



Scientific article

Sustainable solutions for packaging products

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Abstract:

By introducing sustainable packaging, the business is imperative in developed production environments. Environmentally acceptable packaging solutions not only reduce their negative impact on the environment but also increase their positive reputation among consumers. The introduction of innovations in the product design phase makes the most significant progress towards creating an optimal packaging product. Such solutions are usually related to a single product or a group of similar products. When designing packaging, the focus should be on the choice of material that combines functionality and benefit for the environment, optimisation of material consumption and product functionality. In addition to everything mentioned, the designer should take into account the end of the product's life cycle and design packaging that is easy to separate and recycle. Sustainable packaging supports a circular economy, where materials can be reused and recycled instead of becoming disposable waste. In addition to the aforementioned, the application of innovative design and technologies enables a more modern approach to product protection, reducing the need for physical packaging layers and making packaging lighter and easier to recycle. This research work created sketches of conceptual solutions for more sustainable packaging products, respecting the explained principles. In addition to the above examples, it is further explained how one can contribute to the improvement of the sustainability of packaging products.

Keywords:

Sustainability, Conceptual solutions, Packaging products

1. Introduction

Sustainable packaging design plays a key role in reducing the negative impact on the environment, so it is important to include sustainability already in the design phase, and not only during production itself. [1, 2] Increasing the sustainability in the production of packaging products can be achieved through the choice of materials, optimization of design and product development, taking into account the product's life cycle. [3, 4] When designing the conceptual solution, consumers must not be forgotten who value

the functional and visual features of the packaging product. [5, 6] It is necessary to emphasize that the choice of materials and the production of products must comply with legal regulations.

When choosing materials, designers can choose environmentally friendly materials, such as recycled materials, the use of which reduces the need to exploit natural resources. [7] The use of biodegradable plastic materials instead of conventional ones contributes to faster decomposition of the product after the

end of its life cycle. [8] Such materials are often made from bio raw materials such as cellulose or corn starch, which are renewable, so their production reduces the impact on environmental pollution. It would be good if, when designing the product, as many monomaterials as possible are proposed to facilitate recycling because there is no need to separate the components. [9, 10]

By optimizing the design, the use of materials can be minimized. [11, 12] The use of thinner layers of material contributes to the reduction of waste and the consumption of smaller amounts of resources needed to make the product. The repeated use of products can further contribute to the reduction of resources. [13] It can be achieved through modular design or by designing the packaging product in such a way that it can be easily assembled and disassembled. When designing packaging products, more efficient distribution should be considered. Packaging designed to take up less space during transport reduces CO₂ emissions. [14, 15]

When considering the life cycle of a product in the design phase, the ease of recycling the product after the product's use phase is often taken into account That can be achieved by avoiding complex combinations of materials that are difficult to separate. Packaging with a sustainable design can educate consumers through the communication of environmental messages related to highlighting sustainable practices or information on how to recycle a particular product. [16-19] Such promotion will increase the amount of environmentally conscious consumers who will be more and more directed towards ecological products, so packaging that visually and functionally communicates sustainability can attract the attention of the market. [20-22] Sustainable packaging products usually contain innovative solutions that can contribute to a competitive advantage. Businesses that integrate sustainability into design can reduce costs through more efficient use of materials and less waste. [23, 24]

Many countries are introducing stricter packaging regulations, including reducing the use of plastics and increasing recycling requirements. [25, 26] Packaging design that takes these standards into account allows companies to more easily comply with legislation. Incorporating sustainability into the early stages of design enables the creation of packaging that not only meets functional needs but also contributes to environmental protection, reduces costs and improves brand image. [27, 28] This research shows examples of how to improve the design of existing packaging products in a way that increases their sustainability.

2. Methodology

For the redesign of the product, common products found in common stores were taken. The actual products used, their name, brands, and manufacturers are not mentioned in the paper to contribute to the process of negative promotion of an individual product. Only sketches are presented in the paper, which are the results of product improvements.

The creation of sketches of conceptual solutions for packaging products was done in Adobe Photoshop in several steps. Photoshop was chosen as the tool for creating visualizations and conceptual sketches because it offers the flexibility to work with different layers, colours and effects. The process of creating sketches of conceptual packaging solutions consisted of several steps:

In the preparation of the project, the resolution of the document was set to 300 dpi to prepare the documents for printing, while for digital displays the resolution was 72 dpi. Before starting the design phase, basic colours are defined, in this case, grey. This phase was followed by the phase of creating the basic form of packaging for each sketch that was made.

During creation, a separate Layer was used for each element of the packaging, so that it would be easier to edit a specific sketch. For example, the layers contained: basic shape,

text, logo, additional graphic elements and more. Furthermore, the phase of adding visual elements such as logos, branded elements, and texts followed. When creating a product at this stage, attention should be paid to fonts and their readability, as well as to the hierarchy of information. The used colour and its gradients can give a more modern look to the design. This procedure provides flexibility and precision in the creation of conceptual sketches of packaging, enables experimentation with different styles and ideas, and enables an easier decision about the best version of the sketch.

3. Conceptual solutions for improved products

3.1. Material selection

The use of cardboard materials for packaging products has many advantages, especially in the context of sustainability, economy and product protection. [29, 30] Cardboard is made from natural materials (mainly cellulose fibres from wood pulp) and is biodegradable, which means that it breaks down easily in nature, unlike plastic which takes hundreds of years to break down. Most cardboard can be completely recycled, which reduces the need for raw materials and energy in the production of new materials. Recycled cardboard can become packaging again, which contributes to the circular economy. [31] When studying energy consumption, the production of cardboard requires less energy than the production of plastic packaging. The use of renewable sources for the production of cardboard additionally reduces CO₂ emissions. [32] Furthermore, the amount of emitted CO₂ related to transport is reduced, because cardboard is a relatively light material, which means that cardboard packaging reduces the weight of the overall package. It should be noted that in this way transport costs and the energy required for product delivery are reduced, which is important for ecological efficiency. Due to its lightness, cardboard packaging is easy to handle and store, which

facilitates logistics processes and makes it practical in many industries. Cardboard has good product protection functions because it has excellent impact and pressure resistance, which ensures product protection during transport and storage. The product inside the cardboard packaging will also have a certain level of insulation from heat and moisture, which can be useful for protecting products that are sensitive to temperature changes. Cardboard can be adapted to different shapes and sizes, which makes it a flexible material for different types of packaging, from transport boxes to food packaging to luxury packaging. [33] The printing properties of cardboard as a printing surface are good, so packaging products can be easily personalized by printing logos, product information and other necessary elements. For the example below, it is extremely important that certain types of cardboard that are made without harmful additives can come in contact with food (Figure 1). The sketch of the packaging proposal for pasta does not contain a plastic window, because when applying a plastic window to the packaging, adhesives are used that are additionally negative for the environment. Such mixing of materials only makes it difficult to recycle the cardboard, because glue particles remain on the cardboard, which contribute to the formation of sticky particles.



Figure 1 Sketch of packaging for spaghetti: up) Example of combined and excessive packaging, below) Example of cardboard packaging

In Figure 1, example a) shows the packaging made of the combined materials of cardboard, paper and a plastic bag. The presented packaging could be used for exclusive packaging of pasta, as it has an advantage over the usual packaging, as the plastic bag is easily separated from other materials, so it can be recycled and does not need to be heavy. The cardboard box protects the product, while the plastic bag is only responsible for preserving the integrity of the product. The conceptual solution in the sketch in Figure 1 b) is designed in such a way that the box should be made of only one material, i.e. cardboard, which is renewable, recyclable and biodegradable. There are no plastic windows on the box because the pasta is drawn on the box and customers are already familiar with the appearance of the pasta. The ink on the cardboard can be relatively easily separated from the cellulose fibres in the recycling process. The process can re-create the cardboard in an average of 7 rounds of recycling when the cellulose fibres become too short to make paper or cardboard.

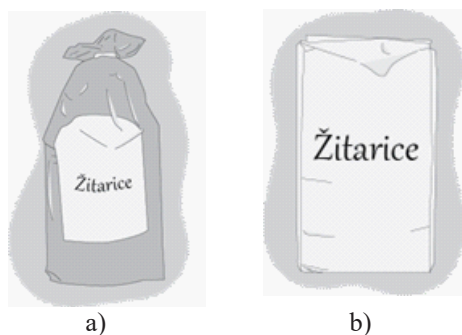


Figure 2 Oatmeal sketch: a) Traditional packaging, b) Packaging proposal

The given example of oatmeal shows the traditional way of packing oatmeal in a plastic bag (Figure 2). The plastic bag is often chosen as a packaging product for bulk products that should not get wet because it is light and suitable for printing. Unfortunately, such packaging is made from non-renewable raw materials and emits harmful gases during production. In addition to what has been said, it should be emphasized that the mentioned

packaging is usually significantly larger than the product it contains. The aforementioned applies to various food products such as chips, pasta, salt, sugar and other food products. The size of the packaging is intended to give customers the false impression that the product is larger than the actual size. The aforementioned has an additional negative impact on the environment. The ideal packaging solution for oatmeal includes a paper bag, which is more affordable than a cardboard box because it contains less material, and adhesives and is lighter. The proposed packaging is easy to store and can be refilled if stores have this option.

3.2.Reduction of excessive material

Excessive packaging refers to the use of unnecessarily large or complex packaging materials that exceed the basic need for product protection and presentation. Reducing the amount of packaging directly affects the reduction of total waste that ends up in landfills. [34] The use of optimal packaging reduces the consumption of resources such as wood, plastic, metals and energy, which reduces the ecological footprint and CO₂ emissions. The production and transport of packaging materials, especially plastic and metal, require a large amount of energy, which can significantly contribute to the emission of greenhouse gases and climate change.

Optimizing the amount of packaging material can contribute to easier use of the product. Reducing excessive packaging often means that the product becomes easier to cover and open. Consumers value the functionality and simplicity of packaging more, instead of complex and often unnecessary solutions. Reducing packaging often encourages designers and engineers to develop innovative and functional solutions that combine efficiency and sustainability. The focus on minimalism and simplicity often leads to the creation of elegant, environmentally friendly packaging solutions. This way of increasing sustainability is often related to better

adaptation of the packaging to the product itself. The packaging is designed to perfectly match the dimensions of the product, which reduces excess material and improves functionality.

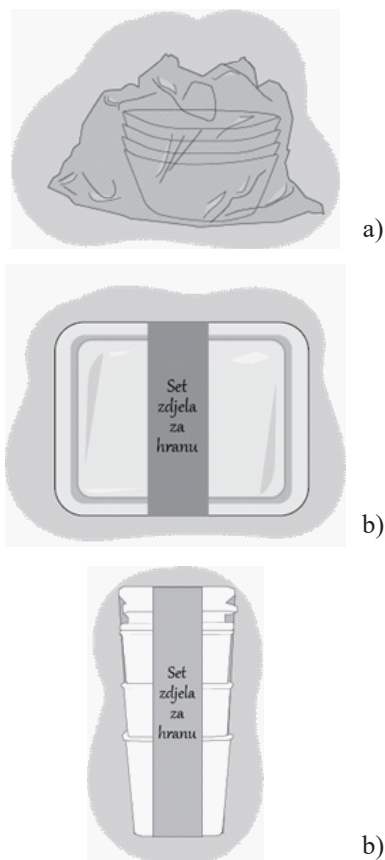


Figure 3 Sketches of packaging for bowls: a) Overpack, b) Paper packaging tape, c) Paper packaging tape

An example of excess packaging material is given in the figure (Figure 3 a)), where it is visible how easy it is to reduce the size of the plastic bag without changing the product packaging technology. With such a solution, production savings would be achieved, the product would be adequately packaged and the consumption of non-renewable plastic material would be reduced, which will reduce the negative impact on the environment during the process of production and disposal of packaging. The positive fact of this type of packaging is the fact that the product is in packaging made of one material, which is easy to properly dispose of or collect for

recycling. The sketches shown in Figures 3 b) and c) reduced the packaging to the smallest possible extent. This is just a paper strip on which all the necessary information and the manufacturer's logo can be printed, and after use, they are easily separated from the product and can be recycled or used as a source of raw material. The paper tape ensures the coherence of the product, and the nature of the product allows that there is no need to take care of the cleanliness of the product because every customer will wash the containers before use. Less packaging means less space that the product takes up in transport and storage. This enables the optimization of logistics, which reduces transport costs, as well as gas emissions due to reduced fuel consumption. Manufacturers can significantly reduce costs by using less packaging material. This not only reduces production costs but also contributes to lower prices for consumers.



Figure 4 Sketch of reducing the amount of packaging material: up) Sweets, below) Croissants

The created sketches for the examples in Figure 4 are related to packaging products that contain more than one unit of food products. The created sketches for the examples in Figure 4 are related to packaging products that contain multiple units of food products. We would like to emphasize here that there is no need to pack different types of candies in separate bags or individual plastic

wraps because even hard or rubber candies will not get dirty or stick together if they are together in a bag. In this way, the consumer can choose which type he wants to eat. When studying croissant packages containing multiple product units, it is not necessary to package each croissant in a separate package. If the consumer wants unit packaging, he can buy it. Unit packs are more expensive, which encourages customers to buy multiple packs. In this way, the price of packages containing more pieces can be further reduced, savings in material consumption can be achieved and environmental pollution can be reduced.

3.3. Solutions in the protective function of packaging

The protective function of packaging can be improved in an environmentally sustainable way through the use of smart materials, design and manufacturing practices. Instead of plastic or metal labels for product protection (which are often difficult to recycle), biodegradable materials based on plant fibres, sugar cane or corn starch can be used. [35] These stamps can provide the same level of security, but they quickly degrade in nature after use. Instead of caps made from brand-new plastic materials, recycled plastic or metal caps can be used. Recycled plastics reduce the need for exploitation of new raw materials and energy consumption in production. Instead of plastic or metal seals, paper or cardboard seals made from recycled or biodegradable materials can be used. [36] These seals provide the necessary protection while being easily recycled together with the packaging. Manufacturers can use a variety of innovative processes to use less plastic without compromising product functionality, such as thinner caps or those with smaller dimensions. The design of the caps can be optimized in such a way that they are easier to separate from the bottle or packaging during recycling. Plastic caps can be made of the same type of plastic as the bottle (e.g. PET plastic), which will facilitate the recycling process. Innovative

caps with integrated sealing can reduce the need for additional protective layers (e.g. aluminium foil), which contributes to the reduction of material and waste. Plant-based wax can replace traditional plastic or metal stamps and seals, providing a natural barrier that can be biodegradable. Another solution is to use clip fasteners made from recycled paper or biodegradable composites instead of traditional plastic strips.

Reducing packaging layers is one approach to increase the sustainability of packaging products. Application of nano-coating can improve the protective properties of the packaging, while at the same time reducing the need for additional materials. These coatings can be made from natural materials and are completely biodegradable, and provide excellent resistance to moisture, oxygen and light. Many packaging products use multi-layered materials to protect against tampering (e.g. a layer of plastic, then an aluminium seal and an additional cap). Sustainable approaches imply the reduction of layers with the use of one multifunctional material that can provide the same protection. Layers of cardboard or paper treated with natural wax can provide excellent protection. Packaging can be designed that combines several protective functions in one element. For example, the bottle cap can have a built-in security seal that shows if the product has been opened, without the need for an additional layer of plastic protection.

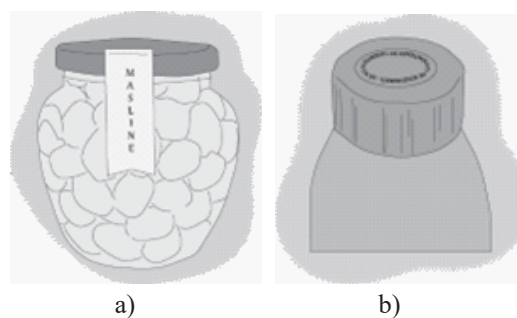


Figure 5 Sketch of the protective cap: a) Olives, b) Shampoo

A paper label can be placed on the jar of olives to indicate which packages have not been opened (Figure 5a)). Closures and labels can be easily separated from the basic packaging, which facilitates the recycling process. If it is about separating other materials such as plastic or metal, perforations or other mechanisms can be installed that could make it easier for consumers to separate different materials. Instead of standard metal or plastic caps, glass jar caps can be made from recycled plastic, metal, biodegradable caps made from materials like PLA (polylactic acid), cork, and more. PLA and cork caps provide good protection, and at the same time, they decompose quickly in the natural environment, reducing the ecological footprint.

Shampoo bottles sometimes contain a plastic film under the cap, which ensures that the contents do not spill (Figure 5 b)). It is better to use caps that have perforations that ensure the integrity of the product. The mentioned caps are more often used for medicines and are more expensive than classic caps. If shampoo bottles were to use the aforementioned caps, they could be designed for multiple uses. These solutions often include refill systems, where bottles and caps can be reused, reducing the need for new packaging.

It should be emphasized that the sustainability of packaging can be further increased if the use of traditional products for printing and gluing stamps, seals or closures is avoided when making packaging products. They can be replaced with environmentally friendly options such as water-based adhesives and plant-based inks that reduce toxicity and facilitate recycling. Instead of synthetic adhesives, those based on starch or other natural materials can be used.

4. Conclusion

This research clearly indicates the need to move from traditional materials and methods to innovative and environmentally friendly solutions that combine functionality and

environmental responsibility. By using biodegradable, compostable and recycled materials, and by reducing unnecessary layers of packaging, the ecological footprint can be significantly reduced. The most important aspects of this research are the reduction of plastic waste, more efficient use of resources and the reduction of CO₂ emissions, which directly contribute to the preservation of natural resources and the reduction of pollution.

The application of new technologies, such as smart seals, nano-coatings and QR codes, brings more sustainable solutions that improve the protective functions of packaging without an unnecessary increase in material. This enables the design of packaging that is lighter, easier to recycle and more economical to produce. The key challenge for the future of packaging will be further innovation in the direction of the circular economy, where every part of the packaging can be reused or recycled, thereby reducing waste and conserving resources. In the future, packaging will increasingly focus on minimalism and multifunctionality, with the integration of digital solutions that reduce the need for physical protection but increase security and product tracking. Advances in materials and technologies, along with the increasing environmental awareness of consumers, will drive the constant development towards packaging that is sustainable, functional and adapted to the demands of the global market and environment.

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