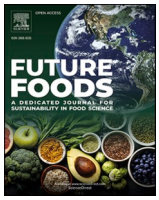
Future Foods 13 (2026) 101006

Contents lists available at ScienceDirect

Future Foods

journal homepage: www.elsevier.com/locate/fufo



The bioplastic paradox: unpacking consumer acceptance and the disposal challenge of home compostable packaging

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ARTICLE INFO

Keywords:
Home-compostable bioplastic
Bioplastic packaging
Consumer acceptance
Disposal behavior
Sensory evaluation

ABSTRACT

The global plastic crisis necessitates a transition toward sustainable alternatives to fossil-based polymers. However, the widespread adoption of bioplastics is hindered by mechanical and barrier performance gaps compared to established industry standards, requiring a "formulation-for-purpose" approach to ensure functional competitiveness. Within this framework, home-compostable bioplastics represent a critical innovation, yet their environmental efficacy remains strictly dependent on overcoming technical, perceptual, and behavioral barriers at the consumer level.

This study investigates these challenges through a consumer test with 110 Italian participants (55.4% females) who evaluated four packaging formats (bag, clamshell, film, sealed film tray), each in both home-compostable bioplastic (HCB) and conventional fossil-based plastic (FBP) versions. The methodology assessed affective responses (liking, purchase intent), sensory and functional properties, and declared disposal accuracy. These variables were analyzed against socio-demographics, habits, logo familiarity, and psycho-attitudinal profiles to identify key predictors.

HCB packaging acceptance is highly format-dependent. While comparable to FBP for flexible formats, HCBs are penalized for attributes like high opacity, unless the perceived benefit of sustainability can offset other sensory flaws. A critical "bioplastic paradox" emerges: despite positive consumer acceptance, correct disposal rates for HCBs (65–74%) are significantly lower than for FBPs (89–96%). The strongest predictors of correct disposal are familiarity with the compostability logo and younger consumer age.

These findings reveal the consumer as an indispensable actor in the HCB value chain, making their active engagement essential. Consequently, achieving the environmental promise of these products hinges on both industry-led innovation and policy-driven initiatives that foster informed consumer acceptance.

1. Introduction

1.1. The role of compostable bioplastics in food packaging

Consumer purchasing decisions are fundamentally driven by the intrinsic quality and safety of food products. In this context, food packaging is essential for containing, protecting, and preserving the food's integrity throughout the supply chain (Cruz et al., 2022). However, the industry is a major contributor to the global plastic crisis due to its high use of fossil resources, limited recyclability, and greenhouse gas emissions (Ghasemlou et al., 2024). In the EU, plastic packaging accounts for roughly 60% of post-consumer plastic waste, with per capita waste increasing significantly from 27 kg in 2009 to 36 kg in 2022 (Bakri et al., 2021; Eurostat, 2024).

To combat this, sustainable alternatives like bioplastics, a category of bio-based and/or biodegradable materials, have been developed (Dimple et al., 2025; Guillard et al., 2018). A subset of these are compostable bioplastics, which can decompose by at least 90% under composting conditions within six months (European Committee for Standardization, 2000). These materials can be further categorized as industrial compostable, home compostable (HCB), or soil and marine degradable (Briassoulis et al., 2010; Ghasemlou et al., 2024). While not always superior to fossil-based plastics, HCB packaging offers several environmental benefits. It reduces plastic waste, enhances soil quality,

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https://doi.org/10.1016/j.fufo.2026.101006
Received 10 November 2025; Received in revised form 2 March 2026; Accepted 25 March 2026
Available online 27 March 2026

and generates fewer greenhouse gas emissions than incineration (Gastaldi et al., 2024). The use of HCB also promotes proximity and reduces the need for complex recycling processes (Schick et al., 2023).

Despite these advantages, the adoption of HCB packaging is limited. Bioplastics currently represent only a small fraction of total plastic production, with packaging being the largest market segment (Ghasemlou et al., 2024). Key barriers include technical and infrastructural challenges in waste management and high production costs (Razniewska, 2022; Wellenreuther et al., 2021). Beyond technological advancements, the role of the consumer remains indispensable for the widespread adoption of eco-friendly packaging, effectively bridging the gap between innovation and market demand (Bora et al., 2026; Ruf et al., 2022). Although consumers show positive attitudes toward bio-based products (Cruz et al., 2025), this doesn't always translate into purchasing or correct disposal behavior (Joshi and Rahman, 2019; Kale et al., 2007; Lin et al., 2025). In fact, packaging is frequently perceived by consumers as a mere secondary byproduct of the food item itself, receiving limited interest and relevance during the purchasing process (Simmonds et al., 2018; Simmonds and Spence, 2017). This perception of “low relevance” ensures that consumer attention is almost entirely absorbed by the characteristics of the food, leading to a low involvement relationship with the packaging material. Consequently, decisions regarding choice or end-of-life management do not typically arise from proactive information seeking. Rather, they are often dictated by entrenched habits or visual heuristics. This suggests that while packaging is rarely the primary purchase driver, its perceived secondary status discourages proactive consumer engagement, such as seeking information regarding material composition or correct disposal routes (Taufik et al., 2020; Uehara et al., 2023). In line with this, while scientific literature identifies food protection as the primary ecological value of packaging, consumers tend to evaluate sustainability exclusively in terms of material type (e.g., paper vs. plastic) and ease of disposal. Consequently, they often ignore the indirect environmental impact of food waste resulting from less effective packaging solutions (Lindh et al., 2016). This gap between perception and functional necessity leads to the technical challenge of designing materials that perform as well as they are perceived.

Recent studies indicate that while the landscape is evolving toward a greater influence of eco-friendly packaging on purchasing decisions (Atta-Delgado et al., 2024), significant ambivalence remains regarding perceived costs and functionality (Findrik and Meixner, 2023). For instance, Italy's correct disposal rate for compostable bioplastics is only 58% (Biorepack, 2024). Therefore, a crucial question remains: why do consumers, despite their apparent interest, remain reluctant to purchase and properly dispose of these products? This research addresses this paradox by investigating the complex interplay between bioplastic packaging and consumer acceptance.

1.2. The "formulation-for-purpose" approach

The widespread diffusion of bioplastics is constrained by a series of formidable technical and economic challenges that prevent them from serving as simple "drop-in" replacements for conventional petroleum-based polymers. The established performance benchmarks for food packaging, honed over decades of optimization with materials like polyethylene terephthalate and polypropylene, create a level that many current bioplastics struggle to meet (Ncube et al., 2020). This performance gap manifests across mechanical, thermal, and barrier properties, creating significant hurdles in manufacturing, product protection, and market competitiveness. Overcoming these deficits is not merely a matter of incremental improvement but requires fundamental re-engineering of materials and processes, a reality that profoundly shapes the pace and direction of bioplastic adoption by consumers.

Bioplastics, particularly polylactic acid, present technical challenges that are well-documented and must be addressed to compete with conventional polymers (O’Loughlin et al., 2023; Rosenow et al., 2025). Polylactic acid in its neat form is known for its brittleness, low impact strength, and limited ductility. The material’s limitations form a complex 'trilemma' where technical trade-offs often lead to unintended consequences for food preservation, thereby diminishing the consumer’s final experience with the product. For instance, a common strategy to reduce brittleness is the addition of plasticizers. However, these additives can lower the material's glass transition temperature, further compromising its thermal stability, and can also increase polymer chain mobility, potentially worsening barrier properties (O’Loughlin et al., 2023), with consequences for the packaging's sensory and functional attributes (e.g., transparency and shelf-life loss). This interdependency means that material development cannot be approached in silos and a holistic process is required. Instead of pursuing a "super-polymer" that excels in all areas, the strategic goal must be to develop specific formulations that are precisely tailored to the performance requirements of a target application. This "formulation-for-purpose" approach, where conscious technical trade-offs are made to meet specific market needs, is key to developing packaging that delivers the specific sensory and functional properties increasingly desired by consumers in the various formats.

1.3. Sensory and functional acceptance of bioplastic packaging

Consumer response to bioplastic products is characterized by a duality, balancing positive affect with significant ambivalence (Sijtsema et al., 2016). Consumers generally feel more positive toward bio-based plastics than conventional plastics, with sustainable packaging evoking moral satisfaction and positive emotions (Steenis et al., 2018). This positive disposition can be defined as an affective evaluation, where the consumer does not choose based on technical knowledge or cognitive facts, but rather responds to a sense of ethical “rightness” linked to the materiality of the packaging (Otto et al., 2021). However, this positive disposition is counterbalanced by uncertainty and negative feelings that influence purchase intention (Koenig-Lewis et al., 2014). In this sense, Drechsel et al. (2025) suggest that the affective component plays a predominant role in shaping consumer preferences. Emotional responses toward sustainable packaging outweigh the importance of technical material knowledge, suggesting that acceptance is driven more by the “feel-good” factor of making a green choice than by a real understanding of polymer properties. At the same time, although consumers explicitly state a preference for bio-based packaging, implicit association tests have revealed that fossil-based plastic is still strongly associated with concepts of protection and functionality (Koenig-Lewis et al., 2022). This suggests that the intention-behavior gap is rooted in automatic biases that are difficult to overcome through rational information alone.

This complex consumer response is the result of a delicate balance between various drivers and barriers. While the food remains the central interest, key factors that condition its acceptance include consumer trust and green values, often mediated by the packaging’s appearance, and frequently amplified by a “halo effect” where sustainability enhances perceptions of other attributes (Granato et al., 2022). For example, compostable packaging triggers a “health halo effect”, leading consumers to associate bio-based materials with superior food quality and healthiness (Koenig-Lewis et al., 2022).

Conversely, significant barriers such as unfavorable cost perceptions, perceived risks, and deeply ingrained habits (Niedermeier et al., 2021) are frequently rooted in the tangible functional and sensory drawbacks of the materials (Findrik and Meixner, 2023; Steenis et al., 2017). The tangible impact of functional and sensory properties on overall packaging acceptability is a key evidence in recent literature (Granato et al., 2022; Ruf et al., 2022)

Decades of exposure have created a subconscious sensory vocabulary where conventional plastic cues are equated with quality and safety. Bioplastics, with their distinct sensory profile, can create a mismatch with these expectations, hindering acceptance. Since consumer attention is absorbed by the food product, packaging characteristics act as

indirect cues for trust. Within this framework, transparent materials are critical only insofar as they enable the visual inspection of the food's intrinsic quality, serving the consumer's goal of product evaluation (Granato et al., 2022; Steenis et al., 2018). However, many bioplastics are inherently opaque or translucent. While some can be engineered for transparency, this often incurs higher costs or performance compromises (Atta-Delgado et al., 2024). This creates the "paradox of naturalness," where producers must either mimic the sensory profile of conventional plastics or re-educate consumers to associate new sensory cues with environmental values. Beyond vision, other senses are crucial. The haptic experience, though often processed subconsciously, can unintentionally influence the perception of the contained food's quality and taste, with texture choices signaling different properties (Piqueras-Fiszman and Spence, 2012). Similarly, acoustic feedback like crinkling is a learned cue, and deviations can signal lower quality in foods (e.g., Spence and Zampini, 2008; Spence, 2016). Odors are also powerful drivers of rejection, making odorlessness a key priority in packaging (Vera et al., 2020).

Globally, consumer acceptance is a trade-off between sensory and functional performance. However, in the case of bioplastics a comprehensive understanding is limited by the predominant reliance on hypothetical scenarios in existing research (Ruf et al., 2022). This approach captures stated intentions rather than real-world behavior, creating an "intention-behavior gap" often exacerbated by social desirability bias (Veselý and Klöckner, 2020). Therefore, there is a critical research gap for studies using non-hypothetical, real-world experiments to increase external validity and more accurately measure consumer behavior toward innovative packaging (e.g., Drechsel et al., 2026).

1.4. Consumer challenges in bioplastic disposal

Despite the environmental potential of bioplastics, their end-of-life management presents significant challenges, primarily revolving around consumer behavior and understanding (Kale et al., 2007). Studies reveal that while compostable bio-based packaging holds a strong environmental appeal for consumers, this positive perception does not consistently translate into correct disposal actions (Mhaddolkar et al., 2025). As highlighted by Otto et al. (2021), there is a gap between theoretical knowledge (knowing that a material is biodegradable) and practical competence (understanding how and where to dispose of it). This issue is worsened by a lack of uniform waste management infrastructure, which further confuses the end user. In a study with German consumers (Taufik et al., 2020), only 37.1% of participants correctly disposed of compostable bio-based packaging in the organic waste bin. In sharp contrast, the correct disposal rates for fossil-based and recyclable bio-based packaging were significantly higher, at 89.2% and 81.3% respectively. This discrepancy is largely attributed to consumers' low familiarity with both the concept of "bio-based" materials and the different practices of composting the packaging (Sijtsema et al., 2016). Consumers show greater familiarity with recycling symbols and practices compared to those for compostability (White and Simpson, 2013). This leads to confusion at the moment of disposal, where ingrained habits override packaging instructions. This uncertainty is particularly critical for innovative materials. When faced with doubt, consumers tend to fall back on established routines, which effectively neutralizes the potential environmental benefits of compostable packaging through incorrect disposal practices. Fogt Jacobsen et al. (2022) clarify that this confusion stems from a lack of procedural knowledge: while consumers may possess high environmental awareness (declarative knowledge), they often fail during the actual disposal process due to the perceived complexity of waste management systems and frequently ambiguous packaging labels. For instance, some consumers, despite acknowledging the compostability label, fail to place the item in recycling waste, driven by the strong conviction that any plastic-like material belongs there (Van den Oever et al., 2017). Others express disbelief, finding it hard to imagine that a plastic bottle could be compostable (Taufik et al., 2020). The convergence of low consumer familiarity, conflicting mental models, and resultant ambivalence leads to high rates of improper disposal, a behavior that ultimately undermines the intended environmental benefits of compostable bioplastics. While the disposal of sustainable packaging by consumers has been the focus of some studies (Martinho et al., 2015; Taufik et al., 2020), the field remains underdeveloped. Specifically, a notable gap exists in the literature regarding how consumers handle the disposal of various bioplastic packaging formats (e.g., rigid vs. flexible). This is particularly salient given that consumers' lack of familiarity with bio-based packages is well-documented (Sijtsema et al., 2016).

1.5. Research aims and overview of the empirical approach

Considering these assumptions, the present study aims to comprehensively analyze how different formats of home-compostable bioplastic (HCB) modulate consumer acceptance and disposal behavior, recognizing its role as a secondary yet functional component of the food product. Specifically, this research has two main aims: i.) to determine consumers' affective performance when comparing different formats of home-compostable bioplastic (HCB) and fossil-based plastic (FBP) packaging; ii.) to compare the packaging's ability to communicate proper disposal behavior and identify drivers/barriers to correct disposal.

The empirical approach involves a consumer study where participants evaluated four common packaging formats (Bag, Clamshell, Film, Sealed film tray), each presented in both HCB and FBP versions. In brief, the steps to achieve Aim 1 were: i.) to compare consumer affective responses (liking and purchase intention) to HCB and FBP packaging across the presented formats; and ii.) to identify the key sensory and functional attributes that act as drivers or barriers to consumer acceptance. The steps to achieve Aim 2 were: iii.) to assess consumers' ability to correctly determine the disposal route for HCBs formats and to quantify the performance gap compared to traditional plastics; and iv.) to determine the socio-demographic, attitudinal, and knowledge-based predictors that influence correct disposal behavior.

By systematically investigating these interconnected aspects, this study seeks to offer actionable insights for packaging manufacturers and policymakers to optimize product design and develop effective communication strategies that can bridge the gap between material innovation and sustainable consumer behavior

This research is part of the “SISTERS” project (Systemic Innovations for a Sustainable Reduction of European Food Wastage), aimed at reducing food loss and waste along the European food supply chain.

2. Materials and methods

2.1. Consumer’s panel

A total of 110 Italian consumers from the Trentino province were recruited for this study (55.4% females; mean age = 40.1 years, SD = 14.1). Recruitment was conducted through various channels, including email announcements, website postings, and word-of-mouth referrals, with the sole requirement that participants be aged 18 or older. Before participating, all subjects were thoroughly informed about the study's objectives, the evaluation procedure, the estimated time commitment, and the handling of their personal data. Informed and written consent was obtained from each participant prior to the commencement of the study. Participation was entirely voluntary, and participants were informed of their right to withdraw at any time without penalty. The study protocol was approved by the Research Ethics Committee of the University of Trento (protocol 2023–19 ESA, approved on December 18, 2023).

2.2. Packaging samples

2.2.1. Home-compostable bioplastic materials and production

In the current market, manufacturers employ a wide variety of proprietary blends to satisfy the functional and biodegradation requirements defined by international standards (i.e., UNI EN 17,427). Consequently, the materials used in this study were designed to reflect this real-world market diversity, providing an innovative example of the various blends consumers encounter in commercial home-compostable packaging.

Specifically, HCB materials were obtained by mixing selected biopolymers with an enzymatic masterbatch. This masterbatch is a compound made with PLA base and protected enzymes to have enough enzymatic activity. Other additives were used to improve material final performance in a conventional extrusion compounding process (Coperion ZSK26 co-rotating twin-screw extruder, semi-industrial) at AITIIP facilities (Zaragoza, Spain) and Natureplast (a TSA co-rotative twin-screw extruder with a 27 mm diameter and a L/D ratio of 50, model TSA TT27–50, gravimetric feeders Schenck Proflex C500). The compounded materials were afterwards dried (Mini dryers Moretto X DRY AIR T) to ensure a low water level content that could not affect the product properties. The compostable materials selected were PLA (Natureplast, France) and Biodolomer® (PLA-based) (Gaia, Sweden). Films were based on Natureplast PLE 005-A and Biodolomer I was used for injection molding and Biodolomer T for thermoforming.

The enzymatic masterbatch was added at a 5% for film packaging and at a 10% for rigid packaging (thickness above 2 mm). Due to the proprietary nature of the formulation, the exact percentages and specific additives cannot be disclosed. The materials compounded were then transformed into final packaging products.

The extrusion blow moulding machine (Labtech LBM 125, semi industrial) equipped with a Laboratory Extruder Types LE25–30/C and LE30–30/C (Labtech Engineering Co., Ltd) at AITIIP and at Industrial level, a blow extruder line equipped with die heads that cover diameters from 80 mm up to 250 mm, die gaps up to 2,2 mm and an L/D ratio of 30: with screw diameter of 65 mm (BIO-MI, Croatia) were used to obtain the compostable flexible films for seal films, lid films, bags and stretch films (Bag and Film formats). The injection moulding machine with an 800 kN clamping force (Krauss Maffei 80/380 CX) at AITIIP and at industrial level (Husky H225 RS55/50) with a prototype mould (ITC Packaging, Spain) for processing of thermoplastics, was used enabling fast and cost-effective production of the injected trays (Tray format).

Finally, a laboratory (Labtech extrusion chill roll sheet and film casting lines type lcr-300) at AITIIP and an industrial cast extrusion equipment (Henschel 1971) (Gaia, Sweden) were used to obtain films to be thermoformed and obtain clamshells (Clamshell format).

2.2.2. Packaging formats

For this study, four distinct packaging formats were identified, representing the diversity of plastic food containers: Bag, Clamshell, Film, and Tray sealed with film (Tray/Film). For each format, two versions were developed: one crafted from fossil-based plastic (FBP) and another from home-compostable bioplastic (HCB). Every effort was made to ensure maximum comparability between these versions regarding shape, thickness, and weight. Appropriate model food products, corresponding to real food items, were selected for each packaging format to facilitate real-world evaluation. This approach allowed us to treat the food as a model within the experimental design while, at the same time, preserving realistic evaluation conditions by using actual products.

The necessary quantity of HCB packaging samples for the entire study was procured directly from the producers (see paragraph 2.2.2), ensuring all units originated from the same production batch. Packaging samples were subsequently delivered to the Edmund Mach Foundation (San Michele all'Adige, Italy) and properly stored until panel evaluation. Prior to evaluation, samples were assembled by placing the model food products into their respective packaging. Employing logos commonly used in the Italian market, an identification label indicating the material type (European Commission, 1997) and a disposal instruction label (International Organization for Standardization, 2016; European Committee for Standardization, 2002) were affixed to the back surface of each package. All eight samples, each with a unique three-digit numerical code, were presented on a single tray in pairs for each packaging format. The order of the presentation of pairs was randomized, as was the order within each pair. The samples were presented to consumers at ambient temperature under white light. Detailed characteristics of each sample, as evaluated by consumers, are presented in Table 1. Images of the evaluated products are provided in Figure S1 in the supplementary materials.

2.3. Evaluation procedure

The evaluation of the samples by consumers was conducted in a single session of 60 min, structured into four main parts: I. Collection of affective responses (Liking and Purchase Intentions); II. Collection of descriptive data (Sensory and functional properties); III. Collection of packaging disposal data; IV. Socio-demographic and psycho-attitudinal characterization questionnaire.

In the first part, participants were asked to observe each sample's packaging from every side, evaluate it by touch and smell, and then open it according to instructions provided on a tablet. Following a comprehensive evaluation of the sample, participants were asked to rate their overall liking of the packaging on a 9-point Likert scale (1: extremely unpleasant; 2: Very unpleasant; 3: Unpleasant; 4: Slightly unpleasant; 5: Neither unpleasant nor pleasant; 6: Slightly pleasant; 7: Pleasant; 8: Very pleasant; 9: Extremely pleasant). They were also asked to indicate how much the packaging would increase their motivation to purchase the product on a 9-point Likert scale (1: Not at all; 9: Extremely). Hedonic scores were evaluated prior to sensory questions to prevent the suppression of hedonic scores observed when analytical tasks precede affective evaluation, thereby ensuring the methodological robustness of the co-elicitation approach (Jaeger et al., 2013).

In the second part, the same eight samples were presented in a new randomized order and evaluated using a two-step Check-all-that-apply (CATA) protocol (Adams et al., 2007). The CATA method was specifically chosen to capture responses that are as close as possible to real-world contexts. This method is specifically tailored for sensory evaluation with consumer panels (Ares and Varela, 2018), and is applicable to both food and non-food products (e.g., Romagny et al., 2024). By ensuring that the descriptors remain intuitive and grounded in the consumer experience, the CATA approach facilitates analytical

Table 1
Physical and material characteristics of home-compostable bioplastic (HCB) and fossil-based plastic (FBP) packaging samples evaluated by consumers.

Packaging samples			Related food content	
Format and material	*Weight (g)*	*Dimensions (cm)*	*Item*	*Weight (g)*
Bag				
FBP: LDPE	0.85	11.5 × 10.5 × 0.06	Almonds	70
HCB: PLA + 5% e.m.	0.90			
Clamshell				
FBP: PP	15.00	10.7 × 10.7 × 3.8	Dried apricots	90
HCB: BIODOLOMER + 5% e.m.	19.00			
Film				
FBP: HDPE	1.30	18×18×0.06	Tomino cheese	90
HCB: PLA + 5% e.m.	0.81			
Tray and film				
FBP: PP	29.10	17×12.4 × 3.5	Fresh cut apple slices	150
HCB: BIODOLOMER + 10% e.m. (tray); PLA + 5% e.m (film)	30.50			

Note: e.m.: enzymatic masterbatch.

testing with non-experts, who have been shown to provide reliable data that capture how expectations and perceptions regarding packaging modulate the consumer experience (Ares and Varela, 2017). By involving consumers and presenting the packaging as a whole, CATA evaluation captures how expectations generated by materials and formats shape perception, mirroring the everyday assessment performed by consumers (Piqueras-Fiszman and Spence, 2015).

From an operational standpoint, the first step of this part assessed sensory descriptors (Transparent, Opaque, Glossy, Soft, Hard, Noisy, Smooth, Rough, Odorless, Plastic-smelling, Foreign-smelling, Fragile, Sturdy, Other), while the consequent second step assessed functional descriptors (Easy to seal/open, Economical, Elegant, Familiar, Innovative, Modern, Practical, Premium, Safe, Simple, Sustainable, Versatile, Other). Both descriptor lists were developed by an internal focus group with experts in sensory analysis ($n = 5$) and based on terms derived from the relevant literature (Steenis et al., 2017; Sohnius et al., 2022). Attributes within each descriptor list were presented to subjects in a randomized order, and the total number of items of each step (12–13 descriptors) was selected to align with the standard range typically employed in CATA tests (Jaeger et al., 2015).

In the third part, participants were asked to indicate the appropriate disposal bin for each package, imagining their daily routine. The following options of dispenser were provided: Plastic, Home composter, Glass, Municipal organic waste, Paper, Non-recyclable waste. These dispensers mirror the main waste disposal containers found in Northern Italy.

Part four involved the administration of a questionnaire designed to characterize participants for: socio-demographics, familiarity with disposal logos, disposal and shopping habits, environmental behavior, attitudes toward innovation and general risk propensity. Table 2 provides a detailed overview of the measured variables, scales, and corresponding references. The validated English-language questionnaires were back-translated into Italian employing an AI-guided protocol as described in Kunst & Bierwiaczonek (2023). The initial translation from English to Italian was generated by GPT-4 (OpenAI). Subsequently, this Italian version was back-translated into English using Gemini Pro (Google). To ensure semantic equivalence and cultural validity, the final Italian version and the English back-translation were independently verified by native speakers ($n = 1$) of each respective language.

Evaluations were conducted within evaluation booths compliant with EN ISO 8589:2010 (International Organization for Standardization, 2010). Data were collected via EyeQuestion online software (www.eyequestion.com, Logic8, The Netherlands). The assessments were conducted over a 4-day period in November 2024 and February 2025.

2.4. Data processing and analysis

Overall, and within each packaging format, data on Liking and Intention to Purchase were analyzed using a two-way mixed-model ANOVA, with material as a fixed factor and subjects as a random factor. This analysis aimed to estimate the effect of the product on Liking and Intention to Purchase within each packaging type.

For both overall data and within each packaging format, and independently for sensory and functional attributes, responses from the CATA questions were treated as dichotomous variables: a value of 1 was assigned to checked terms and 0 to unchecked terms. Cochran's Q test (Meyners and Castura, 2014) was used to identify sensory and functional attributes that significantly discriminated among the samples.

The influence of sensory and functional attributes on Liking and Intention to Purchase was assessed overall and within each packaging type using Penalty-lift analysis (Ares et al., 2014). This method compares the mean scores of the continuous variable (Liking or Intention to Purchase) between evaluations where a specific attribute was selected and those where it was not. A positive difference suggests a positive association (positive impact) between the attribute and the continuous variable, whereas a negative difference indicates a negative impact, i.e.,

Table 2
Survey questions and related items.

Variable	Questions	Response
Gender	Indicate the gender you identify with	Single choice (Man, Woman, Other, prefer not to answer)
Age	Indicate your age (years)	Quantitative
Living area	Choose from the following the type of area you live in	Single choice (1-Large urbanization area; 2-Metropolitan area; 3-Medium-sized urban area; 4-Small urban area; 5-Nearby rural area; 6-Remote rural area)
Working condition	Choose the working condition that suits you	Single choice (Employee part-time job; Employee full-time job; Unemployed; Retired; Houseworker/wife; Student; Other)
Education level	Indicate your level of education	Single choice (None, Primary school, Lower secondary school, Upper secondary school, Bachelor's or master's degree or equivalent tertiary level of education, Doctorate or equivalent level of education)
Monthly household income	Indicate your net monthly household income (Euro)	Single choice (1-<1000; 2-Between 1000 and 1999; 3-Between 2000 and 2999; 4-Between 3000 and 3999; 5-Between 4000 and 4999; 6-Between 5000 and 6000,7-Above 6000)
People in household	How many people are in your household (including yourself)?	
Familiarity "OK compost" logo	Have you ever seen or heard of the following logo? 	Single choice (1-No, I've never seen it; 2-Yes, I've seen it but don't know what it means; 3-Yes, I've seen it and I know what it means)
	Based on what you know or expect, indicate the meaning of the following logo. 	Single choice (It identifies the material the object is made from; It indicates that the object can be recycled; It indicates that the object can be disposed of in the organic waste bin; It indicates that the object can be disposed of in the organic waste bin and in a home composter)
Shopping frequency	Indicate how frequently you shop for groceries	5-point Likert scale (1-Never; 2-Rarely; 3-Sometimes,4-Often, 5-Always)
Waste disposal	Indicate how often you dispose of waste for yourself or your household.	5-point Likert scale (1-Never; 2-Rarely; 3-Sometimes,4-Often, 5-Always)
GREEN scale (Haws et al., 2014)	Indicate your level of agreement with each of the following statements: It is important to me that the	7-point Likert scale (1-Completely disagree; 4-Neither disagree nor

(continued on next page)

Table 2 (*continued*)

Variable	Questions	Response
	products I use do not harm the environment I consider the potential environmental impact of my actions when making many of my decisions My purchasing habits are affected by my concern for the environment I am concerned about wasting the resources of our planet I would describe myself as environmentally responsible I am willing to be inconvenienced in order to take actions that are more environmentally friendly	agree; 7-Completely agree)
Environmental Behavior Scale (Schultz et al., 2005)	Indicate how often you have done each of the following in the past year: Recycled cans or bottles Conserved gasoline by walking or bicycling Looked for ways to reuse things Recycled newspapers Composted food scraps Purchased products in reusable containers Picked up litter that was not your own Encouraged friends of family to recycle Voted for a candidate who supported environmental issues Donated money to an environmental group	5-point Likert scale (1-Never; 2-Rarely; 3-Sometimes,4-Often, 5-Very often)
Attitudes Toward Innovation scale (Tellis et al., 2009; Klein et al., 2019)	Indicate your level of agreement with each of the following statements: I hate any change in my routines and habits New products have an unacceptably high price I am excited to try out new products I enjoy the novelty of owning new products I like to be confronted with new ideas Products are getting shoddier and shoddier	7-point Likert scale (1-Completely disagree; 4-Neither disagree nor agree; 7-Completely agree)
General Risk Propensity Scale (Zhang et al., 2019)	Indicate your level of agreement with each of the following statements: Taking risks makes life more fun My friends would say that I'm a risk taker I enjoy taking risks in most aspects of my life I would take a risk even if it meant I might get hurt Taking risks is an important part of my life I commonly make risky decisions I am a believer of taking chances I am attracted, rather than scared, by risk	7-point Likert scale (1-Completely disagree; 4-Neither disagree nor agree; 7-Completely agree)

the attribute's presence is associated with lower consumer scores.

Disposal performance was evaluated by considering cases in which the HCP packaging was correctly disposed of in the municipal organic waste bin or home composting system. Each participant received a score ranging from 0 (no packaging items disposed of correctly) to 4 (all packaging items disposed of correctly).

The effect of packaging material on disposal performance, both overall and within each packaging format, was analyzed using the chi-square test.

Ordered logistic regression was used to examine the relationships between individual socio-demographic, familiarity-based, habitual, and psycho-attitudinal variables (X) and the dependent variables Disposal Performance (Y) (Neff et al., 2019). For the continuous predictor variables (Recycling, Sustainability, Innovation, and Risk attitudes), an average agreement score was first calculated for each participant across the respective items. Subsequently, participants were categorized into low, medium, and high levels based on the 33rd and 66th percentiles of the total distribution as cut-off points. Model robustness was assessed by the Likelihood-Ratio Test and McFadden's Pseudo-R^2, while the proportional odds assumption was verified via the Brant test. The ordered logistic regression analysis was conducted using a stepwise approach. Initially, socio-demographic variables were tested to identify potential baseline predictors. Subsequently, these factors were integrated into a comprehensive ordered logistic regression model alongside behavioral and attitudinal variables. This allowed for a more parsimonious final model, where the effects of psychological drivers are assessed while controlling for relevant demographic characteristics.

The internal consistency of Likert scale responses was assessed using Cronbach's alpha (Cronbach, 1951).

All statistical analyses were conducted at a significance level of $\alpha = 0.05$ using R version 4.3.9 (R Core Team, 2015), with the packages MASS (v7.3), cata (v0.1.0.6), pscl (v1.5.9), brant (v0.3).

3. Results

3.1. Characterization of participants

The socio-demographic characterization of the consumer panel is reported in Table 3. The sample consists of a slight female majority (55.5%) and is primarily composed of young adults, with the 20–35 age group constituting the largest segment (42.7%). Geographically, participants are predominantly from small urban areas (71.8%) rather than rural or large metropolitan centers. The prevailing family structure is that of couples (48.2%). A key feature of the panel is its high level of education, where the majority holds a university degree, including 39.1% with a Bachelor's or Master's degree and 22.7% with a PhD. Most participants are in full-time employment (55.5%), although a substantial portion is registered as unemployed (29.1%). The monthly household income is relatively evenly distributed across the provided brackets, ranging from €1000 to €5000, indicating that the panel possesses, on average, a medium-to-high purchasing power.

3.2. Consumer affective responses to packaging formats

The ANOVA results conducted to compare consumer evaluations of FBP and HCB samples for each packaging format are presented in Table 4.

A general overview of the consumer responses indicates that all the HCB formats were favorably perceived, with mean scores for liking consistently surpassing the acceptability threshold (threshold liking score=5.0). This positive reception was also largely reflected in the purchase intention scores. Within this context, an analysis of the specific formats reveals some differences in performance. The highest mean liking scores were recorded for the HCB Film (mean (M)=6.2, standard deviation (SD=1.6) and the HCB Tray/film (M = 6.2, SD=1.7) configurations. Slightly lower, but still positive, ratings were given to the HCB

Table 3
Socio-demographic characterization of the consumer panel.

Variable	%
Gender	
Female	55.4
Male	44.6
Other	0.0
Age group	
45-80	28.2
33-44	29.1
18-32	42.7
Area	
Rural (Remote rural, nearby rural)	28.2
Small urban	71.8
Medium size urban	0.0
Metropolitan area	0.0
Large urbanization area	0.0
Family dimensions	
Families	27.3
Couples	48.2
Singles	24.5
Working condition	
Employee, full-time job	55.5
Employee, part-time job	15.4
Unemployed (Unemployed, Retired, Housewife, Student	29.1
Education level	
Phd	22.7
Bachelor or master degree	39.1
Upper secondary school degree	38.2
Lower secondary school degree	0.0
Primary school degree	0.0
Monthly household income (Euro)	
More than 5000	0.0
Between 4000 and 5000	28.3
Between 3000 and 3999	23.6
Between 2000 and 2999	23.6
Between 1000 and 1999	24.5
Less than 1000	0.0

Table 4
ANOVA results of Italian consumers' (n=110) affective responses to different packaging types in home-compostable bioplastic (HCB) and fossil-based plastic (FBP) samples across various formats.

Packaging format	Material Mean (standard deviation)		F	p-value	eta^2
	HCB	*FBP*			
Bag					
Liking	5.9 (1.8)	5.9 (1.5)	0.0	0.904	0.00
Purchase intention	5.0 (2.4)	4.7 (2.1)	1.2	0.285	0.01
Clamshell					
Liking	5.9 (1.9)	7.0 (1.4)	25.4	**<0.001**	0.10
Purchase intention	4.9 (2.3)	6.1 (2.1)	15.6	**<0.001**	0.07
Film					
Liking	6.2 (1.6)	6.1 (1.6)	0.1	0.738	0.00
Purchase intention	5.3 (2.1)	5.0 (2.1)	1.7	0.196	0.01
Tray and film					
Liking	6.2 (1.7)	4.4 (1.9)	57.4	**<0.001**	0.21
Purchase intention	5.3 (2.3)	3.4 (2.1)	31.8	**<0.001**	0.13

Note: Text in bold indicates significant differences (p-value < 0.05). Responses were collected on a 9-point likert scale: Liking: 1 - extremely unpleasant; 9 – extremely pleasant; Purchase intention: 1 - Not at all; 9 – Extremely).

Bag ($M = 5.9$, SD=1.8) and HCB Clamshell ($M = 5.9$, SD=1.9) formats. This trend was closely mirrored in the purchase intention scores. Once again, the HCB Film ($M = 5.3$, SD=2.1) and HCB Tray/film ($M = 5.3$, SD=2.3) configurations garnered the highest intention to purchase. The HCB Clamshell format registered the lowest purchase intention ($M = 4.9$, SD=2.3), followed closely by the HCB Bag, which met the acceptability threshold exactly ($M = 5.0$, SD=2.4). Overall, the results suggest that among the HCB options, the semi-rigid Tray/film and the flexible Film were the most favorably received by consumers.

Regarding the performance comparison between HCB and FBP packaging, the analysis revealed no statistically significant differences for flexible packaging formats. Specifically, for Bag format, neither Liking ($F = 0.0$; $p = 0.904$) nor Purchase Intention ($F = 1.2$; $p = 0.285$) showed significant variation between the HCB and FBP samples. Similarly, for Film format, no significant differences were found for either Liking ($F = 0.1$; $p = 0.738$) or Purchase Intention ($F = 1.7$; $p = 0.196$).

In contrast, significant differences were observed for rigid and semi-rigid packaging formats. For Clamshell format, the FBP version received significantly higher scores for both Liking ($M = 7.0$ vs. 5.9; $F = 25.4$; $p < 0.001$; eta2=0.10) and Purchase Intention ($M = 6.1$ vs. 4.9; $F = 15.6$; $p < 0.001$; eta^2=0.07). An opposite, and even more pronounced, result was recorded for the Tray/Film format. In this case, the HCB sample was significantly preferred over the FBP one for both Liking ($M = 6.2$ vs. 4.4; $F = 57.4$; $p < 0.001$; eta^2=0.21) and Purchase Intention ($M = 5.3$ vs. 3.4; $F = 31.8$; $p < 0.001$; eta^2=0.13).

3.3. Sensory and functional characterization of packaging formats

The CATA results conducted to compare consumer sensory evaluations of HCB and FBP samples for each packaging format are presented in Table 5.

A primary differentiator between the material types was their optical properties. For flexible format, the FBP Bag and FBP Film were perceived as significantly more *Transparent* ($Q = 24.4$, $p < 0.001$ and $Q = 26.1$, $p < 0.001$, respectively) and less *Opaque* ($Q = 25.0$, $p < 0.001$ and $Q = 36.1$, $p < 0.001$, respectively) than the HCB versions. Conversely, in rigid and semi-rigid applications, the HCB Clamshell and HCB Tray/film were described as significantly more *Opaque* ($Q = 63.2$, $p < 0.001$ and $Q = 41.3$, $p < 0.001$, respectively) and less *Transparent* ($Q = 81.4$, $p < 0.001$ and $Q = 40.0$, $p < 0.001$, respectively). Across all formats where a significant difference was noted, FBP samples were consistently associated with a higher degree of *Gloss* (Clamshell: $Q = 26.9$, $p < 0.001$; Film: $Q = 10.3$, $p < 0.001$; Tray/Film: $Q = 32.5$, $p < 0.001$). This suggests that while the base biopolymer may allow for higher clarity in films, the processing required for thicker, molded forms results in a loss of transparency and gloss compared to established petrochemical plastics.

Tactile characteristics also varied considerably. The HCB Bag and HCB Film were more strongly associated with *Smooth* ($Q = 27.2$, $p < 0.001$ and $Q = 27.6$, $p < 0.001$, respectively). However, perceptions of hardness and durability were inconsistent across packaging formats. The HCB Film and HCB Clamshell were more strongly associated with the *Hard* attribute ($Q = 12.8$, $p < 0.001$ and $Q = 7.7$, $p = 0.005$, respectively), whereas the FBP Bag was considered more strongly associated with the *Hard* attribute ($Q = 39.7$, $p < 0.001$) than its HCB alternative.

Consumer perception of material strength, captured by the attributes *Sturdy* and *Fragile*, showed a complex relationship with the material type and format. The HCB Bag and HCB Clamshell were found to be significantly more *Sturdy* ($Q = 39.3$, $p < 0.001$ and $Q = 72.7$, $p < 0.001$, respectively). In contrast, the FBP Film was considered more *Sturdy* ($Q = 6.3$, $p = 0.012$), and its HCB equivalent was simultaneously described as more *Fragile* ($Q = 17.8$, $p < 0.001$). This highlights that the mechanical properties of bioplastics are not universally superior or inferior but are specific to the polymer blend and manufacturing process for a given application.

Auditory feedback was a significant factor for flexible packaging. Both the HCB Bag and HCB film were described as significantly more *Noisy* ($Q = 79.4$, $p < 0.001$ and $Q = 6.0$, $p = 0.014$, respectively), indicating a distinct acoustic signature for the bioplastic materials, which are comparatively quieter.

Regarding olfactory properties, the FBP Bag was more frequently associated with the *Plastic-smelling* ($Q = 13.3$, $p < 0.001$) and *Foreign-smelling* ($Q = 5.3$, $p = 0.021$) attributes. This suggests a potential advantage for bioplastics in reducing characteristic "plastic" odors. However, it is noteworthy that the HCB Tray/Film and HCB Film was significantly more associated with a *Foreign-smelling* attribute ($Q = 4.2$, p

Table 5
Cochran's Q test results for check-all-that-apply **sensory attributes** of home-compostable bioplastic (HCB) and fossil-based plastic (FBP) samples across 4 formats, as evaluated by Italian consumers ($n = 110$).

	Bag (citation %)		Q	p-value	Clamshell (citation%)		Q	p-value	Film (citation %)		Q	p-value	Tray/Film (citation%)		Q	p-value
	HCB	*FBP*			*HCB*	*FBP*			*HCB*	*FBP*			*HCB*	*FBP*		
Transparent	57.3	86.4	24.4	**<0.001**	5.5	89.1	81.4	**<0.001**	62.7	30.9	26.1	**<0.001**	35.5	81.8	40.0	**<0.001**
Opaque	30.9	3.6	25.0	**<0.001**	70.9	5.5	63.2	**<0.001**	25.5	67.3	34.1	**<0.001**	43.6	2.7	41.3	**<0.001**
Glossy	9.1	11.8	0.5	0.491	2.7	31.8	26.9	**<0.001**	11.8	0.9	10.3	**0.001**	5.5	20.9	12.5	**<0.001**
Soft	24.5	68.2	39.7	**<0.001**	4.5	6.4	0.5	0.479	65.5	42.7	12.8	**<0.001**	10.0	10.0	0.0	1.000
Hard	2.7	11.8	7.1	**0.007**	68.2	50.9	7.7	**0.005**	1.8	7.3	6.0	**0.014**	49.1	53.6	0.5	0.483
Smooth	46.4	78.2	27.2	**<0.001**	45.5	69.1	16.1	**<0.001**	78.2	67.3	5.5	**0.018**	63.6	65.5	0.1	0.731
Rough	8.2	0.9	6.4	**0.011**	6.4	1.8	3.6	0.058	2.7	4.5	1.0	0.317	1.8	0.9	0.3	0.563
Fragile	42.7	8.2	36.1	**<0.001**	0.0	2.7	3.0	0.083	15.5	9.1	3.3	0.071	9.1	5.5	1.3	0.248
Sturdy	5.5	44.5	39.3	**<0.001**	90.9	72.7	13.3	**<0.001**	20.9	32.7	6.3	**0.012**	64.5	73.6	2.3	0.122
Noisy	89.1	11.8	79.4	**<0.001**	17.3	10.9	2.3	0.126	25.5	60.9	27.6	**<0.001**	40.0	12.7	22.5	**<0.001**
Odorless	41.8	49.1	1.4	0.238	51.8	49.1	0.2	0.639	21.8	39.1	9.7	**0.001**	50.9	21.8	20.5	**<0.001**
Plastic-smelling	5.5	23.6	13.3	**<0.001**	5.5	8.2	0.8	0.365	9.1	9.1	0.0	1.000	13.6	46.4	27.0	**<0.001**
Foreign-smelling	10.9	3.6	5.3	**0.021**	7.3	5.5	0.3	0.563	36.4	12.7	17.8	**<0.001**	13.6	22.7	4.2	**0.041**
Other	5.5	5.5	0.0	1.000	10.0	2.7	5.3	0.201	1.8	1.8	0.0	1.000	2.7	3.6	0.2	0.654

Note: Text in bold indicates significant differences (p-value < 0.05).

$= 0.041$) than its conventional counterpart, indicating that bioplastics can introduce their own unique and potentially undesirable odors.

The CATA results conducted to compare functional evaluations of FBP and HCB samples for each packaging format are presented in Table 6. Across all four packaging formats, the most significant and consistent attribute associated with bioplastics was *Sustainable*. The selection frequency for this term was higher for all HCB samples, with Cochran's Q values indicating a highly significant difference ($p < 0.001$ in all cases; Q values of 47.0, 56.8, 31.3, and 60.2, respectively). Furthermore, bioplastics were generally perceived as more *Innovative*. This association was statistically significant for the Bag ($Q = 18.8$, $p < 0.001$), Clamshell ($Q = 25.8$, $p < 0.001$), and Tray/Film ($Q = 23.5$, $p < 0.001$) formats. This suggests consumers view these materials as novel and representative of technological advancement. An interesting exception was the Film format, where the FBP material was rated as significantly more *Innovative* ($Q = 10.7$, $p = 0.001$), perhaps due to specific features in the conventional sample that were perceived as more advanced by consumers.

Conversely, FBP formats consistently retained a strong association with attributes related to usability and familiarity. The FBP Bag, FBP Clamshell, and FBP Tray/Film were significantly more associated with the term *Familiar* ($p < 0.01$ for all three), indicating a habituation barrier for new materials. More critically, FBP formats were consistently perceived as superior in terms of handling. The attributes *Easy to seal/open and Practical* were significantly more associated with the FBP samples in the Bag, Clamshell, and Tray/Film formats. For *Easy to seal/open*, the Q values were consistently high (Bag: $Q = 22.2$; Clamshell: $Q = 18.8$; Tray/Film: $Q = 49.3$), signaling a clear perceived performance gap in one of the most fundamental packaging functions.

Perceptions of other key attributes like *Safe, Premium*, and *Economical* were not consistent and appeared to be highly format-dependent. For instance, the HCB Clamshell was perceived as significantly more *Safe* ($Q = 4.2$, $p = 0.030$), whereas the FBP Tray/Film was considered more *Safe* ($Q = 4.3$, $p = 0.039$). This ambiguity in the perception of safety is a critical finding that warrants further investigation. Similarly, the *Premium* attribute was associated with the FBP Clamshell, while the *Economical* attribute was linked to the HCB Tray/Film. The same HCB Tray/Film was also perceived as more *Modern* ($Q = 7.3$, $p = 0.006$) and *Elegant* ($Q = 4.0$, $p = 0.045$), yet the FBP version was deemed more *Premium* ($Q = 5.0$, $p = 0.025$), highlighting a complex and sometimes contradictory consumer perception.

3.4. Impact of sensory and functional properties on affective responses

Fig. 1 presents the results of the Penalty-Lift analysis for the four evaluated packaging formats. A primary finding across all tested formats was the significant negative impact of undesirable olfactory cues. The attributes *Foreign-smelling* and *Plastic-smelling* consistently emerged as the strongest drivers of consumer rejection. This effect was particularly pronounced for the Tray/Film format (Fig. 1D), where the selection of

Table 6
Cochran's Q test results for check-all-that-apply **functional attributes** of home-compostable bioplastic (HCB) and fossil-based plastic (FBP) samples across various formats, as evaluated by Italian consumers ($n = 110$).

	Bag (citation %)		Q	p-value	Clamshell (citation %)		Q	p-value	Film (citation %)		Q	p-value	Tray/Film (citation %)		Q	p-value
	HCB	*FBP*			*HCB*	*FBP*			*HCB*	*FBP*			*HCB*	*FBP*		
Easy to seal/open	36.4	31.8	0.8	0.369	48.2	76.4	18.8	**<0.001**	60.9	63.6	0.4	0.548	50.0	5.5	45.3	**<0.001**
Economical	56.4	60.9	0.6	0.423	17.3	26.4	3.1	0.077	46.4	54.5	2.0	0.159	20.0	36.4	8.1	**0.004**
Elegant	0.9	6.4	4.5	0.330	24.5	20.9	0.5	0.479	7.3	11.8	1.3	0.251	11.8	4.5	4.0	**0.045**
Familiar	14.5	30.9	10.8	**0.001**	13.6	33.6	12.1	**<0.001**	23.6	23.6	0.0	1.000	18.2	31.8	6.8	**0.009**
Innovative	21.8	2.7	16.3	**<0.001**	40.9	5.5	29.8	**<0.001**	20.0	6.4	10.7	**0.001**	26.4	1.8	23.5	**<0.001**
Modern	10.0	5.5	1.5	0.225	29.1	15.5	6.4	**0.011**	16.4	9.1	2.7	0.102	18.2	6.4	7.3	**0.006**
Other	8.2	1.8	5.4	**0.019**	6.4	3.6	1.0	0.317	0.0	0.0	0.0	1.000	6.4	27.3	17.1	**<0.001**
Practical	29.1	38.2	2.6	0.104	48.2	65.5	7.3	**0.006**	58.2	58.2	0.0	1.000	49.1	22.7	17.1	**<0.001**
Premium	2.7	5.5	1.0	0.317	19.1	7.3	6.7	**0.009**	2.7	2.7	0.0	1.000	7.3	2.7	3.6	0.058
Safe	13.6	30.9	10.9	**<0.001**	59.1	48.2	4.2	**0.030**	12.7	20.0	2.6	0.102	32.7	44.5	4.3	0.030
Simple	73.6	71.8	0.1	0.738	32.7	51.8	10.2	**0.001**	74.5	73.6	0.0	0.866	48.2	54.5	0.9	0.345
Sustainable	54.5	5.5	47.0	**<0.001**	65.5	7.3	56.8	**<0.001**	55.5	16.4	31.3	**<0.001**	60.9	2.7	60.2	**<0.001**
Versatile	10.0	22.7	12.2	**<0.001**	47.3	54.5	2.0	0.157	20.0	20.0	0.0	1.000	26.4	21.8	0.8	0.353

Note: Text in bold indicates significant difference (p-value < 0.05).

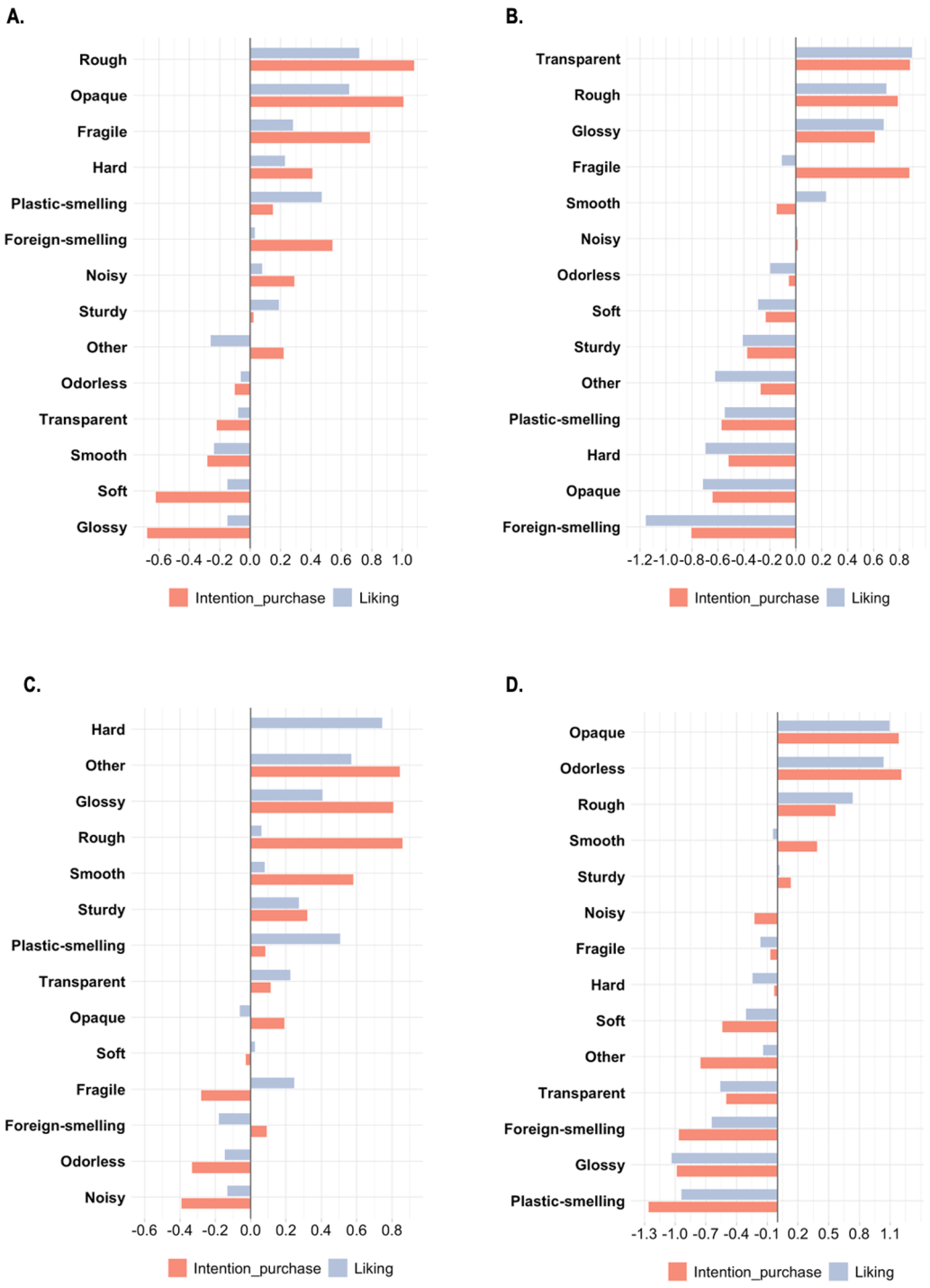

Fig. 1. Penalty-Lift scores for Liking and Purchase Intention based on the **sensory attributes** of Bag (A), Clamshell (B), Film (C), and Tray&Film (D) packaging.

these attributes corresponded with a decrease of both Liking and Intention to Purchase scores. This indicates that the presence of such odors is a critical factor for non-acceptance.

Furthermore, attributes related to structural integrity were strong indicators of consumer response. The perception of a package as *Fragile* was consistently penalized across all formats, leading to lower scores. Conversely, the attribute *Sturdy* provided a positive lift in Liking and Intention to Purchase for all four formats, confirming the importance of perceived durability in driving consumer preference.

Significant and contrasting results were observed for visual attributes, revealing that their impact is highly dependent on the packaging format. For the Clamshell (Fig. 1B), the attribute *Transparent* was a key positive driver, increasing Liking scores. In direct opposition, *Transparent* was a negative attribute for the Tray/Film format (Fig. 1D). The inverse was true for *Opaque*, which was a dominant positive driver for both the Bag (Fig. 1A) and Tray/Film (Fig. 1D), lifting Liking scores by approximately 0.8 and 1.0 points, respectively, while it was penalized for the Clamshell.

Other attributes also showed format-specific effects. The auditory attribute *Noisy* was a significant penalty for the Bag (Fig. 1A) and Film (Fig. 1C) formats, particularly impacting the Liking dimension. The *Glossy* attribute also had a divergent impact: it was a positive driver for the Clamshell but was associated with lower scores for the Bag and Tray/Film packages. Finally, it is noteworthy that for the Tray/Film format

(Fig. 1D), the attribute *Odorless* was identified as one of the most impactful positive drivers, yielding a lift of nearly 1.0 point for Liking.

Fig. 2 displays the results from the Penalty-Lift analysis, focusing on the functional attributes for the four packaging formats. A consistent finding across all four packaging formats is the fundamental importance of usability. The attribute *Easy to open/close* universally provided a strong positive lift to both Liking and Intention to Purchase, highlighting its role as a key driver of consumer acceptance. Similarly, the perception of the packaging as *Practical* was also associated with increased consumer scores in most cases.

The most significant differentiator between flexible and non-flexible formats was the impact of the *Sustainable* attribute. This attribute emerged as the single most powerful driver of preference for the Tray/Film package (Fig. 2D), where its selection correlated with an exceptional increase in Liking and Intention to Purchase. A notable positive lift for *Sustainable* was also recorded for the Clamshell (Fig. 2B), particularly concerning the Liking dimension. In contrast, the effect of this attribute was minimal for the Film (Fig. 2C) and had a slightly negative impact on the purchase intent for the Bag (Fig. 2A).

The analysis also reveals distinct conceptual profiles for the different packaging formats, particularly concerning perceptions of premium quality. The attributes *Premium* and *Elegant* were strong positive drivers for both the Film (Fig. 2C) and Tray/Film (Fig. 2D) formats. This effect was most pronounced for the Film, where *Premium* and *Elegant* substantially increased the Intention to Purchase. Conversely, these same attributes were penalized when associated with the Bag (Fig. 2A),

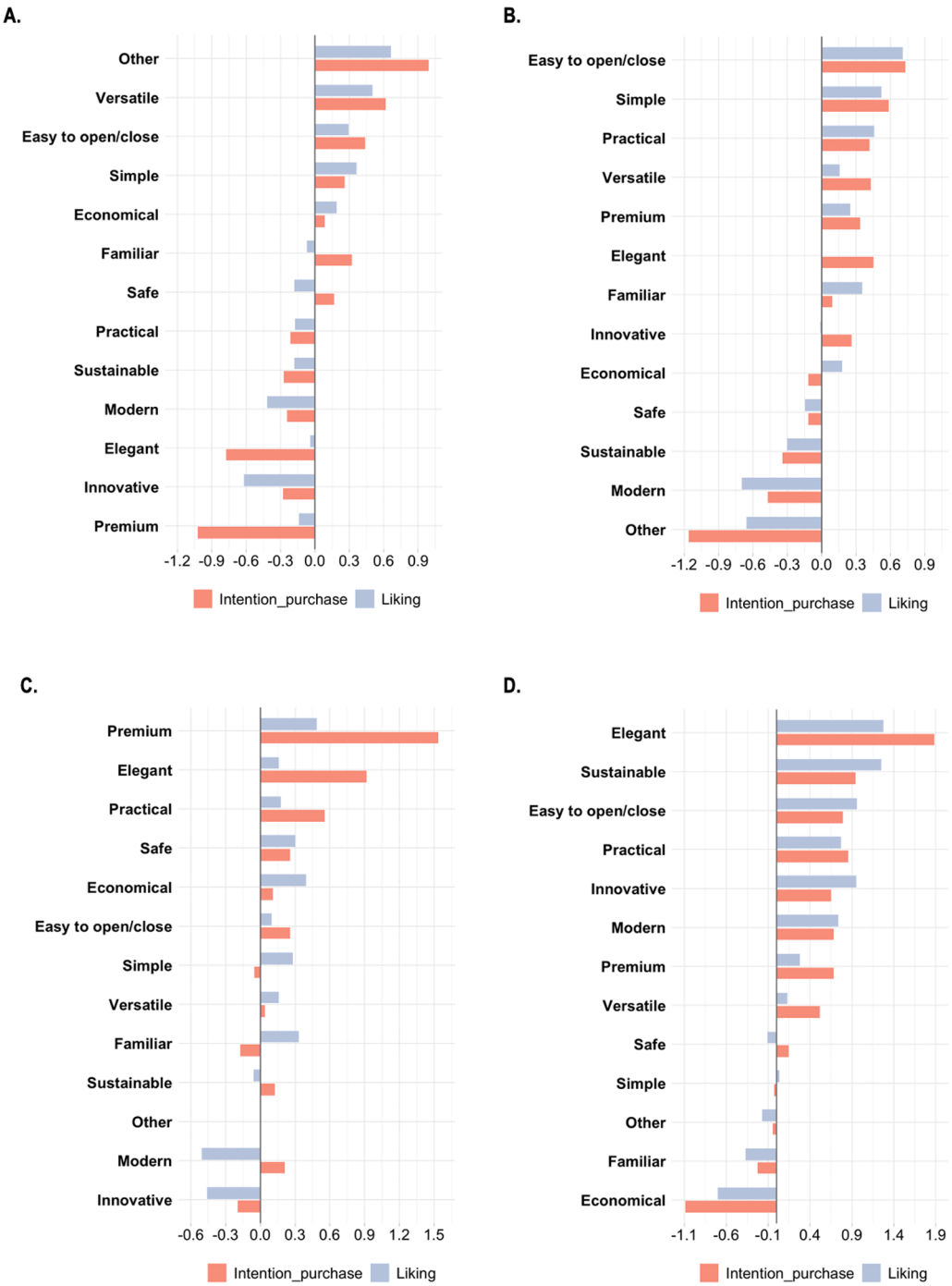

Fig. 2. Penalty-Lift scores for Liking and Purchase Intention based on the **functional attributes** of Bag (A), Clamshell (B), Film (C), and Tray&Film (D) packaging.

suggesting a mismatch between this packaging format and premium positioning in the consumer's perception. For the Clamshell (Fig. 2B), the key positive conceptual drivers were *Simple* and *Practical*, rather than *Premium*.

Finally, attributes related to novelty, such as *Innovative* and *Modern*, generally had a neutral or slightly negative impact on consumer scores across most formats. This suggests that for these product categories, consumers prioritized practical benefits and sustainability claims over perceived novelty.

3.5. Consumer disposal performance of the packaging

The Chi-square tests indicated a statistically significant association between packaging material and the accuracy of consumers' declared disposal methods across all four evaluated packaging formats. The results were highly significant for the Bag (χ^2=28.1, $p < 0.001$), Clamshell (χ^2=22.3, $p < 0.001$), Film (χ^2=11.36, $p < 0.001$), and Tray/Film formats (χ^2=30.13, $p < 0.001$).

A consistent and pronounced trend was observed across all formats: the FBP packaging yielded a substantially higher percentage of correct disposal declarations compared to the HCB packaging. For instance, while the FBP Tray/Film was correctly disposed of by 95.5% of consumers, this figure dropped to 66.4% for its HCB counterpart. A similar discrepancy was observed for the Bag, with 93.6% correct responses for the FBP version versus only 64.5% for the HCB version.

This pattern of lower performance for bioplastic materials was evident across all formats. The HCB Clamshell was correctly disposed of by 73.6% of consumers, compared to 96.4% for the FBP version. The Film showed the smallest, yet still highly significant, difference, with 89.1% correct responses for the FBP and 70.9% for the HCB versions.

When the results are analyzed collectively across all formats, the data reveal a clear and highly statistically significant difference in consumers' ability to correctly identify the disposal method based on the packaging material. FBP packaging was associated with a consistently high rate of correct disposal identification, with success rates ranging from 89.1% to 96.4%. This suggests a high level of consumer familiarity and understanding regarding the end-of-life management for these materials.

In stark contrast, the HCB packaging generated significantly more consumer confusion. Despite featuring the on-pack disposal logo as the conventional versions, the percentage of correct responses for HCB items dropped substantially, falling within a range of 64.5% to 73.6%. This systematic gap was confirmed to be highly significant ($p < 0.001$) for every format tested.

In summary, regardless of the specific packaging shape or function, the data show that the bioplastic packaging itself was the determining factor in increasing the likelihood of consumer error in disposal declarations. This highlights a critical challenge in consumer comprehension of bioplastic end-of-life, even when standard disposal guidance is provided.

3.6. Socio-demographic and attitudinal drivers of correct disposal of home-compostable bioplastic packaging

The results of the comprehensive ordered logistic regression model, developed to identify the integrated predictors of correct disposal behavior for home-compostable bioplastic packaging, are presented in Table 7. Following the stepwise approach described in the methodology, this unified model evaluates the influence of behavioral and attitudinal drivers while controlling for relevant demographic characteristics. Model robustness was confirmed by the Likelihood-Ratio Test (chi^2 = 28.3; $p = 0.041$), indicating a statistically significant improvement over the null model. The McFadden's Pseudo-R^2 was 0.10, representing a satisfactory explanatory power for behavioral data, and the proportional odds assumption was verified via the Brant test ($p = 0.760$), justifying the use of the ordered logit specification.

The analysis identified Age group as a significant demographic predictor. A negative correlation emerged between age and the likelihood of correct disposal: specifically, consumers in the oldest age bracket (45–80 years) showed significantly lower odds of correct disposal compared to the 18–32 reference group (OR = 0.32; $p = 0.038$). This indicates that, holding other factors constant, older individuals have 68% lower odds of falling into a higher category of disposal accuracy than their younger counterparts. However, the most robust effect in the model relates to consumer familiarity with the "OK compost" certification logo. This variable emerged as the strongest predictor of correct behavior: compared to consumers with high familiarity, those with low familiarity were drastically less likely to dispose of the packaging correctly (OR = 0.16; $p < 0.001$). This suggests that a lack of acquaintance with the labeling system reduces the odds of correct disposal by 84%. Regarding attitudinal drivers, the model identified a relevant trend concerning recycling attitudes. Consumers with a low pro-recycling attitude exhibited lower odds of correct disposal (OR = 0.34; $p = 0.080$) compared to those with a high attitude. Although this result only approaches statistical significance in the unified model, it suggests that a general predisposition toward waste sorting remains a key factor in managing novel materials like bioplastics. Similarly, a trend was observed for innovation attitudes, where consumers with low openness to innovation showed reduced odds of correct behavior (OR = 0.39; $p = 0.080$), highlighting the role of consumer proactivity in adopting new sustainable practices.

Table 7
Ordered logistic regression of the association between correctly declared disposal of home-compostable bioplastic packaging (Y) and logo familiarity, habits, and attitude variables (X) among Italian consumers ($n = 110$).

	Odd ratio	p-value
Age group		
18–32 (REF)	1.00	
33–44	0.42	0.126
45–80	0.32	**0.038**
Familiarity "OK compost" logo		
High (REF)	1.00	
Medium	0.50	0.175
Low	0.16	**<0.001**
Food shopping frequency		
Always (REF)	1.00	
Often	1.26	0.658
Occasionally	1.87	0.339
Disposal frequency		
Always (REF)	1.00	
Often	0.74	0.586
Occasionally	0.44	0.283
Recycling attitudes		
High (REF)	1.00	
Medium	0.43	0.160
Low	0.34	0.080
Sustainability attitudes		
High (REF)	1.00	
Medium	1.64	0.358
Low	1..49	0.513
Innovation attitudes		
High (REF)	1.00	
Medium	0.87	0.783
Low	0.39	0.080
Risk attitudes		
High (REF)	1.00	
Medium	1.33	0.569
Low	0.88	0.813

Note: Text in bold indicates significant differences (p-value < 0.05).

4. Discussion

4.1. Unpacking consumer acceptance: the interplay of material, format, and characteristics

Consumer acceptance of bioplastics is a multifaceted and conditional

phenomenon, profoundly shaped by perceptions, familiarity, and individual attitudes. This research reveals that consumer acceptance of bioplastics is not uniform but highly dependent on the specific packaging format. While the affective response to real home-compostable bioplastics (HCB) packaging is generally positive, it exhibits notable variation between flexible and rigid/semi-rigid applications. For flexible formats such as bags and films, no significant differences in liking or purchase intention were observed between HCB and fossil-based plastic (FBP) versions. Conversely, for rigid formats, the FBP Clamshell was significantly preferred over its HCB equivalent, whereas the HCB Tray/Film format garnered greater consumer favor. These outcomes are consistent with extant literature, underscoring the contextual nature of bioplastic acceptability. For instance, Uehara et al. (2023) noted that despite consumers perceiving bioplastics as a promising alternative to conventional plastics, their acceptance is not guaranteed and hinges on various specific product attributes and consumer comprehension thereof. Sijtsema et al. (2016) reported a spectrum of positive, negative, and mixed consumer sentiments regarding bio-based products, suggesting a nuanced emotional response contingent on the specific product context. Koenig-Lewis et al. (2014) identified that while most emotions were positive, negative emotions significantly impacted purchase intention, indicating that even within a broadly positive perception, specific negative associations can impede acceptance. Zwicker et al. (2021) demonstrated a more positive consumer sentiment towards bio-based plastics compared to conventional plastics, and Steenis et al. (2018) confirmed that bio-based packaging can elicit feelings of moral satisfaction. Collectively, these findings suggest that affective responses and subsequent acceptance of bioplastics are highly variable, being influenced by the specific product context and consumer understanding of their benefits. The fact that functionality and protection are still implicitly associated with fossil-based packaging (Koenig-Lewis et al., 2022) suggests that this critical lever may play a decisive role in how consumers perceive and experience HCB packaging.

Specifically, the marked variation in preference found in rigid formats compared to flexible ones is consistent with Nørgaard Olesen and Giacalone (2018), who highlight how packaging format can be a dominant attribute in determining the perceived quality and expected value of both the packaging and the product. Since rigid formats are inherently linked to a perception of higher value, the acceptance of bioplastics in these applications is subject to stricter evaluation criteria compared to flexible formats, where packaging performance expectations are generally lower. The analysis of packaging characteristics that drive consumer acceptance addressed in this study can offer a detailed insight into the sensory and functional role of packaging, providing a compelling explanation for these observed discrepancies. The FBP Clamshell's preference is largely attributable to its superior optical properties, specifically its significantly higher perceived transparency and gloss. The analysis conclusively demonstrates that transparency served as a crucial positive driver for this format, likely stemming from consumers' expectation to clearly view the fresh product contained within. Conversely, the HCB version's opaque nature incurred a penalty, and its perceived sustainability benefits were insufficient to mitigate this fundamental sensory disadvantage.

This finding aligns with prior research on product packaging, which consistently indicates that transparent elements positively influence consumer evaluations and purchase intentions. For instance, studies by Simmonds & Spence (2017) and Billeter et al. (2012) have revealed that transparent packaging is perceived as more trustworthy, receives higher consumer preference scores, and boosts purchase intent. Moreover, research by Simmonds et al. (2018) has shown that transparent packaging, in comparison to packaging featuring food imagery, enhances consumers' expected freshness and perceived quality.

This aligns with the conclusions of Otto et al. (2021), suggesting that while sustainable packaging receives an inherent positive bias, this perception is fragile and diminishes if the packaging is not perceived as "fitting" for the specific product.

The consumer response to the HCB Tray/Film format illustrates a distinct hierarchy of purchasing drivers. For this product category, the FBP version was significantly disadvantaged by a pronounced plastic odor, which acted as a critical driver of non-acceptance. In contrast, the HCB sample's opacity was viewed as a positive attribute, while its sustainability emerged as the principal determinant of consumer preference, yielding a significant increase in both liking and purchase intention. The preference for the HCB Tray/Film format could be fueled by what Koenig-Lewis et al. (2022) define as a positive implicit association between compostable packaging and the perceived "healthiness" of the product, suggesting that the bio-based material may act as a cue that elevates the perceived quality of the content compared to traditional plastic.

The existing literature supports the role of sustainability in driving consumer acceptance of bioplastic packaging, indicating that consumers are willing to pay for packaging perceived as sustainable, and conversely, are unwilling to pay for packaging perceived as non-sustainable or ambiguous (Findrik and Meixner, 2023; Herrmann et al., 2022; Klein et al., 2019).

In this context, it is important to note that consumers do not evaluate sustainability through technical metrics. Instead, they rely on what Otto et al. (2021) describe as "perceived sustainability", an intuitive interpretation that is often misaligned with the actual environmental impact of materials. The present study further contextualizes the influence of sustainability, proposing a scenario where the conceptual benefit of sustainability becomes an influencing factor, particularly when conventional alternatives exhibit negative sensory cues (e.g., plastic odor) and when product transparency is not a primary consumer concern. Across nearly all formats, however, a consistent functional deficit was noted for HCB packagings: consumers perceived FBP packaging as more familiar and practical. The Penalty-Lift analysis confirmed that ease of use is a universal driver of acceptance. This may indicate that while consumers may be attracted to the idea of sustainability, they are not willing to compromise on core functional performance, a significant hurdle for HCB manufacturers to overcome. Product protection remains the primary function of packaging. Consequently, if a bioplastic format does not implicitly ensure the prevention of food waste (e.g., by preventing a visual assessment of the product's shelf life), its environmental value may be negated by the perception of functional inefficiency (Lindh et al., 2016; Wikström et al., 2016). This trade-off concerning sustainability has been previously observed in research on sustainable packaging. For instance, despite an explicit preference for sustainable packaging, research by Koenig-Lewis et al. (2022) suggests that people still subconsciously associate traditional plastic with better protection and functionality. Lignou & Oloyede (2021) demonstrated that while consumers were receptive to sustainable proposals, critical functional quality characteristics (e.g., rigidity, ease of holding) were essential considerations for sustainable packaging to become a viable option. Granato et al. (2022) demonstrated that the appreciation for sustainability can be strong enough to offset some losses in other benefits, such as preservation. However, their findings also indicate that this absorptive capacity diminishes if sustainability incurs excessive costs or significant drawbacks, leading consumers to still perceive the disadvantages. These outcomes imply that manufacturers of sustainable packaging, especially HCBs, must prioritize innovation that bridges the gap between sustainability and functionality. Simply offering a sustainable alternative may not be sufficient if it compromises on user experience. The findings underscore the importance of understanding and addressing consumer perceptions of practicality and ease of use in the design and marketing of sustainable packaging products.

Finally, when interpreting these results, it is essential to acknowledge that consumers frequently perceive packaging as a secondary byproduct of the food item itself, garnering limited conscious attention during the purchasing process. However, this low-involvement relationship implies that decisions are often governed by visual heuristics and physical cues. Within this framework, packaging material does not

operate in isolation. Rather, its sensory and functional properties serve as critical indicators of safety, quality, and environmental value, thereby significantly shaping final purchase intentions.

4.2. The disposal dilemma: a critical gap in consumer knowledge

A relevant finding of this study is the significant disparity in correct disposal performance between materials, which lies at the heart of the bioplastic paradox. While consumers demonstrated a high level of accuracy in identifying the correct disposal route for plastic packaging, this figure plummeted for bioplastic items. This gap was highly significant across all four packaging formats, confirming that the material itself, and the associated on-pack disposal logo, was the primary source of confusion. This decline in performance may reflects the incongruity between the sensory properties of the materials and the indicated disposal route. As demonstrated by Magnier & Schoormans (2015), the effectiveness of sustainability claims depends heavily on their congruence with the visual appearance of the packaging. In the case of bioplastics, the conventional appearance of the material can cognitively invalidate the disposal logo, leading consumers to ignore the verbal instruction in favor of a categorization based on physical appearance.

Paradoxically, despite consumers holding positive attitudes towards the material and perceiving home-compostable bio-based plastic packaging as sustainable, their disposal behavior for this type of packaging does not reflect these attitudes. Despite growing environmental concern, Duarte et al. (2024) observe that this awareness does not always translate into tangible actions. This phenomenon, often influenced by factors such as cost and value perception, supports the existence of a complex decision-making process in which ecological intent is hindered by practical barriers, contributing to the decline in disposal performance observed for bio-based materials. In the context of sustainable packaging, this confusion is exacerbated by a lack of industry consensus regarding definitions and the fragmentation of bioplastic types, making it difficult for consumers to understand the correct disposal behavior. As noted by Boz et al. (2020), the term “sustainable packaging” is often perceived as equivalent only to recycling or composting, overlooking other fundamental disposal modalities. This finding supports previous studies on consumers' ability to correctly dispose of bioplastic materials. Taufik et al. (2020) investigated German consumers' attitudes towards water bottles and observed that despite compostable bio-based packaging being perceived as having the greatest environmental appeal, this positive perception did not translate into correct disposal actions. The authors suggest that on-label instructions were either overlooked or disregarded, as participants expressed deeply ingrained beliefs that plastic-like materials belong in recycling or found it inconceivable that organic waste was the correct receptacle for bioplastics. This phenomenon may be attributed to consumers' prior familiarity with recycling plastic packaging (Boesen et al., 2019). Additionally, consumers may struggle to distinguish between bio-based and fossil-based plastic packaging, especially when both types are recyclable and share similar sensory and functional properties (Dilkes-Hoffman et al., 2019; Van den Oever et al., 2017). To ensure the efforts invested in developing domestic-compostable materials are not wasted, the improper disposal of home-compostable bioplastics is a significant challenge that must be addressed.

To understand the root of this disposal confusion, key predictive factors were identified. The study revealed that familiarity with the "OK compost" logo is the most powerful determinant of correct behavior. Familiarity with the "OK compost" logo was the strongest predictor, with consumers who were unfamiliar with the logo having 84% lower odds of correct disposal compared to those with high familiarity. Bioplastic materials increasingly share physical and sensory characteristics with conventional plastics, making it challenging for consumers to differentiate and recognize them. Consequently, enhancing consumer awareness is considered a crucial step toward fostering product acceptance and influencing purchasing decisions for bioplastic goods. The existing literature suggests that labels are the primary source of information among consumers to identify eco-friendly packaging (e.g., Herbes et al., 2018). The crucial role of logo familiarity is reflected in the cognitive barriers identified by Boz et al. (2020), which are governed precisely by the quality and clarity of the information available about the product. If essential functions and disposal instructions are not communicated effectively, consumers develop an incomplete understanding, leading them toward product preferences and uses erroneously perceived as sustainable. This issue underscores the challenge of accurately interpreting the meaning of logos and ensuring their correct disposal. Literature reveals a critical consumer understanding of product-associated compostability logos. For instance, less than half of European consumers recognize a compostable logo, with slightly better but still incomplete performance in the Italian context (Two Sides, 2020). This limited knowledge and uncertainty lead to disposal errors, posing a risk of contaminating recycling and composting streams (Hann et al., 2020; Purkiss et al., 2022). The current research within the Italian context corroborates this understanding, specifically regarding domestic compostable packaging. This highlights a significant familiarity gap concerning compostability logos and emphasizes how variations in this variable are crucial for proper waste disposal. The crucial importance of familiarity with labeling resonates with the need to increase consumers' environmental familiarity through education and awareness initiatives (Duarte et al., 2024). Indeed, specific knowledge and a clear understanding of environmental benefits are fundamental for consumers to correctly differentiate between conventional and sustainable packaging during the purchasing and end-of-life management stages. Furthermore, it is important to consider that better education about the logo might not be effective. Magnier & Schoormans (2015) observed that consumers with low environmental concern are sensitive to the mismatch between visual design and verbal claims. These consumers react negatively to packaging that claims to be sustainable but looks conventional. This suggests that the “OK compost” logo by itself may not be enough to overcome the visual bias caused by bio-plastics that look similar to traditional plastic.

Further analysis of predictive factors identified a significant generational divide. Age emerged as the sole socio-demographic variable with statistically significant predictive power, wherein older consumers demonstrated a lower propensity for the correct disposal of HCB packaging compared to their younger counterparts (aged 20–32 years). This disparity may be attributable to younger generations possessing greater familiarity with novel material innovations and their specific disposal protocols. Alternatively, it could suggest that younger individuals are less influenced by long-standing disposal habits established prior to the widespread introduction of bioplastics. As the literature indicates, the effect of age on the perception and purchase intention of bioplastic products is not monolithic. Rather, it varies significantly depending on product type, market context, and other socio-economic factors (Ketelsen et al., 2020; Klein et al., 2019; Ruf et al., 2022). Furthermore, this behavioral gap may reflect a broader trend of heightened environmental consciousness among younger demographics. Large-scale studies consistently demonstrate that Gen Z and Millennials are more inclined to allow climate change concerns to influence their career and consumption choices and are significantly more likely to engage in climate activism compared to older generations (Deloitte, 2025; Pew Research Center, 2021). The fact that young people are better at identifying disposal routes for bioplastics may be also linked to their perception of product value. Gomes et al. (2023) suggest that for Gen Z, perceived environmental benefits directly influence the perception of product quality. Consequently, these consumers are likely to pay closer attention to on-pack information (such as the “OK compost” logo) to validate the ethical investment made at the time of purchase.

4.3. Practical implications and policy recommendations

The results of this study offer several actionable insights for

stakeholders across the bioplastics value chain, highlighting a dual imperative for both industry innovation and public policy intervention.

For packaging manufacturers, the findings clarify that while the "Sustainable" attribute is a powerful asset, it cannot consistently compensate for deficiencies in core sensory and functional performance (Granato et al., 2022; Lignou and Oloyede, 2021). The universal importance of usability, particularly attributes like "Easy to open/close", suggests that achieving functional parity with conventional plastics is a non-negotiable prerequisite for market acceptance. Furthermore, research demonstrates that no universal strategy exists regarding sensory properties, especially from a visual standpoint. The impact of transparency versus opacity is highly context-dependent and must be tailored to the expectations of the specific packaging format (Simmonds et al., 2018) and its functions. This was evident in the preference for transparency in the Clamshell format versus the positive perception of opacity for the Tray/Film. Even olfactory properties can play a strategic role. HCBs can gain a significant competitive advantage where conventional alternatives exhibit clear olfactory sensory flaws, such as the "plastic-smelling" attribute that heavily penalized the FBP Tray/Film. In this case, sustainability is allowed to become a driver of acceptability.

For policymakers and environmental agencies, there is an urgent need for widespread public education campaigns to bridge the critical knowledge gap regarding bioplastic disposal. The production and consumption of HCB packaging will benefit the global economy and the environment only if supported by shifts in consumer behavior and favorable regulatory policies that encourage its correct adoption (Stark and Matuana, 2021). The present research indicates that existing on-pack labeling strategies, even those utilizing standard logos, are still inadequate for closing the familiarity gap concerning novel materials such as HCBs. Consumers appear to default to established heuristics (e.g., "all plastic-like items go to plastic recycling"), leading to a high potential for contamination of waste streams (Hann et al., 2020; Purkiss et al., 2022). The confusion surrounding HCBs highlights a critical failure in communicating the end-of-life requirements of these materials to the public, thereby jeopardizing the very environmental benefits they are designed to offer. These findings suggest that a primary goal of communication campaigns should be to improve the recognition and correct interpretation of compostability certification marks, for instance, the "OK compost home" logo (Taufik et al., 2020). In this context, it could be relevant promoting educational campaigns focused not only on logo recognition but also on understanding its practical significance through disposal examples that help avoid common errors caused by sensory similarity with plastic packaging, in addition to clarifying the difference with non-home-compostable bioplastics. For disposal behavior to be correct, the packaging must also be accurately categorized as sustainable by the consumer. As highlighted in this study and confirmed by the literature (e.g., Magnier and Schoormans, 2015), recent innovations allow for the creation of sustainable packaging with a conventional look. However, this aspect can mislead the consumer, making the claim (or the disposal logo) the sole source of information, which is often subject to skepticism or misinterpretation. For this reason, it is also important to educate consumers on the variety of sensory characteristics that bioplastic packaging may possess in the near future.

Given the observed generational gap, targeted outreach strategies should be crafted to engage specific consumer demographics, particularly older consumer segments such as the Baby Boomer generation (Carbonell-Alcocer et al., 2025), addressing the skepticism towards sustainability issues prevalent in this demographic (do Paço et al., 2012).

Finally, policymakers at both the European and national levels should increase efforts to engage citizens in home composting, as only a small share of European households currently practice it. Although recent EU-wide data are lacking, a report by European Bioplastics (2015) provides some indicative figures. While the available data are not directly comparable, they illustrate the variability of household participation: in the Netherlands only an estimated 5–10% of households compost at home; in Sweden, around 14% of biologically treated household waste in 2012 was home-composted; and in the UK, approximately 40% of households with a garden reported composting. Regional data from the Trentino region in Northern Italy further highlight substantial variation across municipalities, with participation rates ranging from 9% to over 57% (Provincia Autonoma di Trento, 2014). This suggests that with targeted policies and greater citizen engagement, there is significant room for growth in home composting practices, which would in turn support the effective disposal of home-compostable bioplastics. However, it must be noted that to date home composting is not a universally feasible solution, as it remains inaccessible to a large segment of the population, particularly those living in dense urban environments. Nevertheless, a range of alternative solutions is emerging to enable organic waste treatment at or near the household level (Sulewski et al., 2021), even in urban contexts (DiGiacomo et al., 2018). These include indoor composting systems, space-efficient technologies designed for apartments, and community-based schemes that provide shared access to composting infrastructure. Moreover, several cities and private initiatives have implemented organized collection of source-separated organic waste for compost production, expanding access beyond single-family homes. This suggests that composting should no longer be framed solely as an activity limited to rural or suburban households. Therefore, promoting the spread of composting practices across diverse contexts can indirectly provide significant support for the adoption of compostable bioplastic packaging and the closing of its life cycle.

4.4. *Research limitations and future research directions*

While this study provides valuable insights into consumer research, its limitations must be acknowledged. The specific demographic profile of the participants (young, highly educated, and affluent individuals from Northern Italy) may constrain the external validity of the results beyond this specific socio-economic group. Consequently, these results may not extend to other national or cultural contexts with varying waste management systems and levels of environmental awareness. Notably, within the European context, Italy is a high-performing country for recycling, with the Trentino region being particularly exemplary (European Environment Agency, 2023; ISPRA, 2024). Consequently, the study's findings likely overestimate the typical disposal behaviors of the general Italian and European populations. Future research should aim to validate these findings with larger, more geographically diverse consumer samples. Secondly, while the CATA approach mimics rapid consumer recognition, the controlled experimental setting cannot fully replicate the cognitive distractions and time pressures of a real-life retail environment. As noted in literature, there is often a value-action gap where consumers' stated perceptions and intentions do not perfectly align with their actual experiences and practices. Future research should therefore integrate observational methodologies to validate whether the perceptions captured through CATA translate into consistent sustainable actions. This would provide a more robust measure of ecological validity and mitigate potential social desirability bias. Furthermore, as the HCB materials used were based on specific proprietary formulations tailored to a "formulation-for-purpose" approach, the results are representative of the materials tested and may not be fully generalizable to the vast and diverse array of commercial home-compostable blends currently available on the market. In this context, further research on different types of materials can support the generalization of the results highlighted in the study. Another potential limitation is related to the choice of packaging formats and their combination with the contained products, which may have influenced the responses. Finally, the experimental design potentially induced a guided focus on the packaging, which may have inflated its perceived influence on consumer choice. However, as this effect was consistent across all samples, the internal validity of the comparisons between categories is preserved.

Beyond consumer-focused research, it is crucial to consider the

strategic role of producers. Indeed, the long-term prosperity of any bioplastic's producer will depend on its ability to align with the legally defined principles of the circular economy. This requires making a clear and decisive strategic choice between the "recyclable" and "compostable" end-of-life pathways. For the recycling pathway, companies must actively participate in developing Design for Recycling standards to ensure their future formulations are compliant with high grades (e.g., Grade B or higher), by investing in R&D to make bioplastics compatible with existing recycling streams without causing contamination. For the compostability pathway, the strategy is to focus on legally mandated niche markets (e.g., coffee pods, ultra-lightweight bags), developing materials with superior performance to become the supplier of choice in these categories.

Looking ahead, sustained investment in next-generation material science will be crucial for maintaining a competitive edge. This includes exploring novel bio-based feedstocks that do not compete with food crops, developing advanced composites, and pioneering new business models such as reuse and refill systems (Barnett et al., 2023). By proactively navigating the intertwined challenges of consumer psychology, technical innovation, and regulatory compliance, the entire bioplastics sector can overcome current critical issues and effectively contribute to a more sustainable economy.

5. Conclusions

The research demonstrates that consumer engagement with home-compostable bioplastics is characterized by a significant tension between positive environmental sentiment and the practical realities of product performance and end-of-life disposal. Consumer acceptance is highly contingent on the packaging format and a delicate trade-off between sustainability and key sensory-functional attributes. While the principle of sustainability is a powerful purchasing driver, it often fails to compensate for perceived deficiencies in core characteristics such as transparency and ease of use, which remain critical determinants of consumer preference.

Critically, the study reveals a profound "bioplastic paradox": despite favourable perceptions, consumers exhibit a significant inability to correctly dispose of home-compostable bioplastics packaging. This behavioural gap is not primarily driven by a lack of environmental concern but by a specific familiarity deficit, most notably the low recognition of certified compostability logos. This confusion is exacerbated by a generational divide, wherein older consumers, potentially influenced by long-standing disposal habits, are less likely to follow correct disposal protocols.

Consequently, the findings present a dual imperative. From an industry perspective, the market success of home-compostable bioplastics depends on innovations that mitigate key performance deficits relative to conventional plastics, such as improving their distinctiveness and recognizability to consumers. For policymakers and public agencies, there is a need for targeted educational campaigns focused on improving logo literacy and addressing specific demographic challenges, to ensure that these materials achieve their intended environmental benefits and do not contaminate existing waste streams.

Funding

This paper is supported by the European Union's Horizon 2020 research and innovation program under grant agreement No 101037796, project SISTERS (Systemic Innovations for a Sustainable reduction of the European food wastage).

Acknowledgements

We would like to express our appreciation to the members of the Sensory Quality Unit at the Edmund Mach Foundation and Sensory Quality and Consumer Behavior team at the University of Trento for their assistance in conducting consumer tests.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work the author(s) used Gemini 2.5 Pro (Google) in order to improve readability and language. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

Ethical statement

The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Research Ethics Committee of the University of Trento (Protocol No. 2023-19 ESA, date of approval: December 18, 2023). All participants provided written informed consent prior to their participation.

CRediT authorship contribution statement

Danny Cliceri: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Michele Pedrotti:** Writing – review & editing, Investigation. **Carolina Peñalva:** Writing – review & editing, Resources. **Flavia Gasperi:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization. **Isabella Endrizzi:** Supervision, Project administration, Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Carolina Penalva reports a relationship with Fundación aiTIIP that includes: employment. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.fufo.2026.101006.

Data availability

Data will be made available on request.

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