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Innovations in Packaging: the Application of New Materials and Technologies

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Abstract. In the modern era, the packaging industry goes beyond simply protecting and transporting products; it must also meet environmental, technological, and economic demands. Traditional packaging materials such as plastic, paper, glass, and metal have revealed various limitations over time, prompting the search for innovative and sustainable alternatives. In recent years, biodegradable materials, recyclable composites, and smart or functional packaging technologies have gained increasing attention. These alternatives not only preserve product quality but also reduce environmental impact, optimize production processes, and better meet consumer needs. Particularly in sectors like food, e-commerce, and logistics, such innovations are being rapidly adopted. The implementation of packaging innovations provides companies with a competitive advantage while contributing to sustainability goals. This abstract provides a general overview of recent developments in packaging technologies, the limitations of conventional materials, and the advantages of modern alternatives.

Keywords: *packaging design, ecological design, biodegradable products, brand differentiation, compostable products, recycling, technological innovations, modern alternatives.*

In the 21st century, rapid technological progress, globalization, and increasing market competition have fundamentally reshaped how industries function. Organizations can no longer depend solely on conventional production and management approaches; instead, they must constantly adapt, innovate, and respond to ever-changing market dynamics. In this context, innovation has become a crucial factor in ensuring sustainable growth, maintaining competitiveness, and achieving long-term success. It extends beyond technological advancements to include new methods in management, design, and strategic decision-making. Therefore, innovation is now understood as a broad, multidimensional concept that impacts every stage of production and distribution.

1. The necessity of innovations in the packaging industry

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The modern era is characterized by the rapid development of technology and the increase in global competition. In this environment, one of the key conditions for the successful operation of any organization or enterprise is the implementation of innovations. The adoption process—i.e., the implementation of new ideas, products, or services—can become more effective, flexible, and goal-oriented through innovative approaches. Innovations are manifested not only in technology but also in management methods, decision-making mechanisms, and strategic planning. In this paper, the importance of innovations, their fields of application, and their role in organizational development will be examined in detail.

Packaging today is no longer limited to protecting and transporting goods; it has evolved into a multifunctional system that reflects technological progress, environmental responsibility, and market competition. Alongside traditional materials such as plastic, paper, glass, and metal, new alternatives are being developed to overcome their ecological and functional limitations. In this context, innovative materials and smart technologies play a crucial role in shaping modern packaging solutions.

Innovation in packaging covers technical, design, and social aspects. Development in this field changes both industry and everyday life. Sustainability and creativity are the main criteria of packaging design. As a result, packaging is seen not just as a covering but as the voice of the brand and the consumer's experience. Packaging forms that meet consumer needs and respect the environment are the main brands of the future. Enterprises that accept these changes and turn innovation into a strategic goal will achieve more sustainable success in the future.

Environmental protection and ecological problems

Innovation in packaging is often a response to changes in social trends. Currently, issues such as food growth and localization of production play a major role in the increase of material innovations. Even if materials themselves are not innovative, their non-traditional use can still be considered innovation. Innovation is also motivated by technological progress. The application of artificial intelligence and sensor technologies in packaging optimizes the product production and sales cycle. Active and smart packaging improves storage conditions, increases food safety, and prevents waste. Such technologies are especially necessary in

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the food, pharmaceutical, and cosmetics industries. Environmentally friendly packaging design approaches, such as material usage, can give a second life to many seemingly unusable materials. (Roncarelli, S., & Elliot, C. (2010). *Packaging essentials: 100 design principles for creating packages.*)

Large corporations such as Procter & Gamble actively invest in sustainable packaging strategies. The company focuses on increasing the use of recyclable materials and reducing dependence on virgin plastics. Initiatives such as the use of mono-material packaging and recycled ocean plastics demonstrate practical steps toward minimizing environmental impact and supporting global sustainability goals.

An example of this is the refillable cleaning products of many brands. P&G is working on a strategy to produce packaging made from 100% recyclable materials. In some products, they use mono-material containers (made from only one type of plastic, which makes them easier to recycle). The company plans to reduce the use of virgin plastic in packaging by 50% by 2030. This step saves resources and reduces environmental pressure. P&G also works on projects such as the "Clean Oceans Project," producing packaging made from recycled marine plastics in order to reduce plastic waste entering the oceans. For example, bottles made from plastic waste collected from the sea have been introduced for Head & Shoulders shampoo. (Procter & Gamble. (n.d.). *Plastic packaging.* <https://pginvestor.com/esg/environmental/plastic-packaging/>)

Procter & Gamble is taking strong steps toward circular economy transition in packaging, waste reduction, and strengthening recycling processes. Their focus on innovative and ecological solutions in packaging can be considered a role model for other manufacturers.

Changes in consumer demand

One of the main driving forces of innovations in the packaging sector in recent years is changes in user behavior. Modern consumers pay attention not only to product quality but also to how it is presented, what materials are used in its packaging, and how that packaging affects the environment. These changes lead to innovations in packaging design, material selection, and technological approaches. Previously, packaging mainly served the function of protecting and transporting the product, but today it is also considered the first visual and emotional point of contact with the consumer. Research shows that a large proportion of consumers choose

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products based on packaging attractiveness. Therefore, design and aesthetic appearance, along with functionality, have become important factors.

One of the changes is the demand for transparency and information in packaging. Buyers want clear and accurate information about the product. For this purpose, many brands place QR codes, digital labels, and interactive elements on packaging. Through these tools, users can learn about the product's composition, production process, and origin. At the same time, modern consumers prefer functional and practical packaging. Easy opening, storage after use, and reusability have become key features that distinguish products from others. Especially for urban consumers with a fast-paced lifestyle, such functional solutions are a reason for choosing a brand and product.

To meet these new demands, brands are exploring environmentally friendly materials and innovative packaging designs.

Some of the most promising solutions are:

Biodegradable and compostable packaging: Materials such as PLA (polylactic acid) and seaweed-based packaging naturally decompose and reduce waste.

Innovative packaging for sustainability: QR codes and NFC labels provide consumers with recycling information, product traceability, and brand transparency. (LBB Online. (n.d.). *Sustainable packaging innovations: Meeting modern consumer demands*. <https://lbbonline.com/news/sustainable-packaging-innovations-meeting-modern-consumer-demands>)

Competitive advantage and brand differentiation

In today's world, where consumer choices are extensive, packaging plays a major role in brand differentiation. Packaging presents a brand's identity, values, and unique selling propositions to the consumer. Through colors, textures, shapes, and typography, products can evoke emotions and communicate messages to consumers. In this way, memorable experiences can be created between the consumer and the brand. In this context, packaging becomes a powerful tool for brand differentiation, helping products stand out on shelves and online platforms.

The use of environmentally friendly materials or innovative designs that minimize waste can distinguish a brand as environmentally conscious. This highlights sustainability advantages and appeals to a specific market segment. As a key component of visual identity, packaging plays an important

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role in brand differentiation.

Packaging helps establish a deeper connection with the target audience, appeal to their values and ethics, and differentiate the brand from competitors. Today, in crowded markets, brands face the challenge of not only standing out but also being remembered and preferred by consumers.

By emphasizing unique selling propositions such as sustainability, technological innovation, or superior quality in packaging, a brand can significantly enhance its differentiation. For example, eco-friendly packaging not only appeals to environmentally conscious consumers but also positions the brand as responsible and caring for the planet. On the other hand, the use of the latest packaging technologies demonstrates a brand's commitment to innovation. Thus, the brand can increase its attractiveness for technology-oriented customers and become a leader in its category.

Packaging does not simply represent the external appearance of products. It is a strategic tool used to strengthen competitive advantage and the brand's market position. Through thoughtful design and innovation, packaging significantly contributes to brand differentiation. Businesses succeed in standing out in crowded markets, connecting with their target audience, and achieving growth and success as a result. (Bay Water Packaging. (n.d.). *The importance of packaging in brand differentiation*. <https://baywaterpackaging.com/the-importance-of-packaging-in-brand-differentiation/>)

2. Application of New Materials

Biodegradable and Compostable Materials

Biodegradable and compostable materials represent one of the most promising directions in sustainable packaging. Unlike conventional plastics, these materials decompose naturally within a shorter period and do not generate harmful residues. Their application contributes to reducing environmental pollution while supporting circular economy principles. In the modern packaging industry, environmental protection is one of the main priorities. The long decomposition period and environmental harm of traditional plastic and synthetic materials force manufacturers to work on alternative, sustainable, and environmentally safe materials. In this context, the application of biodegradable and compostable materials is one of the main directions of packaging innovation. These materials fully decompose under

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natural conditions within a short period of time, do not harm soil and water, and some of them can even be converted into fertilizer through industrial and home composting processes. The use of such materials not only contributes to environmental protection but also demonstrates a brand's ecological responsibility, increasing consumer preference and market differentiation.

- **Polylactic Acid (PLA):**

PLA, usually derived from fermented plant starch obtained from corn, cassava, sugarcane, or sugar beet pulp, exhibits properties similar to conventional plastics. Its versatility allows it to be used in various packaging forms, including bottles, wraps, and containers.

- **Bagasse:**

Bagasse is a by-product of sugarcane processing and is transformed into a valuable packaging resource. It is used for producing disposable containers and food packaging. Bagasse products are compostable and require less production energy compared to paper or plastic products.

- **Cellulose-based films:**

These films, made from wood pulp and cotton, are an eco-friendly alternative to plastic wraps. Transparent, lightweight, and versatile, cellulose-based films are ideal for packaging various products. They are home-compostable and decompose without leaving hazardous residues.

- **Mushroom mycelium:**

As a natural packaging material, mushroom mycelium attracts attention due to its sustainability and versatility. It is formed by combining fungal root fibers with agricultural waste, resulting in compostable and moldable packaging. It is ideal for protective packaging, providing cushioning for fragile items. After use, it can be composted and adds nutrients back to the soil.

Biodegradable packaging is seen as a new norm for environmentally responsible brands. This trend reflects a deeper commitment to sustainable practices and environmental care in society. By adopting naturally decomposing materials, companies not only reduce their carbon footprint but also align with the growing consumer demand for eco-friendly practices. (AA Custom Packaging. (n.d.). *Biodegradable packaging: The new standard for eco-conscious brands*. <https://aacustompackaging.com/sustainability/biodegradable-packaging-the-new-standard-for-eco-conscious-brands/>)

Modern Alternatives to Traditional Materials

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Traditional materials used in the packaging industry for many years include plastic, aluminum, glass, and paper. However, these materials either have very long decomposition times (e.g., plastic) or their production causes environmental harm (e.g., deforestation for paper production or energy-intensive aluminum production). For this reason, in recent years, more sustainable, reusable, and biodegradable alternatives have gained importance. These alternatives provide functionality while reducing the carbon footprint, thus minimizing environmental impact. At the same time, they strengthen the concept of environmental responsibility for both consumers and brands.

1. Compostable plastics

Materials such as bagasse, a fibrous by-product of sugarcane after juice extraction, are increasingly used to replace disposable plastic containers and packaging. Unlike plastic, this alternative material is biodegradable and compostable. Bagasse is flexible, food-safe, and widely used in takeaway services. As a by-product of sugarcane production, its use is sustainable. Similarly, the U.S.-based Saltwater Brewery developed compostable six-pack rings made from barley and wheat residues, which were designed to prevent marine animals from being harmed after entering the ocean.

2. Cardboard paper water bottles

It is natural to think that paper and water cannot coexist. However, in 2018, shower-safe and water-resistant materials were introduced to replace shampoo and shower gel bottles. The beauty giant L'Oréal, through its hair and skincare brand Seed Phytonutrients, released bottles made from recycled paper with a recycled plastic inner liner. The result is a bottle that uses 60% less plastic than a standard shampoo bottle. Since then, the company has increasingly adopted paper bottles for liquid products.

3. Plant-based plastics

Plant-based plastics, also known as bioplastics, are made from starch and bamboo fibers and are then broken down into polylactic acid. Depending on their composition, they can be biodegradable and suitable for either industrial or home composting. Since the cultivation of the plants used does not require pesticides or extensive resources, bioplastics potentially support a more circular economy and reduce environmental impact. They are increasingly used in beverage bottles, food containers, and packaging films by companies such as Innocent.

4. Recycled plastics

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When plastics must be used, recycling them as much as possible is essential, and the plastics industry is working to close the recycling loop. In 2016, out of 3,147,000 tons of PET bottles and containers entering the European market, approximately 1,880,900 tons were collected, equivalent to about 60%. Of this, 1,773,200 tons were mechanically recycled. When a strong and durable material is needed, plastic remains unavoidable in some cases. Fortunately, products made from 100% recycled plastic are becoming more common, from shipping materials to industrial pallets and containment tools. (Earth.org. (n.d.). *5 plastic alternatives for packaging*. <https://earth.org/5-plastic-alternatives-for-packaging/>)

CONCLUSION

Packaging innovations have become a fundamental component of modern industrial and design practices. The integration of new materials and advanced technologies not only enhances product protection and functionality but also addresses critical environmental challenges. Biodegradable materials, smart packaging systems, and sustainable design approaches contribute to reducing ecological impact while improving consumer experience.

Furthermore, evolving consumer expectations and increasing environmental awareness continue to drive innovation in this field. Packaging is no longer perceived as a passive element but as an active medium of communication, brand identity, and sustainability. Therefore, companies that invest in innovative and eco-friendly packaging solutions are more likely to achieve long-term competitiveness and market success.

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