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SUSTAINABLE TAKEAWAY FOOD PACKAGING: TO MINIMIZE ENVIRONMENTAL PROBLEMS OF ONLINE FOOD DELIVERY

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Abstract: Takeaway food consumption is on the rise all across the world. Single-use takeaway food containers generate a high amount of waste and harm the environment because their recycling rate is very low. As a result, it is necessary to determine the best possible alternatives and improvements to minimize the environmental effects of takeaway food containers. This research objective is to reduce environmental issues caused by takeaway food containers and to identify sustainable materials based on three criteria: environmental impact, health aspect, and sustainability criteria. Because reusable plastic takeaway food packaging may be reused multiple times, it beats single-use packaging in terms of environmental performance. Extruded polystyrene (XPS) and reusable polypropylene are better alternatives to single-use polystyrene and aluminum packaging, which have several negative health effects. Bamboo and bagasse-based takeaways are environmentally friendly alternatives to plastic. They have natural and renewable resources, and they have lower environmental consequences. Bagasse packaging is also less expensive than other types of plastic packaging.

Keywords **– Online food delivery; Sustainability; Environmental impact; Plastic pollution; Health Aspect**

1. INTRODUCTION

The online food delivery platform is rapidly expanding, providing many people with new opportunities, but it also creates plastic waste and harms the environment. The major source of environmental damage is single-use takeaway food packaging. The main issue with single-use takeaway food containers is that they ended in landfills, incineration, or marine litter, causing environmental pollution. Poor consumer attitude, poor waste management (including waste handling, collection, and treatment) in some countries, as well as poor design, and a lack of clear guidance to consumers about appropriate disposal methods contribute to the low recyclability potential of such types of packaging. An analysis of the best existing alternatives and innovations must be identified to reduce the environmental issue of takeaway food containers. This study mainly aims is to reduce pollution generated by takeaway food containers and to identify sustainable materials based on three criteria: environmental impact, health considerations, and sustainability.

2. OVERVIEW OF THE SUSTAINABLE PACKAGING

Sustainable packaging is defined as the procurement, development, and usage of packaging solutions with a low environmental impact. Simply sustainable packaging is environmentally benign and does not contribute to additional natural resource depletion.

Sustainable packaging is essential because it decreases the product's environmental effect at every step of its life cycle. The sustainable packaging definition given by Sustainable Packaging Alliance is given in Table 1.

Table 1: Sustainable packaging definition by Sustainable Packaging Alliance

Concept	Concept Definition	Sustainable packaging Indicator
Effective	Increase the economic and social worth of your business	Reduce product waste Functionality prevents Reduce over packaging Reduce business cost
Efficient	Optimized use of materials and energy	Improved water, materials, and energy efficiency Improve the efficiency of logistic Reduce waste to landfill
Cyclic	Packaging	Returnable Reusable Recyclable Biodegradable
Clean	Non-risky for humans and the ecosystem	Reduce toxicity, airborne, waterborne, greenhouse gas emission

Source: Sustainable packaging definition by Sustainable Packaging Alliance[1]

3. METHODOLOGY

This study is based on the review and analysis of prior studies of life cycle assessments (LCA) of different materials. This study compares different Single used plastic takeaway packaging and other single-use materials for takeaway. It is also compared with reusable takeaway packaging. This study provides a general overview of LCA for various packaging materials. The research is organized into three criteria such as environmental impact, health aspect, and sustainability. It is necessary to note that the depth of investigation varies. some offer more precise information about the outcomes (for example, specific percentages), while others contain more general remarks (for example, ranking of compared options).

4. MATERIAL SELECTION

This study is subdivided into three sections: environmental concerns, health aspects, and sustainability.

4.1: Environmental Concern:

This section describes the main findings and outcomes of the LCA study. This study is based on the review and analysis of prior studies of life cycle assessments (LCA) of different materials [2].

Food boxes are made from Polystyrene, Polylactic acid (corn), and Polylactic acid (cassava starch). [3]

The three packaging materials were analyzed such as polystyrene (PS) obtained from crude oil, polylactic acid (PLA) produced from corn, and polylactic acid (PLA) produced from cassava starch blend. When power is modeled using the Thai electrical grid mix, Thai coal grid mix, or Thai gas, the study shows that PLA boxes have significantly greater environmental impacts than PS boxes[3]. In addition to global warming potential, the authors considered acidification and photochemical ozone generation. In all three impact categories, the PS boxes outperformed the PLA boxes. The writers neglected to mention waste management. Because in Thailand landfills mainly control waste management and it would result in much worse results for the PLA boxes. PLA waste results in methane and CO_2 emissions when it is transferred to landfills. The main contributors to PLA's global warming potential are emissions from land-use change from corn and cassava [3].

Food box made from Bagasse and Polystyrene. [4]

This study compares food boxes made from two different materials: Bagasse and Polystyrene. It appears that the bagasse lunch boxes have higher environmental burdens than Polystyrene (PS) boxes if considering only cradle to gate and transport to the customer. The major reason that makes the environmental issue of bagasse boxes larger than PS foam boxes is the weight of the bagasse lunch box, which is five times of the PS foam lunch box. The second reason is the use of chemicals in the bleaching process. Bleached bagasse pulp creates a higher impact. In all effect areas, bagasse food boxes with the recycling option had lower impacts than PS foam food boxes, according to the examination of the whole life cycle of both lunch boxes. There are certain important environmental issues where a bagasse food box would be preferable to PS foam, such as long-term landfilling, marine plastic pollution, and plastic contamination in the food chain, which cannot be accounted for in the LCA research [4].

Takeaway food containers: single-use plastic, reusable plastic, and aluminum. [5]

This study performs comparative LCA for four types of food takeaway containers: Aluminium take-away container, extruded polystyrene (XPS) container, single-use polypropylene (PP) container, and reusable polypropylene food Tupperware. The XPS container has the lowest impact and is the best material among the three single-use takeaway food packaging options. To have the same impact as the XPS container, reusable PP Tupperware food savers must be reused 16 - 208 times (depending on the impact category). The usage of aluminum containers results in the greatest element depletion, ozone layer consequences, human toxicity, and marine and terrestrial ecotoxicity risks. For the remaining seven effect categories studied, the single-use PP container is the poorest option: abiotic depletion of petroleum resources, acidification, eutrophication, freshwater aquatic ecotoxicity, climate change, photochemical ozone creation, and primary energy demand. Other environmental repercussions of XPS containers (such as littering and harmful effects on marine organisms) are also discussed in the paper, which is typically not considered in LCA. XPS containers are readily blown away because of their lightness, leading to litter. However, these effects could be mitigated by the development of an XPS recycling system, which is technically feasible but comes at a great cost, therefore it is not prioritized for development [5].

Reusable containers are made of plastics and glass. [6]

The study looks at two different types of reusable food containers: glass and polypropylene (Reusable). Glass food savers have a higher environmental impact than reusable plastic containers, ranging from 12 to 64 %, and should be used up to 3.5 times more to match the environmental impact of plastic containers [6]. The use stage is the most significant contributor to the environmental impact of reusable

containers (cleaning them after each use). The biggest promise for avoiding environmental implications is improved technology for cleaning reusable containers to reduce the amount of water, power, and detergents consumed [6].

Some other materials excluded from the Life Cycle assessment but included in the study are kraft paper and bamboo takeaway containers. Kraft paper is an eco-friendly material. The manufacturing of kraft paper is quite simple. Few chemicals are used and they are generally recovered, reused, and recycled. Kraft paper is naturally biodegradable. It will break down into cellulose fibers within several weeks. Bamboo is renewable and naturally available material. Bamboo is biodegradable and 100% compostable within 2–6 months, depending on your specific product and composting conditions.

4.2: Health Aspect and Sustainability Concerns

Polystyrene contains both styrene and benzene, two hazardous chemical molecules linked to human health risks[7]. The toxin styrene is released when polystyrene food packaging comes into contact with hot meals or drinks, alcohol, oils, or acidic foods. According to studies, styrene is neurotoxic, cytogenetic, carcinogenic, and alters menstrual cycles[8]. Although Styrofoam containers have the lowest carbon footprint (50% lower than aluminum containers and three times lower than plastic containers), they are not classified as sustainable packaging because Styrofoam is rarely recycled and is usually intended for the landfill, according to the University of Manchester researchers [9].

PLA is a non-toxic, compostable bio-based polymer made from starch or sugar that has great mechanical strength and plasticity. It has been approved by the Food and Drug Administration (FDA) for use in food and beverage packaging as GRAS (Generally Recognized as Safe)[10]. PLA plastic is produced from plants like corn rather than hazardous resources like crude oil, which are used in most other plastics. PLA is, therefore, for the most part, a sustainable material, as plants are generally renewable [11].

Bagasse is a plant-based, natural, biodegradable food packaging material. Bagasse is non-toxic to both humans and animals [12]. Some bagasse products may include PFAS chemicals, which pose a health risk. These are a dangerous collection of compounds that give materials grease and waterproof qualities. Although they are prohibited in many countries, they are nonetheless widely used. Thankfully, worldwide biodegradable certification rules prohibit these chemicals. While sugar cane is cultivated and used for a variety of sugar products, the residual harvest waste of bagasse is being used to help create a circular economy [13]. Bagasse is elegantly compostable due to its plant waste status, and in the correct conditions, it can biodegrade in 30 to 90 days and does not release hazardous residue, and even generate nutrient-rich compost. As a result, it's suitable for all levels of packing and sustainable material [13].

The closed-cell construction of XPS (Extruded Polystyrene) makes it superior to EPS (Expanded Polystyrene), but it is also more expensive [14]. Food-grade XPS material is denser than EPS material used in food packaging as meat trays [15]. XPS (Extruded polystyrene) is an environmentally friendly material. XPS is 98% air and contains no toxic compounds. It is also completely recyclable [16].
Consumption of aluminum-packaged food raises the risk of health problems. Aluminum substances in high concentrations can injure the kidneys, liver, and joints, as well as cause neurotoxic developmental issues [17]. It is not sustainable because it hurts the environment and health. Containers made of aluminum are likewise non-recyclable.

Because no harmful chemicals are utilized in the manufacturing of glass, it does not absorb odors or flavors, nor does it leach dangerous compounds into the food or beverage. It's completely natural, as it's created entirely of organic materials (sand, soda, and limestone) [18]. Glass is a long-lasting, fully recyclable material that has numerous environmental benefits, including helping to mitigate climate change and conserving natural resources [19].

Polypropylene (PP) is the safest and most durable heat-resistant material of all polymers. When exposed to hot water, it does not leak due to its high heat resistance Perfect for storing food and drinks. It can be used with hot beverages and is safe to reuse [20]. Polypropylene is FDA approved for use in food contact. Polypropylene is a useful material that may be reused multiple times and is the safest polymer available [21].

Kraft paper has natural and renewable resources and sustainable materials. Kraft paper is a food-grade packaging material created from wood pulp or agro-based resources that pose no risk of contamination, making it completely safe for consumption.

Food containers made of bamboo are safer than those made of plastic. Although bamboo items contain chemicals such as glue, they are not as harmful as the toxins found in plastic. Bamboo is a rapidly growing plant sustainable material.

5. COST ANALYSIS

The Cost of different materials is based on the current prices available on different platforms such as IndiaMart, Amazon, Flipkart, etc.

The Minimum and Maximum price ranges are given in Table 2.

Table 2: Cost of several takeaway food packaging

Materials	Cost (Rs / Piece)		
	250 ml	500 ml	1000 ml
Polystyrene	7 - 10	12 -14	15 - 18
Polylactic Acid (PLA)	-	11.55 -12	12 -15
Polypropylene	3 - 4	4.5 - 5	9.55 - 12
Aluminum	0.85 - 1	1 – 1.25	2.45 - 3
Kraft paper	10 - 12	14 - 15	18 - 20
Bagasse	5 – 5.20	9 – 10.44	10 – 12.62
Bamboo	-	10 - 12	15 - 20
Reusable Glass	165 - 200	275 -345	530 - 625
Reusable Polypropylene	150 - 200	300- 335	515 - 600

6. SUMMARY OF THE RESULT

The scope of this study was to look into the issue of plastic takeaway food packaging in online food delivery and to find sustainable takeaway materials.

As per the research, Aluminum packaging is the least expensive option but it harms the environment and health also it is not sustainable material.

Polystyrene packaging likewise fails to meet all three requirements for material selection. In comparison to polystyrene, PLA packaging is healthier and more sustainable.

Extruded polystyrene (XPS) is an environmentally and health-friendly takeout packaging material, but it is not a sustainable material because it is currently not recyclable.

Polypropylene is the safest plastic packaging; however, it harms the environment and is not sustainable.

Kraft paper packaging meets all three material selection criteria. Environmentally friendly alternatives to plastic include bamboo and bagasse-based takeout. They have natural and renewable resources, as well as fewer negative environmental effects. Bagasse packaging is also less expensive than other plastic packaging materials.

Single-use products have a high impact on the environment than reusable packaging. Reusable glass and reusable polypropylene are the best in all three categories, although they are substantially more expensive.

The environmental burden of additional logistics, transportation, and washing cycles for reusable packaging products does not reverse their environmental superiority over single-use products.

7. CONCLUSION

The online food delivery sector is rapidly expanding, resulting in a rise in plastic pollution from takeaway food packaging. Sustainable takeaway food packaging is one solution to the problem that online food delivery firms have created. The product used in this study were chosen based on three criteria: environmental impact, health aspect, and sustainability. According to the studies analyzed, when reusable plastic takeaway food packaging is reused a significant number of times, it exceeds single-use packaging in terms of overall environmental performance. When compared to Polylactic acid (PLA) boxes, polystyrene boxes perform better in terms of global warming potential, acidification, and photochemical ozone production. One of the finest alternatives to plastic packaging is kraft paper packaging. It is environmentally friendly, safe, and sustainable. But kraft paper is more expensive than other materials Bagasse-based takeaway food packaging is a new trend toward a sustainable green alternative. Bamboo and bagasse-based takeaways are environmentally friendly alternatives to plastic. They have natural and renewable resources, and they have lower environmental consequences. Bagasse packaging is also less expensive than other types of plastic packaging.

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