Journal of Medeniyet Art, Faculty of Art Design and Architecture of IMU, 11(2), 2025, p.257-285 E-ISSN: 2587-1684

Consumer Awareness and User Experience in AR-Enabled Sustainable Food Packaging

Artırılmış Gerçeklik Destekli Sürdürülebilir Gıda Ambalajlarında Tüketici Farkındalığı ve Kullanıcı Deneyimi

Ayşe Merve KÖSE* Prof. Banu İnanç UYAN DUR**

DOI: 10.46641/medeniyetsanat.1774505

Research Article / Araştırma Makalesi

Abstract

This article examines how augmented reality (AR) can serve the communication aims of sustainable food packaging. Scholarship on sustainability-oriented packaging and AR-mediated consumer communication is synthesized, and the design of a proof-of-concept AR application for an organic food package is presented. The prototype stages information through progressive disclosure, surfaces concise traceability cues and end-of-life guidance, and includes a lightweight game that frames pro-environmental actions. Design choices prioritize clarity, low cognitive load, and cross-device accessibility. To evaluate how the prototype was received by users, an exploratory, cross-sectional user study was conducted in which 31 adults interacted with the prototype on their own smartphones and then completed a brief questionnaire including one open-ended item; analyses were descriptive. Participants reported favorable perceptions of clarity, usability, information effectiveness, and visual quality. Most also reported higher knowledge and awareness and indicated intentions to apply what they learned. Thematic analysis converged with these patterns and identified priorities for improvement, including performance, accessibility, and audio balance. The article's contribution is threefold, comprising a design-led articulation of AR-enabled packaging for sustainability communication, a descriptive account of user responses at the proof-of-concept stage, and actionable implications for practice (progressive disclosure, verifiable, updatable claims, and light gamification that supports information) as well as for evaluation research (comparative or longitudinal designs with behavioral endpoints).

Keywords: *Packaging Design, Augmented Reality, Sustainability, User Experience, Consumer Awareness*

Öz

Bu makalede, artırılmış gerçekliğin sürdürülebilir gıda ambalajının iletişim amaçlarına nasıl hizmet edebileceğini incelenmektedir. Sürdürülebilirlik odaklı ambalaj ve artırılmış gerçeklik aracılı tüketici iletişimi literatürü sentezlenmiş; organik bir gıda ambalajı için kanıt niteliğinde bir artırılmış gerçeklik uygulamasının tasarımı yapılmıştır. Prototip, bilgiyi kademeli açıklama yoluyla sahnelemekte, özlü izlenebilirlik ipuçları ile kullanım sonrası yönlendirmeleri görünür kılmakta ve çevre yanlısı eylemleri çerçeveleyen basit bir oyunlaştırma unsurunu içermektedir. Tasarım tercihleri açıklığı, düşük bilişsel yükü ve çoklu cihaz erişilebilirliğini öncelemektedir. Prototipin kullanıcılar tarafından nasıl karşılandığını değerlendirmek amacıyla, 31 yetişkinin prototiple kendi akıllı telefonları üzerinden etkileşime girip biri açık uçlu olmak üzere kısa bir anketi tamamladığı keşfedici, kesitsel bir kullanıcı çalışması yürütülmüştür; analizler betimseldir. Katılımcılar açıklık, kullanılabilirlik, bilgi etkinliği ve görsel kaliteye ilişkin olumlu algılar bildirmiştir. Çoğu ayrıca bilgi ve farkındalıklarının arttığını ve öğrendiklerini uygulama niyeti taşıdıklarını belirtmiştir. Tematik analiz bu örüntülerle örtüşmüş ve performans, erişilebilirlik ve ses dengesi dâhil olmak üzere iyileştirme

* İzmir University of Economics, Design Studies PhD Program, aysemervekocak@gmail.com, ORCID: 0000-0001-7297-8372

** FMV Işık University, Faculty of Art, Design and Architecture Dept. of Visual Communication Design, inanc.uyan@isikun.edu.tr, ORCID: 0000-0003-0259-1716

Submission Date / Gönderilme Tarihi: August 30, 2025 / 30 Ağustos 2025

Acceptance Date / Kabul Tarihi: December 30, 2025 / 30 Aralık 2025

önceliklerini tanımlamıştır. Makalenin katkısı üç boyutludur: sürdürülebilirlik iletişimi için artırılmış gerçeklik destekli ambalajın tasarım odaklı bir formülasyonu; kanıt niteliğindeki aşamada kullanıcı tepkilerine ilişkin betimleyici bir tablo; ve uygulamaya (kademeli açıklama, doğrulanabilir ve güncellenebilir beyanlar, bilgiyi destekleyen basit oyunlaştırma) ile değerlendirme araştırmalarına (karşılaştırmalı ya da zamana yayılan tasarımlar ve davranışsal uç noktalar) dönük eyleme geçirilebilir çıkarımlar.

Anahtar Kelimeler: *Ambalaj Tasarımı, Artırılmış Gerçeklik, Sürdürülebilirlik, Kullanıcı Deneyimi, Tüketici Farkındalığı*

Introduction

Escalating environmental pressures, intensive resource use, rising waste generation, and the increasingly visible effects of climate change have made sustainable production and consumption a strategic imperative. Within this context, the food sector carries particular weight due to both the scale of its impacts and the frequency of consumer contact. Packaging, the primary touchpoint between product and user, has moved beyond protection and display to become a communication interface for conveying sustainability information. However, consumers do not always grasp this information quickly, clearly, and in an action-oriented manner; in particular, traditional static labels often prove insufficient when recyclability, material composition, or end-of-life guidance is at stake. Packaging design therefore needs communicative strategies that present information clearly, minimize cognitive load, and invite purposeful engagement, while acknowledging the product's life cycle from sourcing to end-of-life.

Building on this need, specific design choices in packaging, including information hierarchy, iconography, micro-copy, and interaction cues, can influence how sustainability messages are processed and whether they translate into intentions to act. In this study, these processes are discussed primarily through cognitive-load and behavior-change lenses, where ease of processing can support comprehension and intention formation, while sustained behavioral outcomes remain an open empirical question. Alongside print-only approaches, interest has grown in interactive communication methods that stage information progressively and invite active exploration. One such method is augmented reality (AR), which overlays digital content on physical artifacts to create situated, interactive encounters. Prior research in marketing and retail shows that AR can enhance consumer experience, brand engagement, and decision processes, with reviews and empirical work documenting rising publication volume, widespread mobile AR use, and effects on product-related, brand-related, and advertising-related outcomes (Du, Liu, & Wang, 2022; Hoffmann & Mai, 2022; Rauschnabel, Felix, & Hinsch, 2019). When the focus narrows to food systems and sustainability communication, work increasingly examines traceability and information flows delivered via AR, positioning AR as a vehicle for communicating product-level data to consumers (Chai, O'Sullivan, Gowen, Rooney, & Xu, 2022; Dimou, Styliaras, & Salomidis, 2024). Related findings also suggest that interactive or AR-enhanced presentations can improve comprehension relative to static labels, for example in nutrition interfaces and in experiments with AR-augmented ecolabels (Wimer, Szymanski, &

Metoyer, 2024; Dekhili & Ertz, 2024). Even so, consumer-facing evaluations conducted directly on packaging remain fewer than studies in the broader AR-marketing domain, which motivates the present descriptive examination.This descriptive study examines how users receive an AR-enabled packaging prototype for an organic food product. Item-level distributions for perceived clarity, usability, information effectiveness, and visual quality are reported, alongside self-reported knowledge, awareness, and intentions to apply what was learned; open-ended responses are analyzed thematically to contextualize these patterns. The aim is to guide subsequent design iterations and to motivate more rigorous evaluations in future work. In line with this aim, the study addresses the following research questions at an exploratory level:

RQ1. How do users evaluate the AR-enabled packaging prototype in terms of perceived clarity of information, usability, information effectiveness, and visual quality?

RQ2. Following interaction with the prototype, to what extent do users report changes in their knowledge and awareness of sustainable packaging, and intentions to apply what they learned?

RQ3. What themes emerge in participants' open-ended feedback regarding the most valued aspects of the AR experience and areas for improvement that should guide subsequent design iterations?

1. Sustainability In Packaging

In the modern consumption environment, packaging has evolved beyond the physical existence of a product, becoming a fundamental component that visually symbolizes its identity and values. Throughout the processes extending from production to the end consumer, the presence of packaging serves as a strategic communication point that shapes initial impressions about the product. "Packaging refers to wrappings and coverings made of metal, paper, cardboard, glass, tin, plastic, and wood, that protect the product from external factors, keep the goods placed inside together to facilitate distribution and marketing processes, and provide information about the contents to the consumer" (Dilber, Dilber, & Karakaya, 2012, p.161). Packaging holds a central position in marketing strategies by influencing consumers' visual perception and purchase intention. In recent years, along with the rise in sustainability awareness, both consumers and producers have begun to prefer more environmentally friendly solutions. This trend is reinforced by legal regulations, international environmental standards, and the proliferation of corporate social responsibility policies, thereby positioning sustainable packaging solutions as increasingly necessary.

The concept of sustainability, as defined in the 1987 report published by the World Commission on Environment and Development (WCED), also known as the Brundtland Commission, embodies an approach that seeks to achieve "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). Following WCED (1987), the concept is widely used as a holistic framework that balances environmental, social, and economic dimensions in the face of accelerating environmental pressures. John Elkington's (1997) Triple Bottom Line (TBL) model also supports this perspective. The TBL model posits that, in achieving sustainability goals, environmental (planet), economic (profit), and social (people) dimensions must be addressed together in a balanced way. The model emphasizes that sustainability policies should be environmentally responsible, economically viable, and socially beneficial. For a sustainable world, eco-design products that are environmentally friendly and highly efficient must be produced to yield the greatest overall benefit from economic, environmental, and social perspectives. Since approximately 80% of a product's environmental impact is determined at the design stage (Acaroğlu, 2020), designers must anticipate these impacts and develop sustainable solutions.

Sustainable packaging design encompasses the process of developing environmentally friendly solutions that minimize the environmental impact of packaging throughout its entire life cycle and align with natural cycles. This approach includes principles such as using biodegradable or recyclable materials, reducing material waste, and promoting the use of renewable energy. Employing renewable materials decreases dependence on natural resources while providing high efficiency in production and waste management processes, which can lower the carbon footprint throughout the packaging's life cycle (Magnier & Schoormans, 2017). Additionally, strategies such as optimizing the form and size of packaging to increase efficiency in transportation and storage processes help reduce the carbon footprint, forming part of sustainable packaging design. In this process, the effective protection of the product and user-friendliness play crucial roles in striking a balance between sustainability and functionality (Grönman et al., 2012). According to the Sustainable Packaging Coalition (2019), design principles should minimize environmental harm while also considering economic feasibility and social welfare. In this regard, multiple factors such as material selection, packaging size, shape, and graphic design elements must be taken into account to ensure sustainability in packaging. By adopting a minimalist approach in graphic design and avoiding unnecessary colors and design elements can reduce ink and energy consumption during printing and may facilitate recyclability of the packaging (Ren, Zhang & Gao, 2022). Moreover, through graphical cues, consumers are guided toward a sustainable approach, thereby contributing to their awareness (Krah, Todorovic, & Magnier, 2019). In sustainable packaging design, it is crucial not only to uphold environmental responsibility but also to raise public awareness of this issue. Providing opportunities for recycling or reusing packaging helps establish an eco-friendly packaging mindset among consumers and aids in correcting misconceptions about sustainability in society (Boz, Korhonen & Sand, 2020). Thus, sustainable packaging design aims not only to minimize harmful environmental factors but also to balance environmental, economic, and social dimensions in a way that enhances society's contribution to a sustainable future.

Many consumers prefer brands that demonstrate greater responsibility toward the environment and society. Notably, younger generations tend to display heightened sensitivity during shopping. Consumers are inclined to choose sustainable packaging provided that convenience is not compromised (Jerzyk, 2016). This growing consumer interest in sustainable packaging also influences companies' marketing strategies. Many brands highlight sustainability elements in their packaging designs to capture consumer attention and strengthen brand reputation. Numerous studies have examined how sustainable packaging is perceived by consumers and how it affects their purchasing decisions. Lignou and Oloyede (2021) found that biodegradable packaging creates a positive sustainability perception among consumers. Similarly, Magnier, Schoormans, and Mugge (2016) demonstrated that sustainable food packaging generates a higher sense of product naturalness for consumers. On the other hand, Koenig-Lewis et al. (2014) suggest that eco-friendly packaging alone may be insufficient to drive purchase behavior. Norton et al. (2022) discovered that consumers often lack sufficient knowledge regarding sustainable packaging and recycling, while informative content provided on packaging can positively influence consumer behavior. These findings underscore the importance of eco-friendly messages and the necessity of delivering accurate information to consumers in the adoption of sustainable packaging designs. In this context, enhancing consumer awareness and encouraging sustainable behavior are as crucial as reducing environmental impacts in the design of sustainable food packaging. Such approaches not only facilitate the widespread availability of environmentally responsible products but also bolster society's commitment to a sustainable future.

2. Using Augmented Reality in Packaging

AR enhances the physical environment by overlaying digital information on it. Azuma (1997) defines AR as a system that combines real and virtual elements, operates interactively in real time, and is registered in three-dimensional space. This definition emphasizes the integration of virtual content with the physical world, allowing users to experience a composite view that enriches their perception of reality. AR is used across education, healthcare, entertainment, industry, manufacturing, retail, architecture, engineering, marketing, and tourism, among other domains.

In recent years, AR has become a prominent mode of interactive consumer engagement in marketing and advertising. Wunderman Thompson Intelligence (2022) identifies advertising as one of the most prominent and impactful domains for AR technology, emphasizing its ability to create immersive and interactive experiences. This pattern is echoed by Pulse (2021), which reports that 79% of consumers aged 13–39 are willing to try AR applications during shopping, highlighting the technology's strong appeal among digitally native demographics. AR's capacity to seamlessly blend physical and digital realms not only enhances consumer engagement but also influences purchasing decisions. Specifically, AR content aligned with the product has been associated, in some contexts, with higher purchase intentions than static alternatives, suggesting potential advantages for AR-integrated packaging in point-of-sale settings (Kyguolienė &

Braziulytė, 2022). Chylinski et al. (2020) highlight how AR blends digital content with physical spaces, enhancing consumer experiences and fostering deeper product connections. In packaging contexts, this means the package can function as an interactive touchpoint rather than a static surface.

From a brand perspective, AR can support attention capture and message retention while offering additional opportunities for consumer engagement. By integrating AR into packaging, brands can captivate consumers' attention and establish deeper emotional connections, fostering a lasting impact on brand recall and loyalty. AR can enhance brand recognition, perception, and communication, offering additional opportunities for consumer engagement. For the packaging industry, AR extends beyond mere consumer engagement; it can deliver dynamic product information, offer interactive tutorials, and integrate lightweight gamified experiences to support customer loyalty. These capabilities position AR as a promising tool for enriching the consumer journey and optimizing brand communication in an increasingly saturated market.

In packaging design, AR can extend access to product-related details beyond what physical labels can feasibly display, including ingredients, nutrition, and allergen warnings in interactive formats, as well as concise information on origin and production. Moreover, AR-enabled packaging can provide real-time usage instructions, maintenance tips, and troubleshooting guides, especially for complex products. Through dynamic content like 3D models, videos, and animations, AR transforms static packaging into a richer interactive medium that not only informs but can also educate.This capability can enhance the consumer experience and may contribute to perceived brand credibility by signaling transparency.

"Augmented Reality enables consumers to virtually try products on their own face or surroundings in real time (e.g., make-up, furniture), which could help providing consumers a 'try before you buy' experience when shopping online" (Smink et al., 2019, p.1). This application helps consumers make more informed purchasing decisions and enables brands to enrich the experience by allowing individuals to virtually try products on themselves or within their surroundings in real time. As a result, consumers are directly engaged in the product experience, making the purchasing process more immersive and meaningful (Smink et al., 2019). Consumers who can digitally explore or experience products demonstrate higher purchase intent and greater satisfaction than those exposed only to static or conventional presentations (Hwangbo et al., 2020). For products such as cosmetics, which are highly influenced by personal preferences, integrating virtual try-on features into packaging can enhance customer satisfaction and may reduce return rates in some categories. The use of lightweight gamification and interactive elements in packaging design can create engaging and memorable consumer experiences when they support rather than distract from the core informational goal. Games and competitions accessible through packaging, incorporating point and reward systems associated with the product or brand, can provide enjoyable experiences that capture consumer interest and strengthen brand loyalty when appropriately scoped. Additionally, such technologies embedded in packaging can open opt-in social touchpoints and complementary communication channels, thereby extending packaging's marketing role (Zhang, 2023).

3. Potential Contributions of AR-Enabled Packaging to Sustainability Goals

Integrating AR into packaging may support sustainability objectives primarily through communication, transparency, and user engagement mechanisms, rather than material substitution alone. To avoid conflating experience-level outcomes with more material or process-level effects, the literature can be organized into two complementary dimensions. First, AR-enabled packaging can function as an experience and awareness interface by shaping attention, comprehension, perceived credibility, and motivation relevant to sustainable practices. Second, AR may support sustainability through operational pathways, for example by shifting supplementary information to a digital layer, enabling version-controlled updates, and supporting traceability and accountability mechanisms, while required on-pack disclosures remain unchanged.

3.1. Experience and awareness pathway (Communication-Level Outcomes)

From an HCI and climate communication perspective, sustaining public engagement with climate issues is widely recognized as challenging. Ferreira, Nisi & Nunes (2022) provide an overview of HCI and Design projects (2010–2020) on climate change communication, centering on academic interventions targeting audiences outside academia. Using a Grounded Theory Literature Review across a corpus of 74 projects, they synthesize recurring interaction and communication challenges and derive five implications for design. This perspective is relevant to AR-enabled packaging because packaging is a situated touchpoint where sustainability information can be encountered at the moment of choice, and where interaction design may shape attention, comprehension, and perceived credibility.

A study by Rodrigues and Pombo (2024) found that an AR-based game increased students' awareness levels in the sustainability education process, making learning both more motivating and more effective. Although conducted in an educational setting rather than on packaging per se, the finding suggests that interactive AR experiences can increase awareness and motivation, which is relevant for sustainability communication. Similarly, research conducted by Rogers (2024) revealed how AR technology supports sustainability-oriented transformations in shopping experiences. Data derived from surveys and expert interviews with 7500 AR users across five different countries show that AR positively impacts both consumer satisfaction and environmental outcomes. According to the findings, carbon emissions in shopping can be reduced by 46% through AR applications, while 80% of consumers believe that AR boosts shopping confidence and will play a vital role in future shopping processes. However, these outcomes are reported at the level of broader shopping contexts and should be interpreted as indicative rather than directly transferable evidence for packaging-specific environmental impact, which was not measured in the present study. Furthermore, a study by Cosio et al. (2023) noted that extended reality (XR) technologies encourage users to become more informed about environmental issues and can be used as an innovative tool to support environmental sustainability. The research demonstrates that these technologies help users address psychological and social barriers (e.g., lack of salience, perceived effort), thereby supporting more conscious environmental behavior.

AR technology's contribution to sustainability goals is not limited to waste management; it also promotes more transparent and accountable production and supply chains. According to Zhang (2023), AR-enabled packaging can surface concise traceability cues and brief disclosures about origin and selected sustainability practices, which may support transparency and can foster trust when claims are verifiable and up to date. Such applications enable brands to gain a competitive edge not only through product quality but also by emphasizing sustainability values. This communicative role aligns with our descriptive findings, where participants reported increased knowledge and motivation to act after the AR experience (see Section 5.2). Moreover, AR applications make recycling and reuse processes more comprehensible, thereby simplifying consumers' contributions to sustainability targets. In this way, information on a product's life cycle and appropriate disposal methods is conveyed to consumers in a straightforward and accessible format.

3.2. Operational and environmental impact pathway (Material/Process-Level Mechanisms)

Rather than implying direct material substitution, prior work typically frames AR's sustainability contribution in packaging as indirect and operational, for example by shifting selected supplementary information to a digital layer where regulations permit, and by supporting updateability and traceability mechanisms. Traditional packaging often includes printed information and visual designs that require large surface areas and substantial amounts of paper and ink. According to Robertson (2013), once their lifecycle ends, protective packaging materials have the potential to harm the environment as waste. However, AR can alleviate spatial constraints on packaging graphics and shift some information to digital channels, where regulations permit, which may reduce print area or ink coverage without changing required on-pack disclosures. Digital content updates do not substitute for required on-pack updates; printed disclosures must remain compliant, while AR channels can deliver version-controlled supplementary information. Bennett (2020) emphasizes that this digital transformation can minimize the use of basic resources such as paper and ink and may also reduce carbon emissions arising from production and transport processes.

Another key benefit of AR lies in the flexibility it provides for updating and redesigning packaging. Whereas revision processes in traditional packaging are costly and resource-intensive, AR allows content to be updated digitally, facilitating a dynamic interaction between brands and consumers. Consequently, a long-term, economically sustainable model is established, as packaging can be changed without physical intervention. AR-based solutions offer an opportunity to view sustainability not merely as a technological innovation but as a strategic tool. Beyond optimizing resource use, AR-based communication may support more informed and deliberate consumer decision-making by making sustainability-related information more accessible and situationally salient, while broader environmental outcomes remain contingent on upstream packaging and supply-chain practices.

4. Designing Augmented Reality Applications for Organic Food Packaging

Within the scope of this research, a specialized AR Application was designed for an organic food product to examine the role of AR technology in the development of sustainable food packaging and to evaluate its potential to inform consumers about sustainability, enhance their awareness, and motivate them to take action. The application includes informative content on sustainable packaging, an educational game, and product details. Key features:

- Information Module: Provides visual and textual information on sustainable packaging materials and their environmental impacts.
- Interactive Game: Includes an educational game designed to reinforce participants' knowledge of sustainability.
- Product Details: Offers detailed information on the organic food product's composition and sustainability certifications.

Within the scope of the research, the AR application designed for organic food products was not developed for a specific brand but rather for a hypothetical organic cereal producer. No brand logo was used in the package design; instead, the word "Marka" ("Brand") was inserted as a general placeholder. Adopting a minimalist approach, the package design aimed to present a clean look. The packaging does not feature product images; rather, it incorporates a transparent area so the product can be viewed directly. Although the prototype was produced using laser printing and a plastic window, the mass-production intent was to utilize sustainable materials. In a mass-production scenario, the outer surface of the packaging could be made from compostable paper sourced from FSC-certified forests, while the inner surface would feature a plant-based, biodegradable barrier coating (e.g., a corn-starch-derived compostable film) to protect the food from air and humidity. Using water-based, non-toxic, and recyclable inks helps maintain product freshness and minimizes environmental impact across the packaging lifecycle.

On the front side of the package, there is a logo area, product name, product quantity, and a QR code, alongside a bee character, that connects the packaging to digital media. This bee character, called "Mizz," was created for use both on the package and in the AR application. On the package lid, there is a QR code directing consumers to an AR experience that explains how the package can be transformed; beneath the lid, another QR code leads to an AR game focused on protecting bees. The back of the package includes fundamental information such as a barcode, product quantity, production date, and expiration date, while other detailed information is conveyed digitally through AR technology (Figure 1). Digital AR content supplements, but does not replace, any legally required on-pack disclosures; printed information remains compliant, while AR channels can deliver version-controlled updates.

Figure 1. Prototype packaging design for an organic breakfast cereal with whole grains and honey (design by the first author).

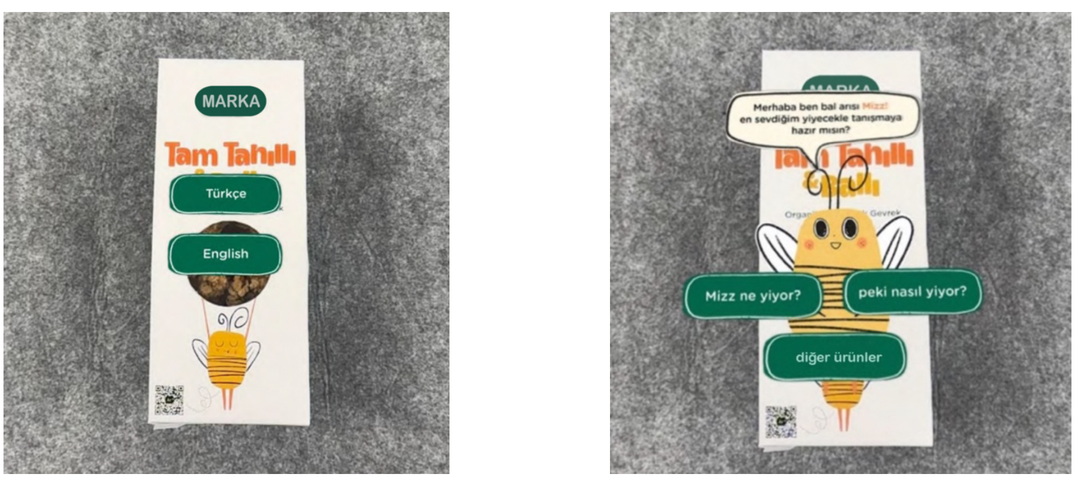

Figure 2. Left: AR application opening interface (language selection); Right: main interface (entry point with feature options). Designed by the first author.

No unnecessary design elements were included in the AR interface design. Two-dimensional, simple line illustrations were used to evoke a childlike drawing style. Where audio is used, captions and on-device volume controls are provided to support accessibility. The AR application was developed using Adobe Aero software, offering users three distinct experiences. The prototype was tested on both iOS and Android smartphones. Access was provided via QR codes in a lightweight launch flow, allowing participants to start the AR experience directly on their devices without requiring a prior installation step; however, because the evaluation relied on participants' own phones in naturalistic conditions, device capabilities and operating system versions were heterogeneous and performance may vary across configurations. In the first experience, scanning the QR code on the front side of the package opens the AR application, displaying an interface where the user can select their preferred language. After choosing a language, buttons appear on the interface to direct users to different sections. By clicking the *"What does Mizz eat? (Mizz ne yiyor?)"* button, users access the *"Ingredients (İçindekiler)"* and *"Nutritional Facts (Besin Değerleri)"* sections, which provide more detailed information than could typically be included on physical packaging. The *"How does Mizz eat? (Peki nasıl yiyor)"* button offers insights into how the product can be consumed. In this section, the bee character Mizz prompts the user to *"follow me (beni takip et)"* and moves to the right side of the packaging, displaying different consumption options such as with milk, yogurt, or eaten plain. By making a selection in this interface, consumers can view the different ways Mizz consumes the breakfast cereal. Through the *"other products (diğer ürünler)"* button, users may visit the brand's online store to view the full product range; external navigation is user-initiated (opt-in). Thus, consumers who wish to learn more about the brand and its products, or make an online purchase, are redirected to the website (Figure 2-4).

Figure 3. Left: Interface displayed after clicking the "What does Mizz eat?" button; Right: Section showing the ingredients and nutritional values. Designed by the first author.

Figure 4. Left: Interface displayed after clicking the “How does Mizz eat?” button; Right: Interface showing Mizz consuming the product with milk. Designed by the first author.

In the second experience, accessible through the QR code located on the package lid, an AR scene explains the steps required to recycle the packaging. Given that the package concept uses fully recyclable paper-based materials, the phrase “a new adventure begins after you finish your cereal (*gevreğin bittiğinde yeni bir macera başlıyor*)” appears on the lid, guiding users to an AR experience via the QR code. This AR experience requires a flat surface, such as a table. Once the application is placed on a flat surface, the bee character emerges with the empty cereal package and greets the consumer, saying, *“Hello! Now that you’ve finished your delicious and healthy cereal, we can embark on a new mission together. (Merhaba! Lezzetli ve sağlıklı kahvaltılık gevreğini bitirdiysen seninle yeni bir göreve başlayabiliriz)”* This introduction pulls the consumer into the game-like experience while preparing them for further instructions. At this point, *“let’s begin (haydi başlayalım)”* and *“I’ll come back later (daha sonra geleceğim)”* buttons appear, giving the user the option to continue interacting with the content or return at another time. If the user chooses to proceed, they receive gamified information about recycling. At the end of the experience, the user is encouraged with the words *“We did it! We saved our world together! (Yaşasın başardık! Beraber dünyamızı kurtardık!)”* as a motivation to take action regarding recycling (Figure 5-6).

Figure 5. Left: Start screen of the recycling game; Right: Informative section emphasizing the importance of recycling. Designed by the first author.

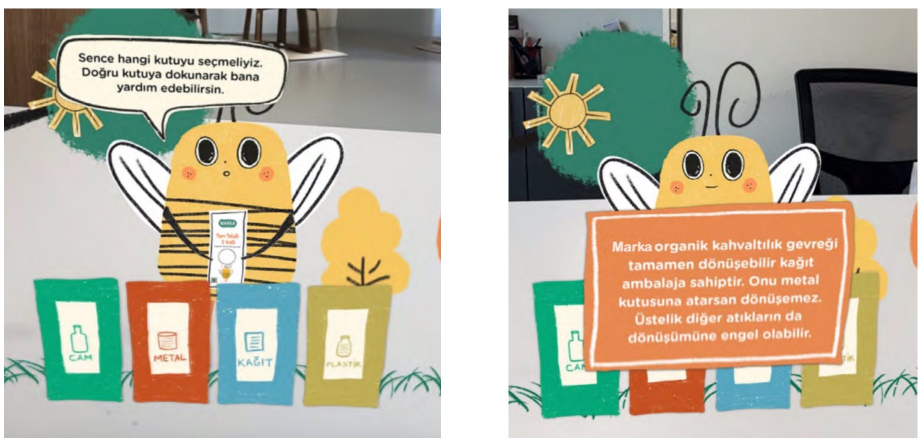

Figure 6. Left: Recycling bin selection interface; Right: Notification for incorrect recycling bin selection. Designed by the first author.

The third experience in the application is accessed via another QR code located beneath the package lid. Upon scanning, the user is greeted with the slogan *"Are you ready to join the Save the Bees Club? (Arıları kurtarma kulübüne katılmaya hazır mısın?)"* and proceeds to clean up the bee's home, which has become a dump site, and plant flowers so the hungry bee, reliant on pollen, can feed. During this stage, the bee character warns the user to avoid harmful chemicals; following the character's guidance, the user waters the flowers. After the bee character is fed and able to drink water (thanks to the tree saplings planted by the user), it expresses gratitude by saying, *"Thank you so much; you've brought me back home again. (Sana çok teşekkür ederim, beni yeniden evime kavuşturdun)"* It then continues, *"You can now become a member of the Save the Bees Club, too. Here's a little gift from me (Artık sen de arıları kurtarma kulübü üyesi olabilirsin. Bu da benim sana hediyem)"* and offers the player a discount coupon (Figure 7-8). If the user wishes, they can tap on the "Join the Save the Bees Club" button to be directed to a page where they can enter their contact information. Contact details are collected only with explicit user consent (opt-in), and the coupon can be redeemed without mandatory data sharing. While the current prototype did not implement interaction logging, AR-enabled packaging can, with explicit consent, support privacy-preserving usage analytics (e.g., module completion and dwell time) to inform iterative refinement. Additionally, the coupon provided at the end of the game can be used on the brand's website. Through this game, users gain an understanding of how waste can harm the environment and learn to be more cautious in protecting nature and other living creatures. The aim of this gamification is to reinforce social sustainability through the packaging.

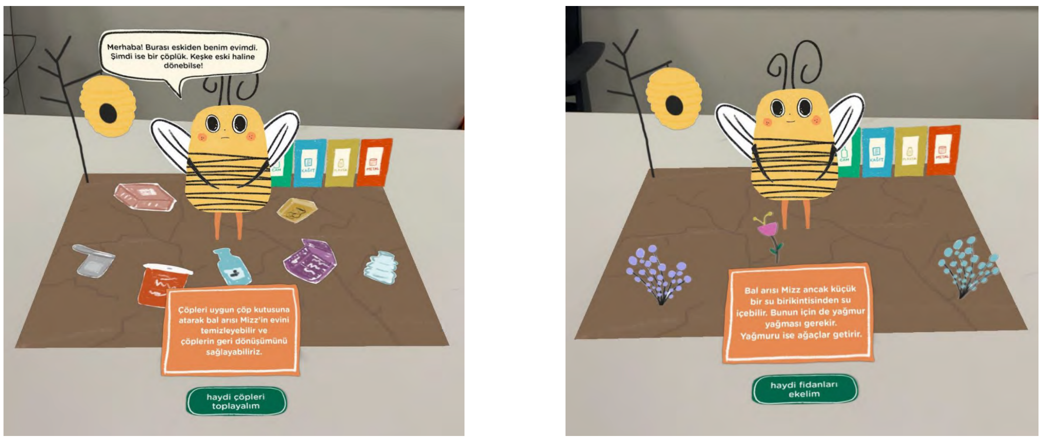

Figure 7. Left: Task interface for collecting and sorting waste into appropriate bins; Right: Task interface for planting a sapling. Designed by the first author.

Figure 8. Left: Sapling planting sequence followed by a rain animation; Right: Membership confirmation interface for the "Save the Bees" club. Designed by the first author.

The design and development of the AR application for organic food packaging presented in this study aim to create a multifaceted approach to sustainability, combining educational, interactive, and engaging experiences to foster consumer awareness and encourage behavior change. By integrating informative content, gamification elements, and user-friendly interfaces, the AR app was designed to transform the conventional role of packaging into a dynamic communication platform. A minimalistic visual design, coupled with accessible digital features, was employed to ensure that both sustainability messages and product-related information could be delivered effectively. The three distinct user experiences, ranging from exploring product content and usage to promoting recycling practices and raising environmental awareness, were developed to demonstrate how AR can merge physical packaging with digital interactivity. This approach aims not only to enhance consumer engagement but also to emphasize the importance of sustainable behaviors through immersive and meaningful narratives.

5. Methods, Results and Discussion

5.1 Methods

This cross-sectional study adopted an exploratory, descriptive design to characterize participants' perceptions regarding an AR-enabled packaging prototype in the context of sustainable food packaging. The choice of a descriptive design reflects the early, proof-of-concept stage of the prototype and the study's aim to obtain item-level distributions and qualitative insights that can guide subsequent iterations. No manipulation, comparison group, or longitudinal follow-up was implemented; consequently, the study does not claim causality or broad generalizability. Findings are interpreted as preliminary and context-bound, intended to inform design refinement and to scope directions for more rigorous future evaluations.

A total of 31 adult volunteers (18+) were recruited via non-probability convenience sampling, with efforts to ensure variation in age and education. Participants were approached through researcher-mediated, direct invitations circulated via the authors' personal and professional networks, and participation was voluntary. The age distribution was 12.9% (18–24), 45.2% (25–34), 25.8% (35–44), 3.2% (45–54), and 12.9% (55+); 61.3% identified as female and 38.7% as male. Education levels were 6.5% high school, 12.9% undergraduate students, 48.4% bachelor's graduates, 6.5% master's/doctoral students, and 25.8% postgraduate degree holders (Table 1). All participants received study information and provided written informed consent; ethical approval was obtained from a university ethics committee. Data were collected online between June 3 and June 23, 2024.

Table 1. Participant demographics by age, gender, and educational background.

Age	%	Education	%	Gender	%

18-24	12.9%
25-34	45.2%
35-44	25.8%
45-54	3.2%
55-above	12.9%

High School	6.5%
Undergraduate Student	12.9%
Bachelor’s Degree	48.4%
Master’s/Doctoral Student	6.5%
Postgraduate Degree	25.8%

Female	61.3%
Male	38.7%

Data were obtained via a 16-item questionnaire developed to match the study objectives, informed by prior literature and revised based on expert feedback. The full 16-item questionnaire is provided in Appendix A. Expert review supported face and content validity; given the heterogeneous item formats and the exploratory aim, responses were analyzed at the item level rather than as a single psychometric scale. The instrument comprised 10 Likert-type items (5-point), 5 categorical items, and 1 open-ended prompt. Items captured demographics (age, gender, education), prior exposure to AR and baseline knowledge of sustainable packaging, evaluations of the AR experience (e.g., perceived clarity of information, ease of use, visual quality), and self-reported motivation and implementation intentions. Open-ended responses were analyzed using conventional content analysis, coded collaboratively by two researchers with coding decisions reached by consensus, to identify themes and illustrative quotations. The instrument was not intended for scale development; analyses were limited to descriptive item-level distributions (n, %) and, where reported in the text, 95% confidence intervals (CIs) for positive response categories. The evaluation was conducted in naturalistic conditions on participants’ own smartphones, therefore the physical setting was not controlled. Participants accessed the prototype by scanning QR codes either from a physical package mock-up or from a package-front visual (print or digital image), depending on availability at the time of participation. Interaction with the AR experience was self-paced and participants were encouraged to explore all three modules; however, time-on-task was not instrumented or logged, so an average interaction duration cannot be reported. This approach aligns with the proof-of-concept intent but also implies that performance and perceived smoothness may vary across device and network configurations. Participants first interacted with a prototype AR application designed for an organic food-packaging concept that featured informational content, interactive elements, and product details, on their own smartphones, and they were encouraged to explore all features. The interaction was self-paced and occurred prior to survey completion to ensure that evaluations referenced the immediate experience. Participants then accessed the online questionnaire via a study link and completed it in a single session. Likert-type questions used clearly labeled anchors (e.g., *Strongly disagree* = 1 to *Strongly agree* = 5; *Very difficult* = 1 to *Very easy* = 5), with higher values indicating more favorable evaluations. Analyses were conducted on the 31 complete submissions; no imputation procedures were required.

5.2 Results

Descriptive analyses indicate favorable evaluations of the AR-enabled packaging prototype together with high rates of self-reported knowledge gain, awareness, and motivation/ implementation intentions (Table 2). Consistent with the study's exploratory scope, item-level results are reported as proportions (%) with corresponding counts (n), and 95% confidence intervals (CIs) for positive categories are provided in text to convey estimation uncertainty. Positive categories (e.g., *Agree/Strongly agree; Clear/Very clear*) were combined when summarizing key outcomes, and percentages are shown to two decimal place; therefore, row totals may differ from 100% due to rounding. All analyses were performed on complete cases (N = 31); no imputation procedures were required, and there were no planned subgroup comparisons.

Prior AR familiarity and baseline knowledge: Before this study, 32.3% had never used AR, 41.9% had tried it a few times, 19.4% used it occasionally, and 6.5% were frequent users; no participant reported expert-level use. Baseline knowledge of sustainable packaging clustered at limited to moderate levels (none = 16.1%, limited = 22.6%, moderate = 48.4%, good = 12.9%).

Perceived knowledge, awareness, and motivation: After the AR experience, 93.5% (29/31; 95% CI = 0.79–0.98) agreed that their knowledge increased (Q6). Feeling encouraged to use sustainable packaging was endorsed by 87.1% (27/31; 0.71–0.95) (Q7). The AR game was rated effective/very effective for raising awareness by 96.8% (30/31; 0.84–0.99) (Q8). At the individual level, motivation to act was reported by 80.7% (25/31; 0.64–0.91) (Q14). Regarding implementation in daily life, 77.4% (24/31; 0.60–0.89) stated they would probably or definitely apply what they learned (Q15).

User-experience evaluations: Participants rated the clarity/comprehensibility of product information as clear/very clear in 93.6% of cases (29/31; 0.79–0.98) (Q9). Usability/ease of use was judged easy/very easy by 77.5% (24/31; 0.60–0.89), with no "difficult" responses (Q10). Content understandability was easy/very easy for 83.9% (26/31; 0.67–0.93) (Q13). The effectiveness of information presentation was effective/very effective for 96.7% (30/31; 0.84–0.99) (Q11). Visual design quality received good/very good ratings from 93.6% (29/31; 0.79–0.98) (Q12).

Table 2. Percentage distribution of participants' responses to AR evaluation items (%, N=31). (Positive category combinations and 95% confidence intervals are reported in the text)

		None	Tried a few times	Occasionally	Frequently	Expert level
Q4	How would you rate your previous experience with AR applications?	32.30%	41.90%	19.40%	6.50%	0%

Q5	How much knowledge did you have about sustainable packaging before using the AR application?	No knowledge at all	Limited knowledge	Moderate knowledge	Good knowledge	Very good knowledge
		16.10%	22.60%	48.40%	12.90%	0%

Q6	Do you think your knowledge about sustainable packaging increased after using the AR application?	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
		0%	0%	6.50%	67.70%	25.80%

Q7	Did the AR application encourage you to use sustainable packaging?	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
		0%	6.50%	6.50%	64.50%	22.60%

Q8	How effective do you think the AR application's game was in raising awareness about sustainability?	Not effective at all	Slightly effective	Neither effective nor ineffective	Effective	Very effective
		3.20%	0%	0%	77.40%	19.40%

Q9	How clear and understandable did you find the presentation of product content in the AR application?	Not clear at all	Slightly clear	Neither clear nor unclear	Clear	Very clear
		3.20%	0%	3.20%	45.20%	48.40%

Q10	How user-friendly did you find the AR application interface?	Very difficult	Difficult	Neutral	Easy	Very easy
		0%	0%	22.60%	58.10%	19.40%

Q11	How effective was the AR application in presenting information?	Not effective at all	Ineffective	Neither effective nor ineffective	Effective	Very effective
		0%	0%	3.20%	67.70%	29%

Q12	How would you rate the visual design of the AR application?	Very poor	Poor	Neutral	Good	Very good
		0%	0%	6.50%	58.10%	35.50%

Q13	How easy was it for you to understand the content of the AR application?	Very difficult	Difficult	Neutral	Easy	Very easy
		0%	0%	16.10%	35.50%	48.40%

Q14	Did the content of the AR application motivate you to take individual actions for sustainability?	Not motivated at all	Slightly motivated	Neither motivated nor unmotivated	Motivated	Very motivated
		3.20%	3.20%	12.90%	71%	9.70%

Q15	Do you consider applying what you learned from the AR application in your daily life?	Definitely not	Probably not	Maybe	Probably yes	Definitely yes
		0%	3.20%	19.40%	51.60%	25.80%

Q16	What features of the AR application did you like, and in which areas do you think it needs improvement?

Open-ended responses (Q16): Content analysis grouped answers into five themes: (1) Design and Visual Elements (frequent mentions of visual appeal and attractiveness; e.g., the bee figure and audio-visual synchrony; several suggested adding a storyline, especially for children); (2) Educational and Informative Content (awareness-raising; educational and memorable presentation supporting learning); (3) User Experience - UX (user-friendly interface noted, alongside accessibility constraints, e.g., iPhone-only functionality, typical for early prototypes); (4) Gamification and Entertainment (engaging elements encouraging continued interaction); and (5) Areas in Need of Improvement (requests to enhance graphics/animation, performance/loading speed, and sound/voiceover balancing prior to public release). Open-ended responses were coded collaboratively by two researchers using conventional content analysis, and coding decisions were reached by consensus (Table 3).

Table 3. Thematic content analysis of open-ended responses with themes, subthemes, frequencies, and exemplar quotes.

Theme	Subtheme	Frequency	Example Quote
Design and Visual Elements	Visual appeal	8	"The bee figure was cute. The harmony of sound and visual content is successfully integrated."
	Attractiveness	5	"The story section could make it more engaging for children."
Educational and Informative Content	Awareness of sustainability	4	"It successfully reminds users to take quick actions related to sustainability."
	Educational and memorable content	8	"Presenting the information in such an engaging virtual world makes it more memorable."
User Experience (UX)	User-friendly interface	5	"The AR application's interface is simple and intuitive, which makes it easier to use."
	Usability challenges and access issues	6	"It's hard to use, and tracking is difficult." / "The QR code only works on iPhone; I think this is an issue."
Gamification and Entertainment	Effectiveness of gamification	4	"I liked how it used drawings and games to explain the content."
	Enjoyable experience	3	"It creates a sense of exploration, encouraging us to spend more time with the product."
Areas for Improvement	Graphics and animation enhancements	5	"The graphics could be improved to make the videos more engaging."

	Speed and performance	3	"The application loads slowly, distracting users during shopping."
	Sound and audio	3	"The fluctuations in sound levels could be reduced."

Taken together, the quantitative distributions and qualitative themes present a coherent pattern: participants experienced the prototype as clear, usable, and visually engaging, and they reported increased knowledge, high awareness, and motivation to act. Because favorable responses were common across several items (e.g., Q8, Q11), ceiling effects and/or social desirability may partly contribute to the observed proportions; accordingly, findings are interpreted as descriptive and preliminary. In addition, because participation required willingness to scan a QR code and engage with an AR prototype, the sample may over-represent individuals who are already more receptive to AR technologies and sustainability messaging, which could have further inflated favorable ratings. Nonetheless, the convergence of item-level results with the themes in Table 3 offers actionable guidance for subsequent iterations prioritizing performance and accessibility fixes while preserving the information clarity, visual quality, and light gamification that participants valued. These Results serve as an empirical basis for the Discussion that follows, where design implications and avenues for more rigorous future evaluation are outlined.

5.3 Discussion

This study offers preliminary, descriptive insight into how an AR-enabled packaging prototype is received by consumers in the context of sustainable food packaging. Across items, participants reported high levels of clarity, usability, and visual quality, together with self-reported gains in knowledge and awareness and a strong orientation toward acting on what they learned. Read cautiously, this pattern suggests that, in a proof-of-concept setting, an AR layer can function as a just-in-time information interface that makes sustainability content more accessible and memorable at the point of interaction. Because the design was exploratory and cross-sectional with no manipulation or comparison group, these outcomes are interpreted as descriptive and non-causal, serving primarily to guide subsequent iterations and more rigorous evaluations.

From a communication-design perspective, the alignment between favorable UX evaluations (clarity/comprehensibility of content; ease of use; perceived effectiveness of information presentation; visual quality) and participants' stated motivation and intended application is noteworthy. The qualitative themes triangulate this alignment: participants valued the integration of visuals and audio, the simplicity of the interface, and light gamification that invited exploration without overwhelming the message. Together these patterns indicate that the form of the AR experience, including the pacing of information, micro-interactions, and the visual system, may help scaffold attention and comprehension, which in turn can support implementation intentions related to everyday sustainability practices (e.g., mindful purchasing or correct sorting). Although mechanisms cannot be inferred, the convergence of quantitative and qualitative evidence provides an actionable basis for design decisions in AR-mediated sustainability communication. The findings can also be read through established sustainability frames. The emphasis on clarity of information and memorability engages the environmental and social pillars of sustainability by improving public understanding of packaging choices and by inviting small, feasible actions at the individual level. The qualitative suggestions around performance and accessibility speak to the economic/operational pillar: an AR solution that loads quickly, functions across devices, and minimizes friction is more likely to be adopted and sustained. This distinction mirrors the two pathways outlined in Section 3: the experience and awareness interface (communication-level outcomes) versus the operational and environmental pathway (process-level mechanisms), which helps interpret our findings conservatively at the level of perceived knowledge, motivation, and design implications. In short, even at prototype stage, the data indicate where AR packaging can create communicative value (clear content, narrative cues, light gamification) and where technical debt must be addressed (cross-platform support, loading times, audio balance) to avoid eroding that value.

Design implications follow directly. First, information architecture should prioritize succinct micro-copy, progressive disclosure, and consistent iconography so that key sustainability claims (materials, recyclability, disposal guidance) are legible at a glance and expandable when desired. Second, interaction economy matters: keep gamification lightweight (progress cues, micro-goals, immediate feedback) and subordinate to the informational goal to mitigate distraction. Third, performance and accessibility are prerequisites, not embellishments: ensure fast load, low asset weight, and broad device compatibility; provide captions/alt-text and audio controls to respect diverse contexts of use. Finally, several participants recommended narrative scaffolds (e.g., a short storyline); a carefully bounded narrative that maps to concrete personal actions could enhance engagement without introducing cognitive overload. This request can be interpreted in relation to the prototype's modular structure, which was intentionally designed as short, self-contained interactions to support progressive disclosure. While this structure can help manage informational density, it may reduce perceived continuity for younger users who benefit from clearer goal progression and an explicit through-line across stages. A lightweight narrative spine, for example a character-guided mission that links the three stages and points to concrete actions, could increase coherence and orientation without materially expanding content. Several limitations warrant emphasis. The sample was small (N = 31), recruited via convenience sampling, and comprised a single-session, self-report evaluation immediately after use; thus, selection bias, social desirability, and ceiling effects (visible on multiple items) may have inflated favorable responses. The prototype ran with restricted device support, and open-ended responses were consensus-coded by two researchers without formal inter-rater coefficients; while this approach ensured coherence of themes, it limits claims about coding reliability. Items were tailored to context and not intended for scale development, and the design lacked a comparison condition or behavioral outcomes. Collectively, these factors constrain external validity and preclude causal inference. Moreover, the sample's likely above-average educational attainment and digital literacy may have inflated ease-of-use ratings and receptiveness to sustainability messaging, thereby further limiting generalizability to broader consumer populations. This emphasis on behavioral endpoints is consistent with broader evidence on sustainability-oriented digital interventions. Systematic mapping studies show that immersive approaches, including AR/VR and gamification, are frequently employed to promote pro-environmental action; however, the strength of evidence often depends on whether evaluations move beyond self-reported intentions toward observable behavior and longer-term outcomes (Mosca et al., 2024). Similarly, systematic reviews of eco-feedback systems indicate that the effectiveness of visualization and interaction techniques is highly sensitive to design choices and usage contexts, and that recent work explicitly incorporates AR within this landscape, underscoring the need for evaluation designs that connect interaction patterns to measurable behavioral outcomes (Chalal et al., 2022).

Building on these constraints, concrete directions for future work are outlined. At minimum, subsequent studies should employ pretest–posttest or comparative designs that contrast AR-enabled packaging with information-equivalent static labels and conventional QR-linked web pages, using larger and more diverse samples, and should include behavioral endpoints such as correct bin selection in a sorting task, recycling choice, dwell time, or click-through to sustainability resources. Short validated scales for UX and sustainability attitudes could complement bespoke items, allowing effect-size estimation and cross-study comparability. On the design side, A/B tests can isolate the contribution of narrative elements and specific gamification mechanics, and performance budgets should be enforced to guarantee sub-second responsiveness on mid-range devices. A concrete research question for the next iteration is whether adding a child-oriented narrative scaffold, compared with the current modular flow, improves engagement and comprehension without increasing perceived cognitive load, and whether it yields better task performance in the recycling activity (e.g., correct bin selection). Finally, longitudinal follow-ups would clarify whether perceived knowledge and intent translate into retention and habitual behaviors beyond the immediate session. Overall, this exploratory study does not claim effects; rather, it offers a coherent descriptive portrait of users' encounters with the prototype. Participants experienced it as clear, usable, and visually engaging, and they reported high motivation to act on sustainability information. Reading the item-level distributions together with the qualitative themes yields a practical roadmap that preserves the qualities supporting comprehension and engagement while prioritizing engineering work on speed, accessibility, and audio-visual polish. With these refinements and more rigorous evaluation designs, AR-enabled packaging can be assessed more systematically as a vehicle for sustainability communication and, potentially, for encouraging everyday pro-environmental practices.

Conclusion

This article brings together a conceptual synthesis on sustainable packaging and AR-mediated communication, the design of a proof-of-concept AR application for an organic food package, and a descriptive user study examining how that prototype is received. Viewed holistically, the work positions AR-enabled packaging as a communicative layer that can complement printed labels by staging information progressively, making traceability and end-of-life guidance more legible, and framing pro-environmental actions through lightweight interaction. The prototype description and the survey findings thus operate in tandem: the former clarifies what is being designed and why, while the latter documents how participants perceived and interpreted that experience immediately after use. Across items, participants reported favorable perceptions of clarity, usability, information effectiveness, and visual quality, alongside higher self-reported knowledge and awareness and stated intentions to apply what they learned. The qualitative themes aligned with these patterns, drawing attention to the role of succinct micro-copy, consistent iconography, audiovisual coherence, and modest gamified elements in keeping the sustainability message salient. For packaging designers and brand teams, a practical implication is to treat AR as a progressive disclosure layer that extends, rather than replaces, a clear and compliant on-pack information hierarchy, using consistent micro-copy and iconography across physical and digital touchpoints. This also implies coordinating graphic design, content strategy, and engineering early, so that interaction elements remain lightweight and performance and cross-device accessibility are protected, preventing friction from diluting the sustainability message. Read in the context of the literature reviewed earlier, these observations suggest that AR-enabled packaging can function as a just-in-time interface for sustainability communication when communicative clarity and accessibility are maintained. While preserving the communication design principles that support comprehension, subsequent iterations should prioritize technical accessibility and performance, particularly cross-device robustness and faster loading, to prevent interaction friction from undermining the sustainability message. Importantly, the boundaries of inference are clear. The study used a small convenience sample in a single session and relied on self-report without comparison groups or behavioral endpoints, and the prototype context was specific. These features limit generalizability and preclude causal claims.

Future research employing comparative or longitudinal designs with larger and more diverse samples, and incorporating behavioral outcomes (e.g., correct sorting or follow-up retention), would allow more decisive evaluation of AR-enabled packaging as a vehicle for sustainability communication. The article offers a design-led articulation of AR-enabled packaging for sustainability, a descriptive portrait of user responses at the proof-of-concept stage, and a concise research path for assessing effectiveness under stronger designs. It integrates conceptual rationale, concrete design, and early reception into a coherent basis for subsequent inquiry.

References

Azuma, R. (1997). A survey of augmented reality. *Presence: Teleoperators & Virtual Environments*, *6*(4), 355-385. https://doi.org/10.1162/pres.1997.6.4.355

Bennett, G. (2020). Sustainable packaging: Is AR the solution we have been looking for? Retrieved from https://thedieline.com/blog/2020/9/18/sustainable-packaging-is-ar-the-solution-we-have-been-looking-for

Boz, Z., Korhonen, V., & Sand, C. K. (2020). Consumer considerations for the implementation of sustainable packaging: A review. *Sustainability,* 12(6), 2192. https://doi.org/10.3390/su12062192

Chalal, M. L., Medjdoub, B., Bezai, N., Bull, R., & Zune, M. (2022). Visualisation in energy eco-feedback systems: A systematic review of good practice. *Renewable and Sustainable Energy Reviews*, 162, 112447. https://doi.org/10.1016/j.rser.2022.112447

Chai, J. J. K., O'Sullivan, C., Gowen, A. A., Rooney, B., & Xu, JL. (2022). Augmented/mixed reality technologies for food: A review. *Trends in Food Science & Technology*, 124, 182–194. https://doi.org/10.1016/j.tifs.2022.04.021

Chylinski, M., Heller, J., Hilken, T., Keeling, D. I., Mahr, D., & Ruyter, K. (2020). Augmented reality marketing: a technology-enabled approach to situated customer experience. *Australasian Marketing Journal,* 28(4), 374-384. https://doi.org/10.1016/j.ausmj.2020.04.004

Cosio, L. D., Buruk, O., Fernández Galeote, D., Bosman, I. D. V., & Hamari, J. (2023). Virtual and augmented reality for environmental sustainability: A systematic review. *In Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23)*, 1-23, ACM. https://doi.org/10.1145/3544548.3581147

Dekhili, S., & Ertz, M. (2024). Augmented reality enhances ecolabel understanding. *Journal of Cleaner Production*, 434, 139987. https://doi.org/10.1016/j.jclepro.2024.139987

Dilber, U. F., Dilber, Ö. A., & Karakaya, P. M. (2012). Gıdalarda ambalajın önemi ve tüketicilerin satın alma davranışlarına etkisi (Karaman ili örneği). *Gümüşhane Üniversitesi İletişim Fakültesi Elektronik Dergisi*, 1(3), 159-190. Retrieved from https://dergipark.org.tr/en/pub/e-gifder/issue/7472/98397

Dimou, V., Styliaras, G. D., & Salomidis, K. (2024). AR-based food traceability as a means for sustainable development. *Sustainability,* 16(7), 3037. https://doi.org/10.3390/su16073037

Du, Z., Liu, J., & Wang, T. (2022). Augmented reality marketing: A systematic literature review and an agenda for future inquiry. *Frontiers in Psychology*, 13, 925963. https://doi.org/10.3389/fpsyg.2022.925963

Elkington, J., (1997). *Cannibals with forks: The triple bottom line of 21st century business.* Oxford: Capstone Publishing Limited.

Ferreira, M., Nisi, V., & Nunes, N. (2022). Interaction for Crisis: A Review of HCI and Design Projects on Climate Change and How They Engage with the General Public. In: Bruyns, G., Wei, H. (eds) *With Design: Reinventing Design Modes.* IASDR 2021 (pp. 850–879). Springer, Singapore. https://doi.org/10.1007/978-981-19-4472-7_56

Grönman, K., Soukka, R., Järvi-Kääriäinen, T., Katajajuuri, J., Kuisma, M., Koivupuro, H., ... Linnanen, L. (2012). Framework for sustainable food packaging design. *Packaging Technology and Science*, 26(4), 187-200. https://doi.org/10.1002/pts.1971

Hoffmann, S., & Mai, R. (2022). Consumer behavior in augmented shopping reality: A systematic review and research agenda. *Frontiers in Virtual Reality*, 3, 946519. https://doi.org/10.3389/frvir.2022.946519

Hwangbo, H., Kim, E. H., Lee, S. & Jang, Y. J. (2020). Effects of 3D virtual "try-on" on online sales and customers' purchasing experiences. *IEEE Access*, 8, 189479-189489. https://doi.org/10.1109/access.2020.3023040

Jerzyk, E. (2016). Design and communication of ecological content on sustainable packaging in young consumers' opinions. *Journal of Food Products Marketing, 22*(6), 707–716. https://doi.org/10.1080/10454446.2015.1121435

Koenig-Lewis, N., Palmer, A., Dermody, J., & Urbye, A. (2014). Consumers' evaluations of ecological packaging-rational and emotional approaches. *Journal of Environmental Psychology*, 37, 94-105. https://doi.org/10.1016/j.jenvp.2013.11.009

Krah, S., Todorovic, T., & Magnier, L. (2019). Designing for packaging sustainability. The effects of appearance and a better eco-label on consumers' evaluations and choice. *Proceedings of the Design Society: International Conference on Engineering Design*, 1(1), 3251-3260. https://doi.org/10.1017/dsi.2019.332

Kyguolienė, A., & Braziulytė, R. (2022). Application of augmented reality in product packaging: challenges and development opportunities. *Management of Organizations Systematic Research*, 88(1), 85-100. https://doi.org/10.2478/mosr-2022-0014

Lignou, S., & Oloyede, O. O. (2021). Consumer acceptability and sensory profile of sustainable paper-based packaging. *Foods*, 10(5), 990. https://doi.org/10.3390/foods10050990

Magnier, L. & Schoormans, J. (2017). How do packaging material, colour and environmental claim influence package, brand and product evaluations? *Packaging Technology and Science*, 30(11), 735-751. https://doi.org/10.1002/pts.2318

Magnier, L., Schoormans, J., & Mugge, R. (2016). Judging a product by its cover: Packaging sustainability and perceptions of quality in food products. *Food Quality and Preference*, 53, 132–142. https://doi.org/10.1016/j.foodqual.2016.06.006

Mosca, O., Manunza, A., Manca, S., Vivanet, G., & Fornara, F. (2024). Digital technologies for behavioral change in sustainability domains: a systematic mapping review*. Front. Psychol.* 14:1234349. https://doi.org/10.3389/fpsyg.2023.1234349

Norton, V., Waters, C., Oloyede, O. O., & Lignou, S. (2022). Exploring consumers' understanding and perception of sustainable food packaging in the UK. *Foods*, 11(21), 3424. https://doi.org/10.3390/foods11213424

Rauschnabel, P. A., Felix, R. & Hinsch, C. (2019). Augmented reality marketing: How mobile AR-apps can improve brands through inspiration. *Journal of Retailing and Consumer Services*, 49, 43–53. https://doi.org/10.1016/j.jretconser.2019.03.004

Ren, Z., Zhang, D., & Gao, Z. (2022). Sustainable design strategy of cosmetic packaging in china based on life cycle assessment. *Sustainability*, 14(13), 8155. https://doi.org/10.3390/su14138155

Robertson, G. L. (2013). *Food packaging: Principles and practice* (3rd Edition). Oxfordshire: CRC. Taylor & Francis Group.

Rodrigues, R. & Pombo, L. (2024). The potential of a mobile augmented reality game in education for sustainability: Report and analysis of an activity with the EduCITY App. *Sustainability*, 16, 9357. https://doi.org/10.3390/su16219357

Rogers, D. (2024). Uncovering the power of AR in sustainable shopping. Retrieved from https://researchworld.com/articles/uncovering-the-power-of-ar-in-sustainable-shopping

Smink, A. R., Frowijn, S., van Reijmersdal, E. A., van Noort, G., & Neijens, P. C. (2019). Try online before you buy: How does shopping with augmented reality affect brand responses and personal data disclosure. *Electronic Commerce Research and Applications*, 35, 100854. https://doi.org/10.1016/j.elerap.2019.100854

Sustainable Packaging Coalition. (2019). *Definition of sustainable packaging.* Retrieved from https://sustainablepackaging.org/wp-content/uploads/2019/06/Definition-of-Sustainable-Packaging.pdf

Wimer, B. L., Szymanski, A., & Metoyer, R. A. (2024). Beyond static labels: Unpacking nutrition comprehension in the digital age. *In Proceedings of the CHI Conference on Human Factors in Computing Systems (CHI '24)* (15 pp.). New York, NY: Association for Computing Machinery. https://doi.org/10.1145/3613904.3642672

World Commission on Environment and Development. (1987). *Report of the world commission on environment and development: Our common future*. Oxford University Press. Retrieved from https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf

Wunderman Thompson Intelligence. (2022). *The future 100: 2022.* Retrieved from https://www.wundermanthompson.com/insight/the-future-100-2022

Y, Pulse. (2021). *Brands are adding AR experiences to their packaging - Do young people care?* Retrieved from https://www.ypulse.com/article/2021/10/26/brands-are-adding-ar-experiences-to-their-packaging-do-young-people-care/

Zhang, Y. (2023). The exploration of AR on intelligent packaging. *Applied and Computational Engineering*, 8(1), 543-549. https://doi.org/10.54254/2755-2721/8/20230272

Visual References

Appendix A. Questionnaire items (16 items)

Q1. Age (select one): 18–24; 25–34; 35–44; 45–54; 55+

Q2. Gender (select one): Female; Male

Q3. Education (select one): High School; Undergraduate Student; Bachelor's Degree; Master's/Doctoral Student; Postgraduate Degree

Q4. How would you rate your previous experience with AR applications?

(None; Tried a few times; Occasionally; Frequently; Expert level)

Q5. How much knowledge did you have about sustainable packaging before using the AR application?

(No knowledge at all; Limited knowledge; Moderate knowledge; Good knowledge; Very good knowledge)

Q6. Do you think your knowledge about sustainable packaging increased after using the AR application?

(Strongly disagree; Disagree; Neutral; Agree; Strongly agree)

Q7. Did the AR application encourage you to use sustainable packaging?

(Strongly disagree; Disagree; Neutral; Agree; Strongly agree)

Q8. How effective do you think the AR application's game was in raising awareness about sustainability?

(Not effective at all; Slightly effective; Neither effective nor ineffective; Effective; Very effective)

Q9. How clear and understandable did you find the presentation of product content in the AR application?

(Not clear at all; Slightly clear; Neither clear nor unclear; Clear; Very clear)

Q10. How user-friendly did you find the AR application interface?

(Very difficult; Difficult; Neutral; Easy; Very easy)

Q11. How effective was the AR application in presenting information?

(Not effective at all; Ineffective; Neither effective nor ineffective; Effective; Very effective)

Q12. How would you rate the visual design of the AR application?

(Very poor; Poor; Neutral; Good; Very good)

Q13. How easy was it for you to understand the content of the AR application?

(Very difficult; Difficult; Neutral; Easy; Very easy)

Q14. Did the content of the AR application motivate you to take individual actions for sustainability?

(Not motivated at all; Slightly motivated; Neither motivated nor unmotivated; Motivated; Very motivated)

Q15. Do you consider applying what you learned from the AR application in your daily life?

(Definitely not; Probably not; Maybe; Probably yes; Definitely yes)

Q16. What features of the AR application did you like, and in which areas do you think it needs improvement? (Open-ended)

Bu makale iThenticate intihal tespit yazılımıyla taranmıştır. / This article has been scanned by iThenticate plagiarism detection software.

Bu çalışmada "Yükseköğretim Kurumları Bilimsel Araştırma ve Yayın Etiği Yönergesi" kapsamında uyulması belirtilen kurallara uyulmuştur. / In this study, the rules stated in the "Higher Education Institutions Scientific Research and Publication Ethics Directive" were followed.

Araştırma iki yazar tarafından yürütülmüştür (Katkı Oranı: %50 - %50). / The research was conducted by two authors (Author Contribution: : %50 - %50).

Çalışma kapsamında herhangi bir kurum veya kişi ile çıkar çatışması bulunmamaktadır. / There is no conflict of interest with any institution or person within the scope of the study.