International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Return to Soil: A Material-Driven Approach to Sustainable Packaging for Indian Consumers

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Abstract

This study investigates how waste-derived material development and materials experience can be integrated to make sustainable packaging perceptible, desirable, and actionable for Indian consumers. Originating in the observation that household compost was being distributed in plastic bags, the project adopted a practice-based design research methodology combining material experimentation, iterative prototyping, and qualitative user evaluation. Sawdust, used tea waste, coconut husk, cow dung, and pencil shreds were tested with natural binders and protective treatments across six iterations. The final material, composed primarily of cow dung and sawdust, was moulded into packaging for a gardening-related application and designed to return to soil through composting after use. Twenty-two participants evaluated the prototype in blind and informed phases, with responses analysed across sensorial, interpretative, affective, performative, and cultural dimensions (Giaccardi & Karana, 2015). Smell and curiosity dominated initial encounters, whereas disclosure of the material composition and end-of-life proposition increased associations with sustainability, attraction, and willingness to compost. Cultural familiarity with cow dung supported acceptance for many participants, although seven concluded the informed phase with discomfort, hygiene concerns, or disgust. The findings demonstrate that sustainability is not automatically legible through material composition alone. It is produced through the interaction of sensory qualities, contextual information, cultural memory, and the proposed post-use practice. The study consequently argues that material development, communication, and end-of-life participation must be designed together if sustainable packaging is to become a compelling everyday experience.

Keywords: sustainable packaging; waste-derived materials; materials experience; Material Driven Design; cow-dung composite; return to soil; Indian consumers

Introduction

Packaging is one of the most visible yet short-lived material outputs of contemporary production and consumption. Designed to protect, contain, communicate, and transport products, it is frequently discarded shortly after use, while its environmental consequences can persist for decades. This disparity has made packaging an important site for sustainable material innovation. Global plastic production exceeds 360 million tonnes annually; approximately 36 per cent of all plastic produced is used for packaging, packaging contributes about 40 per cent of short-lived plastic waste, and only about 9 per cent of plastic waste is effectively recycled (OECD, 2022; UNEP, 2023). The challenge is therefore not only to reduce packaging waste, but also to develop alternative materials that are environmentally viable, functionally suitable, and capable of competing with conventional materials in everyday consumer markets.

India presents a particularly significant context for this inquiry. As the world's most populous country (UNFPA, 2023) and a rapidly developing economy, its expanding patterns of production and consumption have major implications for resource use and waste generation. Open dumping and inadequate management of agricultural and municipal waste (Kumar et al., 2017) continue to create environmental and public-health risks. At the same time, India has longstanding traditions of material reuse. The use of cow dung in rural households for fuel, insulation, pest control, and cleaning, (Gupta et al., 2016) for instance, demonstrates forms of indigenous material knowledge in which waste is treated as a resource capable of acquiring new functions. This principle has renewed relevance as material science increasingly explores agricultural residues, organic matter, natural composites, and other waste streams as potential alternatives to petroleum-based packaging (Mohite et al., 2022;Kossalbayev et al., 2025) .

However, the development of sustainable materials alone does not guarantee their adoption. A significant gap persists between environmental awareness and everyday consumer behaviour (Kollmuss & Agyeman, 2002) . The Ipsos India Sustainability Segmentation Survey identifies 41 per cent of Indian consumers as *Busy Bystanders* and 24 per cent as *Disengaged Denialists*, compared with 23 per cent classified as *Activists* (Ipsos, 2024). This suggests that sustainability, even when recognised, may not consistently determine consumer choice. Sustainable packaging must therefore address not only environmental performance and material functionality, but also how consumers perceive, handle, interpret, and respond to alternative materials.

The concept of materials experience provides a framework for examining the relationship between material properties and consumer interaction. Karana, Hekkert, and Kandachar (2008) describe material experience through the sensorial, interpretative, and affective dimensions of people's encounters with materials. Giaccardi and Karana (2015) subsequently add a performative dimension, recognising that materials also shape interaction and practice. Within packaging, characteristics such as texture, weight, surface irregularity, visual appearance, rigidity, flexibility, and associations with naturalness or waste can consequently influence not only functional performance, but also how a material is understood and valued. This paper investigates sustainable packaging at the intersection of material science, design, and consumer experience. It examines how sustainable and waste-derived materials can be developed not simply as environmentally responsible substitutes for conventional packaging, but as materially desirable alternatives. By connecting environmental and functional properties with sensorial, interpretative, affective, performative, and cultural experience, the study considers how materials experience can make sustainable packaging a more compelling and viable everyday consumer choice.

Literature Review

Research on sustainable materials has expanded significantly in response to the environmental consequences of contemporary production and consumption. Within design practice, natural composites, recycled synthetic polymers, and organic materials have become prominent areas of experimentation. Much of this exploration, however, has focused on furniture, household products, clothing, and accessories, while the application of alternative materials to packaging remains comparatively limited. This is significant because packaging represents one of the largest uses of plastic globally and is characterised by an exceptionally short functional lifespan. Material substitution and innovation are therefore central concerns within sustainable packaging design.

Material science research has increasingly examined agricultural, food-processing, and forestry residues as potential raw materials for packaging. Cereal straw, husks, fruit peels, cellulose-rich fibres, and other

organic by-products contain varying proportions of cellulose, hemicellulose, lignin, pectin, (Dhalsamant, K., Dalai, A., Pattnaik, F., & Acharya, B., 2025) and other compounds that influence mechanical behaviour, durability, processability, and suitability for fabrication. Sustainable material development consequently requires more than the identification of biodegradable resources. The physical and biochemical properties of a waste material determine the treatments it requires and the functions it can perform within a packaging system. Research into biodegradable plastics derived from renewable resources such as starch and cellulose similarly demonstrates attempts to create materials capable of performing functions conventionally fulfilled by petroleum-based plastics (Aarsha Surendren, Amar K. Mohanty, Qiang Liu, Manjusri Misra, 2022) .

An important strand within this literature concerns the transformation of waste from a discarded substance into a material resource. Studies and design experiments have investigated agricultural and forestry side streams, discarded leather, microbial materials, bacterial cellulose, coffee waste, and other unconventional sources (Camera, S., and Karana, E.,2018). These interventions demonstrate that waste-derived materials can possess functional as well as aesthetic possibilities. Material Driven Design extends this approach by asking designers to begin with the qualities and limitations of the material itself and develop applications around those characteristics rather than forcing new materials to imitate established ones (Karana et al., 2015).

The coffee-waste composite examined by Karana and colleagues illustrates this relationship particularly clearly (Karana et al., 2015). Although the addition of coffee particles limited the composite's structural strength, its irregular surface, natural associations, biodegradability, and visible imperfections became potential experiential strengths (Karana et al., 2015 . Rather than treating these qualities as defects, the design process used them to communicate naturalness, individuality, and uniqueness (Rognoli & Karana, 2014) . Such research indicates that sustainable materials may generate value not only through environmental performance, but also through the particular experiences their physical qualities make possible .

This relationship between material properties and user response is central to materials experience. Karana, Hekkert, and Kandachar (2008) define material experience as the experience people have with and through the materials of a product. Their framework distinguishes among sensorial experience, meanings attributed to materials, and emotional responses. Giaccardi and Karana (2015) later introduce a performative dimension, recognising that materials also influence actions, interactions, and practices. Material experience is therefore produced through the relationship among material, object, user, context, and time rather than residing exclusively within the physical material.

This framework has important implications for sustainable packaging. Conventional material-selection approaches have frequently prioritised measurable engineering properties such as strength, durability, manufacturability, and cost (Ashby & Johnson, 2002) . Design research, however, has emphasised that material selection also involves intangible qualities, including texture, appearance, tactility, associations, meanings, and emotional responses (Karana, E., Hekkert, P., & Kandachar, P.; 2010) . For a designer, the question is therefore not only whether a material can technically perform a packaging function, but also how its surface, weight, flexibility, colour, texture, and other sensory characteristics shape the user's interpretation of the product (Magnier, L., & Schoormans, J.; 2015). Materials experience offers a means of connecting these physical properties with consumer perception and interaction (Karana & Hekkert, 2010) .

Design research further translates materials experience into practical experiential objectives such as gratifying the senses, conveying meanings, eliciting emotions, and shaping action (Desmet, P., & Hekkert, P.; 2007; Camera, S., and Karana, E. (2018)). These objectives are especially relevant to sustainable materials because alternative and waste-derived materials often differ perceptibly from conventional plastics or highly processed packaging surfaces. (Elvin Karana, Noortje Nijkamp, 2014) Their visible fibres, irregular textures, natural colours, imperfections, or unfamiliar tactile qualities may initially challenge established consumer expectations (V. Rognoli, E. Karana, and O. F. Pedgley, 2011; Meng & Leary, 2021). Design may either conceal these qualities or employ them strategically to communicate environmental value, naturalness, craftsmanship, uniqueness, or innovation. ((Rognoli & Karana, 2014; Van Schoubroeck, 2023)

The consumer dimension becomes particularly important in the Indian context. Increasing environmental education and public discussion around sustainability have not necessarily produced equivalent changes in consumer behaviour. The Ipsos India Sustainability Segmentation Survey identifies 41 per cent of respondents as *Busy Bystanders*, 24 per cent as *Disengaged Denialists*, and 23 per cent as *Activists* (Ipsos, 2024). These findings indicate that a substantial proportion of Indian consumers either deprioritise environmental concerns or remain unwilling to translate concern into action. Sustainable packaging consequently operates within a market in which environmental responsibility may not consistently outweigh convenience, price, familiarity, or desirability. (Joshi & Rahman, 2015; Ketelsen et al., 2020)

This produces a gap between the development of sustainable materials and their acceptance as everyday consumer materials (Karana et al., 2015; Pedgley & Karana, 2011) . Existing research demonstrates considerable innovation in biodegradable materials, natural composites, recycled polymers, and waste-derived substances (Camere & Karana, 2018b; Kossalbayev et al., 2025; Mohite et al., 2022). Materials Experience and Material Driven Design scholarship , meanwhile, demonstrates how sensory, interpretative, emotional, and performative qualities shape people's relationships with materials (Giaccardi & Karana, 2015; Karana et al., 2015). Consumer research in India further indicates that environmental awareness alone may be insufficient to produce behavioural change (Ipsos, 2024; Joshi & Rahman, 2015) . These strands, however, are less frequently integrated in research on sustainable product packaging within the Indian consumer context.

The present study addresses this gap by examining how the material science of sustainable and waste-derived packaging can be integrated with materials experience as a design strategy (Karana et al., 2015). Rather than treating sustainability, material performance, and consumer desirability as separate concerns, it considers how they can inform one another during material experimentation, prototype development, and user interaction. It therefore investigates whether sustainable packaging can become desirable not only because consumers recognise its environmental benefits, but also because its physical, sensorial, interpretative, affective, performative, and cultural qualities make it compelling as a material experience.

Research Gap and Research Question

Existing research on sustainable packaging has extensively examined biodegradable, bio-based, recycled, and waste-derived materials, particularly in relation to environmental impact and functional performance (Dhalsamant et al., 2025; Kossalbayev et al., 2025; Ruf et al., 2022) . Material science research has similarly demonstrated the potential of agricultural and organic waste as an alternative material resource (Kossalbayev et al., 2025; Mohite et al., 2022) . In parallel, Materials Experience and Material Driven Design scholarship has established that materials are experienced through sensorial, interpretative,

affective, and performative dimensions (Giaccardi & Karana, 2015; Karana et al., 2015). These areas, however, remain insufficiently integrated within sustainable packaging research, particularly in the Indian context.

Limited attention has been paid to how locally available organic waste can be developed into packaging that combines material viability, environmental circularity, and experiential desirability, or to how consumers perceive and interact with such materials (Sauerwein et al., 2017). This study addresses that gap by experimentally developing waste-derived packaging and examining its material and experiential qualities through iterative prototyping and user evaluation. It specifically investigates whether sustainability can become perceptible and actionable through the material and its intended post-use return to soil rather than functioning only as an environmental claim (Magnier & Schoormans, 2015) attached to the product.

The study is guided by the following research question: How can locally available organic and everyday waste be developed into sustainable packaging whose material qualities and return-to-soil proposition make sustainability perceptible, desirable, and actionable within the Indian consumer context?

Research Methodology

This study adopted a practice-based design research methodology combining material experimentation, iterative prototyping, and qualitative user evaluation. A material-led approach was used to investigate locally accessible organic and everyday waste as potential resources for sustainable packaging (Karana et al., 2015). Initial experimentation included sawdust, used tea waste, coconut husk, cow dung, and pencil shreds, alongside natural binders comprising corn starch, wheat flour, and gond. Vinegar and neem oil were subsequently explored as natural treatments in response to fungal and mould formation observed during experimentation.

Material development proceeded through six iterative experiments in which the composition of the principal materials, binders, and protective treatments was varied. Each iteration informed the next through observation of properties including mouldability, cohesion, drying, structural stability, surface quality, and susceptibility to biological deterioration. Later experiments combined cow dung with pencil shreds and subsequently cow dung with sawdust, leading to the final material composition (Manafi-Dastjerdi et al., 2022).

The resulting material was translated into a packaging prototype for an Indian gardening brand. This application was selected to create continuity among the package, its contents, and its intended end of life. Rather than functioning only as disposable packaging, the prototype was designed to return to soil and enter the composting process after use, extending the proposed material lifecycle beyond its primary packaging function.

The prototype was evaluated by 22 participants through physical interaction and semi-structured interviews informed by the Materials Experience framework. (Camere & Karana, 2018; Giaccardi & Karana, 2015). Each participant completed two phases. During the blind phase, participants were not informed of the material composition (Magnier & Schoormans, 2015). During the informed phase, they were told about the constituent materials and the proposed return-to-soil function.

Responses were coded across five dimensions (Giaccardi & Karana, 2015; Karana et al., 2015). The sensorial dimension examined texture, smell, colour, weight, and surface qualities. The interpretative dimension considered associations with waste, nature, sustainability, hygiene, quality, and value. The affective dimension recorded attraction, curiosity, familiarity, discomfort, hygiene concerns, and aversion.

The performative dimension examined participants' understanding of and willingness to engage with composting and the package's proposed end of life. A fifth, cultural, dimension recorded memories, prior knowledge, and contextual associations connected particularly with cow dung and village life. Cost and perceived value emerged as a supplementary theme.

Responses from the blind and informed phases were compared and analysed thematically to identify patterns in material perception, desirability, usability, cultural interpretation, and willingness to participate in the proposed post-use function (Braun & Clarke, 2006). Through this methodology, the study examined sustainable packaging simultaneously as a material system, a designed object, and a consumer experience.

Case Study: Material Development and Prototype

The project originated from a contradiction observed at the household level: compost produced from organic waste was being distributed in plastic bags, thereby undermining its environmental purpose. Although the compost returned organic matter to the soil, its packaging entered a waste stream that could ultimately lead to landfill accumulation (OECD, 2022).

The project therefore sought to develop packaging composed entirely of biodegradable constituents. The material needed to retain sufficient structural integrity during the product's period of use and subsequently decompose in soil, thereby avoiding the persistent waste associated with conventional plastic packaging (OECD, 2022; UNEP, 2023).

The investigation began with an exploration of biodegradable materials, particularly discarded organic and everyday waste with the potential to provide structural stability (Kossalbayev et al., 2025; Mohite et al., 2022). The materials initially examined were cow dung (Gupta et al., 2016) , sawdust, coconut husk, used tea waste, and pencil shreds. Following preliminary testing, cow dung, sawdust, and coconut husk emerged as the principal materials for further development because they could provide structure while also containing nutrients beneficial to plants (Manafi-Dastjerdi et al., 2022). Used tea waste and pencil shreds were retained in selected comparative iterations.

Because these materials were predominantly fibrous or powder-like, they required binders capable of producing a cohesive composition without introducing synthetic chemicals. Wheat flour, corn starch, and gond were tested for their adhesive properties. Initial experiments indicated that corn starch and wheat flour were susceptible to fungal growth because of their water content, whereas gond's resin-like composition proved more resistant under humid conditions (Dhalsamant et al., 2025. These findings established the need to investigate both structural reinforcement and protection against fungal deterioration.

Vinegar and neem oil were subsequently introduced as natural protective treatments. Vinegar was explored because its acidity could make the material environment less conducive to fungal growth (Pornpukdeewattana et al., 2017). Neem oil was examined because it contains bioactive compounds, including azadirachtin, nimbin, and nimbidin, associated with antifungal activity (Biswas et al., 2002) . Both treatments were selected because they remained consistent with the project's biodegradable, return-to-soil system.

Material development proceeded through six iterative experiments. In each iteration, the composition of the principal materials, binders, and protective treatments was modified in response to observations from the preceding experiment.

Experiment One

The first experiment examined the behaviour of gond as the sole binder when combined with sawdust and treated with vinegar. The powdered texture of the sawdust and the resin-like quality of the gond produced a brittle prototype, demonstrating that the composition required an additional element to improve its structural strength.

Experiment Two

The second experiment combined sawdust, coconut husk, and used tea waste with gond and wheat flour, followed by vinegar treatment. This mixture established a stronger structural foundation than the first experiment.

Experiment Three

Drawing on these findings, the third experiment isolated coconut husk as the principal material and combined it with gond and corn starch. This iteration was intended to examine the combined effect of the binders without the influence of multiple principal materials. Although the binders improved structural stability, the resulting prototype was not sufficiently strong to hold a product.

Experiment Four

The fourth experiment investigated whether combining all three binders would increase cohesion. Coconut husk and sawdust were mixed with corn starch, gond, and wheat flour. This combination strengthened the dry materials and produced a substantially more stable structure.

Experiment Five

The fifth experiment marked a decisive shift through the introduction of cow dung as a principal material. Cow dung and pencil shreds were combined in a six-to-three ratio, bound with all three adhesives, and treated with both vinegar and neem oil. The drying process was slow and required a combination of oven treatment and natural sunlight. Nevertheless, the resulting prototype achieved structural strength while retaining a relatively smooth surface.

Experiment Six

The sixth and final experiment retained cow dung as the principal material but replaced the pencil shreds with sawdust (Manafi-Dastjerdi et al., 2022). The three-binder paste and the vinegar and neem oil treatments remained unchanged. This composition was selected for the final prototype. The resulting material was moulded into a box form with a fibrous surface texture and subsequently prepared for user evaluation.

User Evaluation and Findings

The two-stage evaluation enabled a comparison between participants' immediate physical impressions and their subsequent interpretations after learning about the material's origin and intended end of life.

Sensorial Dimension

During the blind phase, smell dominated participants' sensorial responses. Sixteen of the 22 participants identified odour, either independently or in combination with texture or weight, as one of the first qualities they noticed. Other participants initially focused on surface irregularity, texture, colour, or weight.

After disclosure, attention shifted towards the packaging's visual and tactile properties. Surface irregularity became the most frequently identified quality, noted by seven participants, followed by texture, noted by six, and colour, noted by five. Participants began to examine the packaging more analytically through its weight, surface, and appearance.

This shift suggests that the initial emphasis on smell may have been partly shaped by the unfamiliarity of the object. Once participants understood its composition and purpose, they increasingly interpreted its sensory properties as evidence of naturalness and material craft.

Interpretative Dimension

Interpretative responses during the blind phase were varied. Eleven participants described the packaging as natural, while six associated it with waste. Two participants raised concerns about hygiene based on its appearance and texture, one immediately connected it with sustainability, and two interpreted it through ideas of quality and value.

Following disclosure, interpretations converged more strongly around sustainability, with 11 participants identifying it as the principal meaning of the material. Most participants who had initially associated the packaging with waste revised their interpretation towards naturalness, sustainability, or quality and value, although one participant retained the waste association.

These changes indicate that knowledge of the material's composition and lifecycle substantially influenced how the packaging was understood. Its meaning was therefore not communicated through appearance alone; it emerged through the relationship between material experience and contextual information (Karana & Hekkert, 2010).

Affective Dimension

Curiosity was the dominant emotional response during the blind phase and was expressed by 14 of the 22 participants. Four participants expressed discomfort, three expressed attraction, and one described the packaging as natural.

During the informed phase, attraction became the largest response category and was recorded for 13 participants. Two participants remained curious, while seven concluded the informed phase with discomfort, hygiene concerns, or disgust. In at least one instance, initial discomfort intensified into a more explicitly negative response after the disclosure of cow dung as a principal material.

For these participants, the environmental rationale of the package was insufficient to overcome concerns about hygiene and the cultural meanings attached to cow dung. Material disclosure therefore increased attraction for many participants while intensifying aversion for others.

Performative Dimension

The performative dimension was assessed primarily during the informed phase because participants needed to understand the packaging's intended end of life before responding to its proposed use.

Eleven participants expressed a willingness to compost the packaging, while nine understood and accepted its end-of-life function. One participant remained uncertain, and another responded with disgust and demonstrated no interest in engaging with the composting proposition.

For most participants, sustainability did not remain an abstract label; it became associated with a possible post-use action. Nevertheless, these responses represent stated intentions rather than observed behaviour.

The two participants who remained uncertain or disengaged illustrate circumstances in which the proposed return-to-soil system failed to become persuasive.

Cultural Dimension

Cultural context played a significant role in shaping participants' responses. Memories of village life emerged as the dominant association during either the blind or informed phase. Several participants referred to childhood or familial memories involving cow dung, while three specifically mentioned their prior awareness of its uses (Gupta et al., 2016).

This familiarity helps explain the movement from curiosity towards attraction among many participants. Disclosure introduced them to a material that was already culturally recognisable and carried positive or neutral associations. At the same time, three participants expressed distrust despite appreciating aspects of the packaging, primarily because of concerns relating to hygiene and disgust (Meng & Leary, 2021).

Cost and Perceived Value

Cost and perceived value emerged as a supplementary theme. Eight participants felt that the environmental value of the packaging could outweigh its cost, while another eight identified cost as an important consideration. Cost therefore remained a significant factor in evaluating the potential viability of the packaging for Indian consumers (Joshi & Rahman, 2015; Ruf et al., 2022) .

Across the responses, disclosure frequently activated memories that made participants feel more familiar with the packaging. However, the seven participants whose informed responses ended in discomfort, hygiene concerns, or disgust indicate a potential source of resistance.

Critical Discussion

The findings demonstrate that the meaning of a sustainable material is shaped not only by its physical composition and end-of-life pathway, but also by what users know about its construction and purpose (Karana & Hekkert, 2010; Giaccardi & Karana, 2015). The package remained physically unchanged across the blind and informed phases, yet participants' perceptions shifted substantially after disclosure.

During the blind phase, the experience was dominated by smell and unfamiliarity. Once participants learnt about the material composition and return-to-soil system, the fibrous texture, irregular surface, and colour were more frequently interpreted as evidence of naturalness and sustainability (Karana, 2012; Karana & Nijkamp, 2014) . Sustainability was therefore not necessarily legible through the material's appearance alone; it became more clearly recognisable through the narrative connecting its origin, function, and disposal (Magnier & Schoormans, 2015; Steenis et al., 2017) .

This distinction is important for the design of sustainability-oriented packaging. Desirability cannot depend exclusively on the environmental performance (Karana et al., 2015) of a material or the circularity of its end-of-life system. The package must also communicate its purpose during the user's first encounter, or its communication system must provide sufficient context for unfamiliar sensory qualities to be interpreted meaningfully (Magnier & Schoormans, 2015; Van Schoubroeck et al., 2022) .

The movement from curiosity towards a stated willingness to compost suggests that environmental awareness can be translated into intended action when users understand the relationship between the material and its post-use function. However, because the evaluation recorded intentions rather than observed behaviour, the findings cannot establish whether participants would actually compost the package in practice (Sheeran, 2002; Kollmuss & Agyeman, 2002) .

The findings also correspond with the Material Driven Design account of coffee-waste composites, in which surface irregularities and material imperfections functioned as experiential qualities that communicated naturalness and uniqueness (Karana et al., 2015; Rognoli & Karana, 2014) . The present study extends this concern (Sauerwein et al., 2017) into a different material and cultural context by examining how Indian participants interpreted waste-derived packaging made primarily from cow dung and sawdust.

The results nevertheless invite a sceptical interpretation. Positive responses may not have arisen solely because the material communicated sustainability. They may also have been shaped by participants' cultural familiarity with cow dung and its established use within household, agricultural, and village contexts (Gupta et al., 2016) . Cultural recognition may therefore have mediated the movement from curiosity to attraction.

Conversely, the cases of pronounced aversion demonstrate that disclosure can intensify hygiene concerns (Meng & Leary, 2021). For these participants, familiarity with cow dung did not necessarily translate into acceptance of its use as packaging, particularly when the material was imagined in proximity to consumable products (Meng & Leary, 2021). This tension shows that cultural familiarity can produce both acceptance and resistance, depending on the imagined context of use (Karana & Hekkert, 2010).

The study also has practical limitations. Manufacturing feasibility, shelf life, and durability were not measured (Hussein et al., 2023; Manafi-Dastjerdi et al., 2022). Because the investigation developed as an extension of a university project and was conducted at the household level, it was not possible to generate precise quantitative measurements for these aspects. The small, context-bound sample also limits the extent to which the findings can be generalised to Indian consumers more broadly. Further development would therefore require a larger and more diverse participant group alongside controlled testing of material strength, moisture resistance, biological deterioration, storage conditions, and manufacturing consistency (Kossalbayev et al., 2025).

Conclusion

The central finding of this study is that sustainability becomes more persuasive when it is experienced as a relationship among material origin, use, and end of life rather than presented only as an environmental claim. Knowledge of the packaging's composition and return-to-soil function reorganised participants' responses from an initially smell-dominated impression towards a broader consideration of naturalness, sustainability, and composting.

For many participants, qualities such as smell, fibrous texture, and surface irregularity became evidence of the package's natural composition once its purpose was disclosed. Perception was therefore shaped not only by the object's physical characteristics, but also by the contextual knowledge through which those characteristics were interpreted.

The favourable response of the majority was partly connected to positive or neutral cultural associations with cow dung. However, the seven participants whose final responses involved discomfort, hygiene concerns, or disgust demonstrate that alignment among material, environmental intention, disposal system, and cultural context does not guarantee universal acceptance. Sustainable materials remain subject to individual interpretations of cleanliness, quality, value, and appropriate use.

The broader problem addressed by the study was how to bridge the distance between environmental awareness and everyday behaviour among Indian consumers. Within the limitations of a university- and household-scale investigation, the project offers a modest direction for approaching packaging as a

sustainable material experience. It suggests that material development, communication, and end-of-life participation must be designed together if sustainable packaging is to become both compelling and practically adopted in everyday life.

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