

SUSTAINABLE MATERIAL OPTIMIZATION FOR COST REDUCTION

Abstract

This chapter provides a thorough analysis of the sustainable material optimization strategies used by the pharmaceutical and cosmetic packaging sectors to cut costs. Despite notable advancements in the field of sustainable pharmaceuticals and cosmetics, the production of sustainable packaging in large quantities has proven to be difficult. It can be challenging to choose the best course of action among diverse supply-chain components located all over the world due to the complexity of environmental, economic, social, technological, and policy considerations, as well as differences in consumer behavior and corporate objectives. Additionally, the expense and effort involved in creating, evaluating, and validating alternative strategies deters empirical research into possible alternatives. One industry that is constantly growing worldwide is pharmaceutical and cosmetic packaging. By 2018, it is projected that the market will have grown to a value of \$78.79 billion. Success, safety, and sales all depend on packaging. Pharmaceutical packaging must meet the same standards for quick packing, protection, identification, product quality, patient comfort, display, and security as other packaged commodities. Pharmaceutical research and development advancements have always been reliant on packaging technology. High-quality packaging ensures that drugs maintain their integrity during transportation, storage, and delivery.

Keywords: Sustainable Material, cost reduction, pharmaceutical and cosmetic packaging.

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I. INTRODUCTION

Packaging is a term used to describe a method that keeps pharmaceutical and cosmetic products contained from the point of manufacture until they are used. Pharmaceutical packaging is used to supply solid and semisolid dosage forms, powders, poultices, blood and blood products, surgical instruments, life-saving medications, and nutraceuticals[1]. In essence, pharmaceutical packaging offers transportation convenience, drug safety, identity, and confinement. Packaging for pharmaceuticals must strike a balance among several intricate factors. Pharmaceutical packagers have moved on from relatively simple issues like creating attractive designs and interacting with customers to more urgent ones like combating counterfeiting, promoting patient compliance, guaranteeing drug integrity, and striking a balance between accessibility for the elderly and child resistance. A cosmetics product's overall appearance, in addition to its quality, is one of the most critical drivers of its market attractiveness[2].

Sustainability is becoming an essential necessity for human activity, making sustainable development a critical aim for human progress. Sustainable development aims to address social, economic, and environmental issues holistically and simultaneously throughout the development process [3]. Human wellness, the field of economics and ecological sustainability are the three primary components of sustainability. These three categories can be viewed as a means of promoting human well-being (i.e., equitable burden-sharing and social fairness) while also preserving the ecosystem's resilience. If the use of virgin resources is decreased and post-consumption products are recyclable or reusable from readily available materials, packaging materials are said to be sustainable. Material sustainability is governed by a multitude of factors ranging from economic to environmental, including expenses and consequences, the utility of aesthetic characteristics, production to end-of-life processing and its impacts on a local and global scale [4].

Sustainability is defined as the intersection of three important aspects, with examples of traits found at the intersection of any two sections.

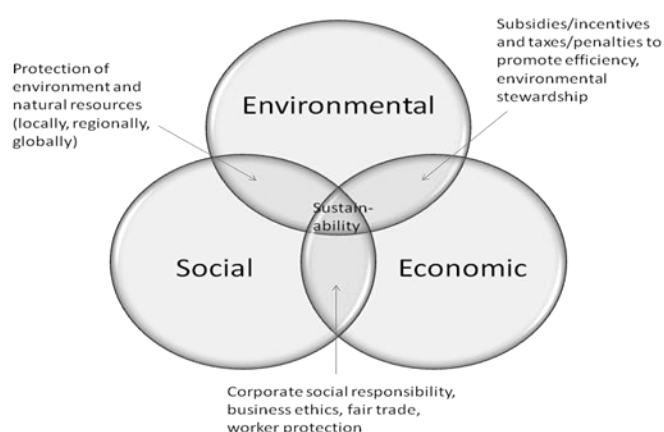
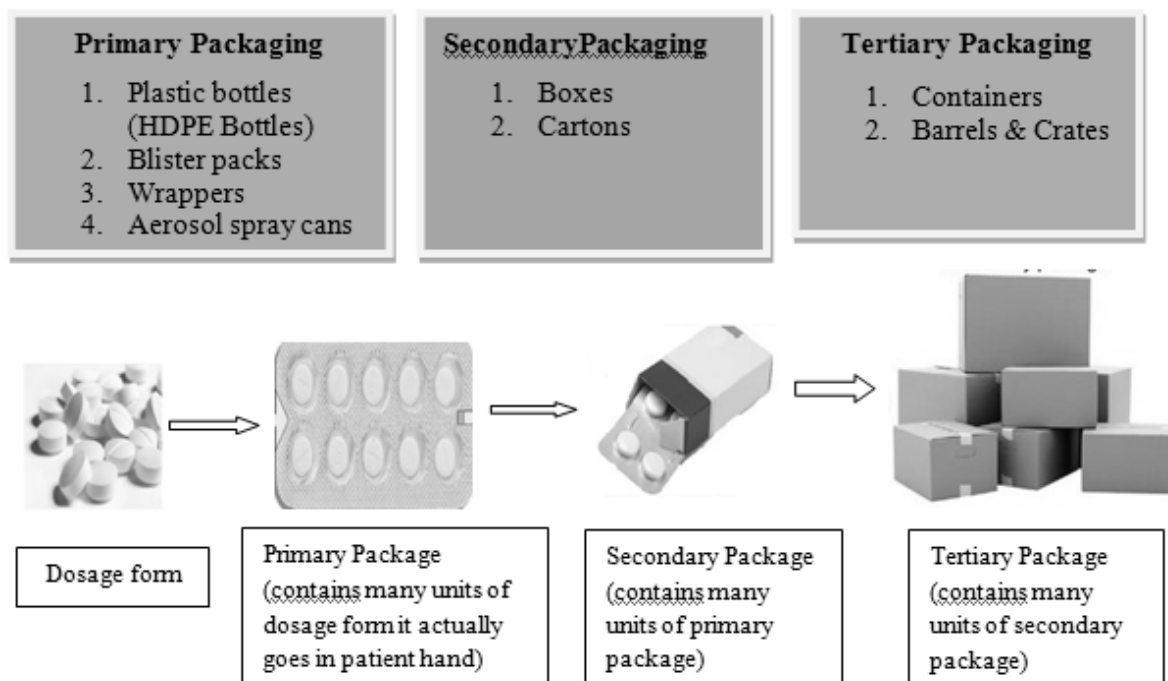


Figure 1

Sustainability indicators play a crucial role in measuring and improving sustainability initiatives. Indicators provide insight into a project's state, progress, challenges, and necessary steps to overcome obstacles. Sustainability indicators differ from those used to track

economic, social, and environmental progress. Indicators for a sustainable community highlight weak linkages between economy, environmental stewardship, and society, and prioritize solutions to solve these issues. Sustainability indicators take into account the interconnectedness of the three elements of sustainability and the different variables that impact them, unlike traditional indicators such as economic profitability, health, and water quality, which only evaluate one aspect of a society.

1. Packaging Materials in Pharmaceuticals and Cosmetics



2. Types of Packaging Materials

The quality of the packing serves as a link between the customer and the manufacturer, ensuring the customers' trust in their product[5]. The materials used for packing are a significant part of product display and preservation. When it comes to choosing packing materials, the type of product is also an important consideration. Various sectors (food, cosmetics, medicines, meat, etc.) use materials that are best suited to their products and services. As a result, there is a need for in-depth discussions of various materials[6].

- a. **Plastics:** Petroleum-based polymeric polymers are commonly employed as packaging materials. Polymers commonly found include PE, PP, PS and PET. The most common materials are plastic-based widely used packaging materials, accounting for approximately 26% of all polymer usage in packaging[7, 8]. Plastics are predicted to double in use over the next 20 years as they quickly replace traditional packaging materials. This is owing to intrinsic qualities like as good barrier properties, light weight, low cost, and so on. Despite the multiple advantages of plastic packing materials, the manufacture of petroleum-based materials emits CO₂ into the atmosphere. [9]. Mishandling of packaging plastics, as well as collection and recycling, will result in their ending up in landfills and bodies of water, polluting and

poisoning the land and oceans. Numerous sectors are looking into sustainable and ecologically favorable solutions. Recycling plastic materials with numerous layers is difficult and expensive, highlighting the critical need for sustainable and ecologically friendly alternatives[10].

Researchers are working to improve the physical and mechanical qualities of bio-based packaging materials by using biodegradable components. Biodegradable polymers can be both natural and manmade, although there is a distinction between biopolymers and biodegradable materials. All biopolymers are biodegradable, however not all biodegradable materials are biopolymers. Biopolymers can be manufactured from renewable resources, for example, starch, whereas biodegradable materials can disintegrate into inorganic chemicals, such as CO_2 , CH_4 , H_2O , or biomass[11, 12].

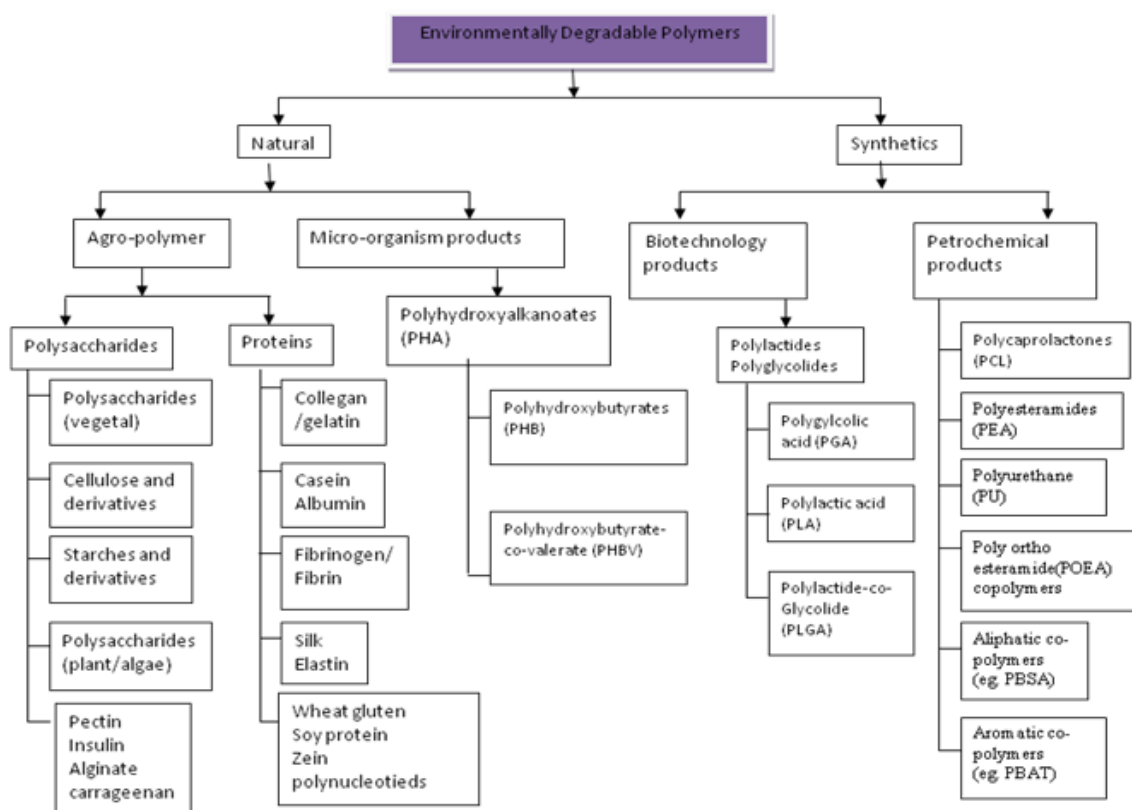


Figure 3

- b. Metals:** Most of the time, the packaging materials and their contents come into direct touch, particularly with can drinks. Metal-based packaging materials are a popular choice for various applications, manufacturers put consumer's health and safety first. To prevent dangerous interactions between the content and container, it's important to follow fundamental regulations and conduct regular risk assessments[13]. Several metals are commonly used for packaging. These include Al, Sn, Pb, and Cr, among others. Al is commonly used metal for packaging because of its cost-effectiveness, lightweight, flexibility, recyclable nature, and great heat resistance[14].

3. Applications of Packaging Materials

Packing enhance product quality and prevent contamination. The product will decide the sort of packing material to use. Similarly, the financial burden of creating packaging materials, as well as environmental concerns, are major decision-making variables. Various regulations govern the selection of materials for dry and moist packaging. The subheadings below cover the various applications of sustainable packaging materials[15].

Cosmetics

Plastic and glass are commonly used packaging materials for cosmetics business. This is for their direct engagement with the product. Paper or cardboard can be utilized, but must be encased with polymers or aluminium foil to prevent it from absorbing contents[16]. Packaging shields materials from contamination by microbes and light while also giving product information for marketing. When designing packaging materials for cosmetics, food, or medicines, it is critical to consider leaching, happens when certain chemicals move from the container material to the contents.

Priority should be given to carefully selecting and improving materials during manufacture. The necessary qualities necessitated the creation of biodegradable polymers applied to cosmetic packaging. The heart of this is the increased demand for new and superior materials, as well as sustainability of packaging materials. Glass is another essential material for cosmetic packaging. Glass is thought to be one of the oldest packing materials. Glass is opaque, nonporous, inert, non-biodegradable, and recyclable. Cosmetic glass containers vary in shape and size. Glass containers have multiple applications, including perfume jars, lip balms, eye shadow, and liquid foundation. It can be translucent or colored glass, depending on the content and attractiveness to clients[17].

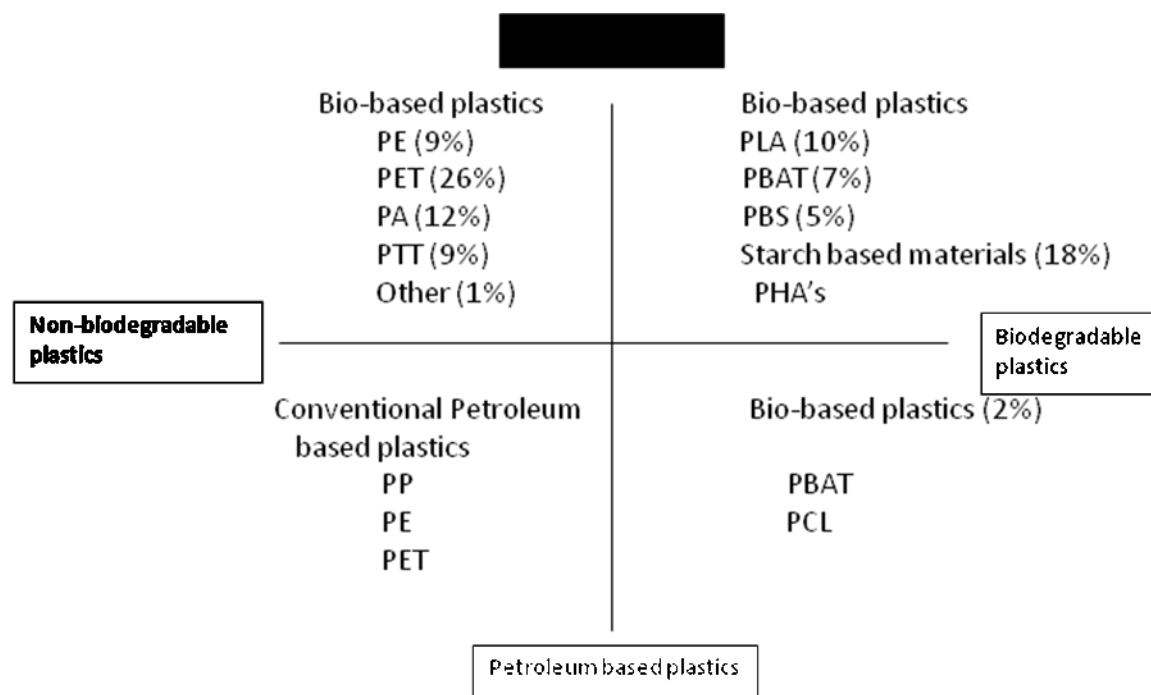
Pharmaceuticals

Pharmaceutical goods are chemical compounds, both manufactured and natural, that have therapeutic impacts on the body. These items are classified according to their medicinal effects, administration methods, and chemical features. The author also mentions that these include antipyretics, analgesics, antibiotics, antiseptics, stimulants, antimalarials, stabilizers, statins, contraceptives, and tranquilizers[18]. They can also target the cardiovascular, digestive, central nervous, endocrine, respiratory, reproductive, urinary, and immunological systems, as well as organs (skin, musculoskeletal, ear, eye, and nose). Thus, pharmaceutical packaging is critical in ensuring that the product satisfies the appropriate specifications. This might occur during manufacturing, transit, storage, sales, delivery, or usage. Pharmaceutical packaging materials safeguard medicines against deterioration, loss of potency, contamination, and undesired environmental conditions (light, moisture, and O₂) while also providing product and dose information. Pharmaceutical items are packed in plastics, paper, and glass using primary, secondary, and tertiary methods. The primary system directly contacts the drug, whereas the secondary system is located outside of the primary container. Pharmaceutical items are packed in plastics, paper, and glass using primary, secondary, and tertiary methods. The primary system directly contacts the drug, whereas the secondary system is located outside of the primary container [19].

4. Strategies to Enhance Sustainability in Packaging

High usage of virgin resources may cause their depletion. Another consequence of the depletion of virgin materials is a scarcity of raw materials for the creation of packaging materials. Exploiting raw resources (from extraction to refinement) for packaging causes global environmental challenges. To promote sustainability in packaging, it's important to recycle discarded materials into new products. Packaging materials include paper, plastic, metal, and glass [20]. The packaging industry's sustainability depends on various aspects, including raw material availability, recycling methods, renewable resource use, and efficient product packaging policies. Plastic packaging, manufactured from petroleum-based polymers including PE, PP, PS, and PET, has been in use for decades. These petroleum-based polymers are not biodegradable and have a recycling rate of less than 14%. Exploring ecologically friendly biodegradable polymers is crucial for the sustainability of plastic-based packaging products. Biodegradable polymers, including Proteins, polysaccharides, lipids, and vegetal sources (e.g., cellulose, starch, chitosan, maize zein, whey protein, waxes, collagen) have been widely researched[21]. These materials should be encouraged for packaging purposes. The government should adopt and implement policies promoting the utilization of recyclable and biodegradable materials. Likewise, packing material manufacturers should endeavour to make their products 100% recyclable.

Investigating the impact of biodegradable and non-biodegradable plastics on packaging.



Manufacturers of packaging materials (e.g. glass, metals, paper/paperboards) should prioritize environmental sustainability by using recyclable and reusable materials. Metals such as Al are 100% recyclable [22]. Recycled pulp is less water and energy-intensive than virgin pulp, with a lower environmental impact. Glass can be reused for several purposes, including fine aggregate in concrete and mortar. The % recyclability of packing materials is an excellent indicator of their sustainability. Package manufacturers emphasize the use of biodegradable and sustainable materials with high recycling rates[23].

5. Strategy to Reduce Cost of Packaging

- a. Enhancing Material Storage and Packaging Lines:** Is there a method to streamline your designs and speed up the packing process? If you'd like to improve your current operations, take these steps:
- Analyze existing inventory of product packing
 - Identify and organize comparable objects.
 - Identify and categorize seldom used packaging materials.
- b. Automation can Significantly Reduce Packing Time:** An automated packing line may benefit your company in a variety of ways:
- **Increased Output:** Automation accelerates the picking and packing process, increasing your company's profitability.
 - **Reduce your Environmental Impact:** Manual sealing causes a lot of garbage. A machine that is automated only consumes the precise material required.
 - **Reduce Workplace Injuries:** Minimizes chance of repetitive strain injuries, lowering absenteeism and occupational injury claims.
 - **Boost the Credibility of your Company:** Machinery provides accuracy, resulting in neatly wrapped and protected items. As a result, you can display a more appealing product to your consumers while also lowering the risk of harm.
- c. Use Smaller Boxes for Optimal Packaging** When you transport relatively little commodities in large boxes, you are missing out on a simple cost-cutting opportunity. Consider the following tactics to enhance packing and reduce delivery costs:
- Optimize packing space: Ship as many items in a single packaging box.
 - Diversify your packing materials: Instead of utilizing the same three box sizes, consider your typical shipment size and make sure adequate packaging that does not incur dimensional volume fees.
 - Use cushioned envelopes: Some of your items may be small enough to fit into big, use cushioned envelopes instead of tiny boxes.
 - Automation of operations: Technology can quickly identify the right box for each product depending on its size.
 - Negotiate shipping expenses: If you send a significant number of products frequently, contact your account manager to deal pricing. Remember, everything is negotiable. Before negotiating with your carrier, review your shipping data to gain a better understanding of your profile.
- d. Minimize Returns by Ensuring Proper Product Packaging and Transportation:** Poor load stability might also cause transportation damage. Product damage can occur if a transporter fails to correctly stack its products or piles the pallets are excessively high. Some causes, such as extended vibration, are difficult to prevent. In these circumstances, investing in long-lasting packaging, such as heavy-duty boxes or protective stuffing materials, is crucial. Poor load stability, while the carrier's responsibility, is more difficult to establish. A recommended technique is to employ different carriers and identify which carrier handles the most damaged and returned

merchandise. If you find such a carrier discuss with your account manager or switch to a different, more dependable carrier.

- e. **Optimize Packaging through Redesign:** Cutting unit costs while sacrificing product safety is never a smart idea. However, product packaging might be expensive for reasons of design rather than substance. Consider revamping your present packaging to be more space-efficient. Furthermore, you may avoid costly add-ons like as labels by printing designs or right into the box.

REFERENCES

- [1] Otto, S.; Strenger, M.; Maier-Nöth, A.; Schmid, M. Food packaging and sustainability–Consumer perception vs. correlated scientific facts: A review. *J. Clean. Prod.* 2021, 298, 126733.
- [2] Martin, J.; Henrichs, T.; Francis, C.; Hoogeveen, Y.; Kazmierczyk, P.; Pignatelli, R.; Speck, S. Environmental Indicator Report 2012: Ecosystem Resilience and Resource Efficiency in a Green Economy in Europe; European Environment Agency: Copenhagen, Denmark, 2012.
- [3] Reichert, C.L.; Bugnicourt, E.; Coltelli, M.B.; Cinelli, P.; Lazzeri, A.; Canesi, I.; Braca, F.; Martínez, B.M.; Alonso, R.; Agosti-nis, L.; et al. Bio-based packaging: Materials, modifications, industrial applications and sustainability. *Polymers* 2020, 12, 1558.
- [4] Hamouda, T. Biopolymers and Biocomposites from Agro-Waste for Packaging Applications; Saba, N., Jawaid, M., Thariq, M., Eds.; Woodhead Publishing: Sawston, UK, 2021; pp. 113–126.
- [5] Malathi, A.; Santhosh, K.; Nidoni, U. Recent trends of biodegradable polymer: Biodegradable films for food packaging and application of nanotechnology in biodegradable food packaging. *Curr. Trends Technol. Sci.* 2014, 3, 73–79.
- [6] Gurunathan, T.; Mohanty, S.; Nayak, S.K. A review of the recent developments in biocomposites based on natural fibres and their application perspectives. *Compo. Part A Appl. Sci. Manufac.* 2015, 77, 1–25.
- [7] Chinaglia, S.; Tosin, M.; Degli-Innocenti, F. Biodegradation rate of biodegradable plastics at molecular level. *Polym. Degrad. Stab.* 2018, 147, 237–244.
- [8] Cela, E.; Kaneko, S. Determining the effectiveness of the Danish packaging tax policy: The case of paper and paperboard packaging imports. *Resour. Conserv. Recycl.* 2011, 55, 836–841.
- [9] Chen, W.; Wang, X.; Tao, Q.; Wang, J.; Zheng, Z.; Wang, X. Lotus-like paper/paperboard packaging prepared with nano-modified overprint varnish. *Appl. Sur. Sci.* 2013, 266, 319–325.
- [10] Asgher, M.; Qamar, S.A.; Bilal, M.; Iqbal, H.M.N. Bio-based active food packaging materials: Sustainable alternative to conventional petrochemical-based packaging materials. *Food Res. Int.* 2020, 137, 109625.
- [11] Muller, J.; González-Martínez, C.; Chiralt, A. Combination of poly (lactic) acid and starch for biodegradable food packaging. *Materials* 2017, 10, 952.
- [12] Rhim, J.W.; Lee, J.H.; Hong, S.I. Increase in water resistance of paperboard by coating with poly (lactide). *Pack. Technol. Sci. Int. J.* 2007, 20, 393–402.
- [13] Lahtinen, K.; Maydannik, P.; Johansson, P.; Kääriäinen, T.; Cameron, D.C.; Kuusipalo, J. Utilisation of continuous atomic layer deposition process for barrier enhancement of extrusion-coated paper. *J. Surf. Coat. Technol.* 2011, 205, 3916–3922.
- [14] Coles, R. Paper and paperboard innovations and developments for the packaging of food, beverages and other fast-moving consumer goods. In *Trends in Packaging of Food, Beverages and Other Fast-Moving Consumer Goods (FMCG)*; Farmer, N., Ed.; Woodhead Publishing: Sawston, UK, 2013; pp. 187–220.
- [15] Bruton, G.; Sutter, C.; Lenz, A.-K. Economic inequality - Is entrepreneurship the cause or the solution? A review and research agenda for emerging economies *Journal of Business Venturing* 2021, 36, 106095.
- [16] Gao, P.; Lei, T.; Jia L.; Yury, B.; Zhang, Z.; Du., Y.; Fang, Y.; and Xing, B., Bioaccessible trace metals in lip cosmetics and their health risks to female consumers *Environmental Pollution* 2018, 238, 554–561.
- [17] Bilal, M.; Mehmood, S.; Iqbal H.M.N., The Beast of Beauty: Environmental and Health Concerns of Toxic Compounds in Cosmetics *Cosmetics* 2020, 7, 13.
- [18] Teo, T.L.L.; Coleman, H.M.; Khan S.J. Chemical contaminants in swimming pools: Occurrence, implications and control *Environment International* 2015, 76, 16–31.
- [19] Giokas, D.L.; Salvador, A.; Chisvert, A. UV filters: From sunscreens to human body and the environment *Trends in Analytical Chemistry* 2007, 26(5), 360–374.
- [20] Sanchez-Quilez, D.; Tovar-Sanchez, A. Are sunscreens a new environmental risk associated with coastal tourism *Environment International* 2017, 83, 158–150.

- [21] Kim, Y.; Choi, S.M. Antecedents of Green Purchase Behavior: an Examination of Collectivism, Environmental Concern, and Pce. In NA - Advances in Consumer Research Volume 32; Menon, G., Rao, A.R. , Eds.; Association for Consumer Research, 2005; 592–599.
- [22] Chang, T.-W. Double-edged sword effect of packaging: Antecedents and consumer consequences of a company's green packaging design. *Journal of Cleaner Production* 2023, 406, 137037.
- [23] Bluher, T.; Riedelsheimer, T.; Gogineni, D.; Klemichen, A.; Stark, R. Systematic Literature Review—Effects of PSS on Sustainability Based on Use Case Assessments. *Sustainability* 2020, 12, 6989.