*

Consumer confusion can be defined as a failure to correctly infer the various facets of a product, or service, when processing information, leading to misunderstanding or misinterpretation [19]. It is argued that consumer confusion stems from the over-choice of products, similarity across different products and a lack of clarity in the information provided [20]. Within the literature, consumer confusion has been reported on with respect to electronics [19], food and food waste [21,22] and packaging [23]. Furthermore, the impacts of consumer confusion on sustainable consumption and disposal have been reported to include the reduction of informed consumer choice [22], the undermining of decision-making processes [19], a lack of holistic understanding [21], the lack of industry agreement/ alignment and the lack of differentiation [23].

### *2.2. Unrealistic expectations*

Unrealistic expectations can be defined as a belief that something should behave or act in a certain way, where these beliefs are not based on the whole truth, or do not fully appreciate the difficulties/complexities involved. The definition provided here synthesizes the two dictionary (oxford) definitions given for the terms: "unrealistic" and "expectations". Within the literature, unrealistic expectations have been reported on within the social sciences, namely with respect to marriage and relationships [24,25], psychology [26,27] and healthcare [28,29]. When considering the impact of unrealistic expectations on sustainable consumption and disposal specifically, little research has been published to date. However, it can be assumed that in line with consumer confusion, unrealistic expectations may lead to more instances of perceived green wash and increased consumer skepticism [19].

### 2.3. *The value-action gap*

The value-action gap (also known as attitude-behavior gap, intention-behavior gap, or belief-behavior gap) can be defined as: the differences between beliefs and actions, and in the context of the circular economy, the difference between reported concerns about sustainability and actual lifestyle choices [30]. Within the literature, the value-action gap has been reported on with respect to household energy use [31] and waste management [32], brand loyalty [33] and student engagement [34], to name a few. Overall, the impact of the value-action gap on sustainable consumption and disposal has been reported to include indecision and compromise when choosing the most sustainable option [31], displacement of responsibility [34], and the continuation of the non-normative status of sustainable actions [32].

## 3. **Materials and methods**

A qualitative review of academic literature was undertaken to identify the potential reported impacts of consumer confusion, unrealistic expectations, and the value-action gap on bioplastics.

Relevant articles were identified through a literature search of the Science Direct database (<https://www.sciencedirect.com/>) in February 2022. As one of five databases (others being Springer, Scopus, Web of Science and Google Scholar) that contain significant scientific contribution regarding sustainability, material/resource use and waste management, the use of Science Direct provides an initial platform to start the exploration into this topic. Here it is noted that the use of the other four databases in future research may help elaborate or oppose the findings of this initial scoping study. For example, a search in Scopus using the keywords “bioplastics” AND “consumer acceptance” returned 84 results since 2020 by article title, abstract and keywords (and 151 results with no date filter).

To achieve the aim of this study, papers that specifically focused on bioplastics and in some way referred to either consumer confusion, unrealistic expectations and/or the value-action gap were identified via bibliometric analysis. To ensure comprehensiveness, the database search was targeted at the following fields: article title, abstract and keywords, and used the following Boolean search string: (bioplastics) AND (“consumer confusion” OR “unrealistic expectations” OR “value-action gap”).

In total, 134 papers were found. To ensure timeliness and to reflect the increased attention given bioplastics by EU policy (e.g., the Green Deal and the Circular Economy Action Plan) in the last few years, papers published prior to 2020 were excluded, as were those where the full text was not available. Following this, the abstracts of the remaining 72 papers were reviewed for relevance (i.e., does the paper explicitly discuss one of the three aspects with respect to bioplastics). After the removal of any duplicates, the following inclusion-exclusion criteria was applied: (1) article should be written in English, (2) article should refer to either bio-based plastics, biodegradable plastics, compostable plastics or bioplastics, (3) article should refer to either consumer confusion, expectations and/or the value-action gap (also referred to as attitude-behavior gap, intention-behavior gap, or belief-behavior gap), (4) combined references of criteria 2 and 3 should highlight possible impacts or implications to either use or disposal.

Following the application of the inclusion-exclusion criteria, a total of 14 papers [35–48] were taken forward for review and thematic analysis. Thematic analysis is a widely used tool that is used

to analyze qualitative data by identifying themes and relationships within text-based, visual and/or audio data by employing an inductive approach [49].

The content of the selected papers was mapped, where bibliographic information was extracted, including the name(s) of author(s), date of publication, the article's title and the name of the journal or source where the article was published. Next contextual information was extracted as full quotes with page numbers, focusing on explicit references to one of three aspects of concern (consumer confusion, unrealistic expectations and/or the value-action gap). The contextual information (full quotes) was then coded by theme. Here, specific reference to either the uptake/use phase or the end of life/disposal phase, or both was noted, along with any stated impact or implication. The key arguments presented within each quote were then summarized and collated to underpin the reminder of the discussion and conclusions.

From the bibliographic information, two-thirds of the papers sampled were published by three journals: *Journal of Cleaner Production* [38,44,47], *Sustainable Production and Consumption* [42,46,48], and *Resources, Conservation and Recycling* [40,41,43]. Out of the 14 papers sampled, 11 were based on at least one type of empirical data, including semi-structured interviews [39,40,43,44,47], online surveys [36,40,46], workshops or focus groups [42,47] and observational experiments [42,45]. The remainder utilized the review of literature, either systematic [36,38] or narrative [48], or the review of taxonomy [37]. Information presented in Table 1 (see Section 4: Results), provides a synopsis of the key arguments, and indicates the source article from which each point has been taken.

#### 4. Results

This study reveals the potential impact of the consumer experience on the uptake, use and disposal of bio-based and biodegradable plastics. This section first presents how the three concepts of: consumer confusion, unrealistic expectations, and the value-action gap, have been reported within the literature with respect to the use and disposal of bioplastics. This is followed by a discussion (Section 5) on the potential (and broader) ramifications of consumer experience aspects with respect to enabling the transition to a circular economy.

Table 1 presents potential implications of consumer confusion, unrealistic expectations, and the value-action gap on the use and disposal of bioplastics, as reported by the reviewed literature. The table highlights that consumer confusion, unrealistic expectations and the value-action gap can have a marked impact on the use and correct disposal of bioplastics, and indeed indicates that these aspects are not necessarily independent of each other.

**Table 1.** Implications of consumer confusion, unrealistic expectations, and the value-action gap on the use and disposal of bioplastics.

	Consumer confusion	Unrealistic expectations	Value-action gap
Uptake/use phase	<ul style="list-style-type: none"> <li>• Insufficient information is available, limiting informed decision making [36]</li> <li>• Confusion leading to a lack of confidence [39]</li> <li>• Lack of ability and knowledge to pass sustainability-related judgements [40]</li> </ul>	<ul style="list-style-type: none"> <li>• Mismatch between characteristic vs intended use [35]</li> <li>• Perceived level of sustainability does not always correspond with LCA results, uncertainty feeds perceived greenwash [40]</li> <li>• Exaggeration of positives and/or negatives [42]</li> <li>• Technical properties do not match conventional plastics [46]</li> <li>• Novelty and partly inferior technical properties limit applications [47]</li> <li>• Opportunistic companies may exploit green brand benefits [47]</li> </ul>	<ul style="list-style-type: none"> <li>• Poor availability [36]</li> <li>• Choice often determined by economic factors, leaving producers unsure about consumer preference [39]</li> <li>• Choice often determined in context of personal benefits, low willingness-to-pay, increased cynicism and skepticism [42]</li> <li>• Difficult to mobilize consumer demand, only “green consumers” make purchasing decisions based on environmental criteria [47]</li> <li>• Absence of incentives to mobilize sustainable behavior [48]</li> </ul>
Disposal/end of Life	<ul style="list-style-type: none"> <li>• Contamination of conventional recycling streams [38] due to lack of clarity and understanding [39]</li> <li>• Consumers not clear where and how to discard of bioplastics [39]</li> <li>• Misleading design, signage or verbal cues can lead to mis-sorting within waste streams [41]</li> <li>• Inability to distinguish/separate materials [43], unaware of difference between bioplastic [45]</li> <li>• Overcharged with multiple non-transparent labels and disposal instructions [44]</li> </ul>	<ul style="list-style-type: none"> <li>• Rebound effects, lower recyclability, unsustainable feedstock leading to green wash and uncertainty [39]</li> <li>• Distrust in the current waste management systems due to lack of understanding [39]</li> <li>• Unaware of consequences of substituting trad. plastics [41]</li> <li>• Different terms may skew perceptions of suitability [43]</li> <li>• Rebound effects due to moral licensing is perceived to pay less attention to disposal phase [45]</li> <li>• Rebound effects of over-extensive production [46]</li> </ul>	<ul style="list-style-type: none"> <li>• Requirement of new community configurations [37]</li> <li>• Take-back schemes require awareness/willingness [38]</li> <li>• Lack of access to waste separation bins in public [39]</li> <li>• Lack of understanding and/or inclination to sort waste [42]</li> <li>• Insensitivity/unresponsiveness to information and ineffective logos, with visual cues insufficient to change behavior [45]</li> <li>• Absence of responsibility/appropriate incentives to sort waste correctly [48]</li> </ul>

## 5. Discussion

The literature suggests that the impact of consumer confusion on the use of bioplastics includes limited decision making due to the availability of insufficient information. Indeed,

D'Amico et al. [50] argue that insufficient information may discourage consumers from purchasing sustainable alternatives, largely due to the lack of justification regarding any price differentiation when compared with traditional products. This is in addition to an overall lack of confidence, ability, and knowledge to make valid judgements. Consumer confidence, and its impact on decision making, can be influenced by an individual's general self-esteem<sup>4</sup> and/or their feelings about current/future economic conditions [51,52]. Furthermore, the proliferation of visual cues (i.e., too much information) can also influence an individual's self-esteem (and thus consumer confidence) by reducing their sensitivity to messages i.e., the consumers no longer recognize/acknowledge the messages being conveyed. The knock-on effect of this may be that the existing messages become insufficient in causing the required (and desired) change. Indeed, in a study on ecolabels, D'Souza et al. [44] found that trust is a required element of visual cues, especially if they are to positively impact purchase intent and consumer confidence.

Likewise, with regards to unrealistic expectations, the literature suggests that a mismatch between the actual material characteristics and perceived use could develop. In addition, exaggerated positive(s), which may not fully align with LCA results, could be exploited by opportunistic companies, leading to accusations of green wash. Overall, the lack of understanding and skewed perceptions could trigger backlash and/or rebound effects. Hameed et al. [53] substantiates that greenwash, here described as a misleading concept where companies spend more resources on persuading consumers of their green credentials than on implementing green business practices, create a negative impact for sustainable (or green) purchasing behaviors by increasing consumer cynicism towards more sustainable products. Furthermore, it is noted that the effectiveness of product marketing relies heavily on consumer trust, which can be eroded through over-extended producer promises and unrealistic consumer expectations [53].

Finally, with respect to the value-action gap, consumer choice is often determined by availability and economic factors, as such producers can be unclear over consumer preferences (e.g., consumers may indicate an intention to behave more sustainability, but the cost implication means that the less sustainable option is taken). This also reflects the second type of consumer confidence, which is influenced by current and future economic conditions. Furthermore, there is variation in the needs and wants of different consumer groups, where mobilizing these different groups of consumers requires varied and tailored approaches.

Regarding disposal, the lack of access to appropriate infrastructure, low levels of understanding and lacking an inclination to follow adequate disposal steps, can create barriers. For example, confusion about disposal etiquette may cause contamination of waste streams, ambiguous visual cues may lead to incorrect sorting, and too many visual cues may lead to waste apathy. Indeed, Knickmeyer [54] notes that waste classification can be confusing for some, where new material-mixes, multi-component products and the use of novel labels create further confusion, which can lead to incorrect separation and increased material refusal by waste management systems.

These impacts may also have further ramifications for the transition to a circular economy. In the quest to decouple production from the use of fossil-based materials, feelings of cynicism, skepticism and insensitivity to information created by unrealistic expectations and the value-action gap may in the least, reduce the uptake of more sustainable options in the future and at the most,

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<sup>4</sup> An individual's belief in their own capacity to acknowledge, identify and assess relevant information in order to distinguish between accurate and inaccurate claims.



foster perceptions of green wash. Conversely, where uptake is successfully promoted, consumer confusion and unrealistic expectations may lead to unfavorable rebound effects, where overall levels of consumption increase, thus in contradiction to the “reduce” ethos of the circular economy. Finally, consumer confusion and the value-action gap may lead to the incorrect separation and disposal of products. This may lead to inefficient waste management and have broader implications for the effectiveness of a circular economy to recirculate and maintain resources within systems across multiple life cycles.

In this study, the use and disposal of bioplastics has been assessed from a consumer’s perspective. To successfully promote uptake of alternative materials, attention should also be given to the role played by the producers and other value-chain actors. Indeed, previous research from the producer perspective, has shown the impact of public perceptions on product development (especially when actions are tarnished as greenwash) where producers have been more reluctant to introduce bioplastics as a plausible option due to perceived “public backlash” [55]. While out of scope of this current assessment, existing and potential incentives that may reduce (or detrimentally) create confusion, seek to identify and meet consumer expectations and increase turnover (or financial viability) could be an avenue for future research. Furthermore, the indicative findings of this study such as need to improve the clarity and availability of information provided to consumers, as well as increased transparency concerning the potential impacts of bioplastics across the full product life cycle could be explored in more depth.

## 6. Conclusions

In conclusion, this mini review set out to understand what possible impacts consumer confusion, unrealistic expectations, and the value-action gap may have on the use and disposal of bioplastics, especially in the context of a circular economy. Overall, it has been shown that all three aspects (individually and combined) can have a marked effect on the uptake of sustainable options such as bioplastics. When wider ramifications are considered, especially with respect to the transition to a circular economy, it can be argued that the three concepts do not act in isolation of each other. Indeed, it can be suggested that consumer confusion and unrealistic expectations both lead to unfavorable rebound effects where overall consumption increases. In addition, the combination of unrealistic expectations with the value-action gap, may reduce confidence in other/broader sustainability options, fostering perceptions of green wash and cynicism. Finally, the combination of consumer confusion and the value-action gap may lead to the incorrect separation and disposal of products, leading to increased efficiencies in household waste management.

It is acknowledged that the scale of this study does present some limitations. And while comprehensive conclusions cannot be drawn, this study does provide indicative results that point toward wider implications. This study indicates that consumer attitudes and behaviors towards more sustainable approaches to consumption and waste management are complex and often interwoven with levels of awareness, understanding, skepticism and unresponsiveness.

Future avenues of enquiry may involve the comprehensive and systematic review of literature (including the use of snowballing techniques) to fully comprehend the reported impacts of consumer confusion, unrealistic expectations, and the value-action gap on the use and disposal of bioplastics, and to build a conceptual framework for understanding the linkages between the concepts. On the other hand, empirical research could be used to collect data (integrated with consumer engagement

activities) on the role and success of interventions based on clearer information, sustainability education and enabling legislation, thus creating a framework or roadmap to greater market acceptance, uptake and behavior regarding bioplastics and other sustainable alternatives. The creation of a roadmap may also assist, and thereby should also be evaluated, with respect to the innovation of new materials and products, ensuring that developers/researchers are clear in what attributes are important for different applications, and enabling retailers to be confident that the marketing and communication associated with new products is unambiguous.

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## Conflict of interest

The author declares no conflict of interest.

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