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Edible plastics: feasibility and challenges of solving environmental pollution problems

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Abstract: Nowadays, plastic pollution has become a major threat to the marine environment. With the increasing environmental awareness and the demand for sustainable alternatives, edible plastics provide a promising biodegradable alternative to traditional plastic packaging. The use of edible plastics as a solution to the problem of marine plastic pollution also faces many opportunities and challenges. This paper proposes strategic recommendations for a wider range of sustainable materials by providing practical solutions to integrate edible plastics into the mainstream packaging market, ultimately reducing the impact of plastics on the marine environment.

Plastic pollution is a major threat to the marine environment. Plastic pollution is increasingly becoming a global concern, with adverse effects on marine life, habitats, and human health. More than 10 million tons of plastic enter the ocean each year, which has serious impacts on marine life and ecosystems, and chemical additives in plastics also pose a potential threat to human health (Carney Almroth & Eggert, 2019) *[1]*. As people's environmental awareness increases, the demand for sustainable products is also growing. The persistence of plastics in the environment, their harmful effects on ecosystems, and the limited effectiveness of current waste management systems require innovative solutions. Goldberg mentioned that the accumulation of plastic waste affects the gas exchange between seawater and affects the normal ecological environment of marine life. Traditional plastics are ubiquitous in packaging, especially disposable products, due to their light weight and durability. Unfortunately, these plastics degrade slowly and cause long-term damage to the environment. Microplastics, i.e. small fragments resulting from the breakdown of larger plastic items, have now been detected in food and water sources (Nikiema et al., 2020, as cited in Nikiema and Asiedu, 2022) *[2]*, raising serious concerns about human exposure to microplastics. Finally, this paper will discuss the feasibility of using edible plastics as an innovative solution to reduce marine pollution and its wider environmental impacts.

1. Why marine plastic pollution persists

Marine plastic pollution is a growing problem, and multiple factors are contributing to this environmental problem. To solve this problem, it is necessary to understand its root causes, which come from both human behavior and the inherent properties of traditional plastics.

One of the main reasons is the widespread use of single-use plastics, which are cheap, lightweight

and convenient for consumers. However, these characteristics also make plastics difficult to manage once they enter the waste stream. Single-use plastics are often mishandled, resulting in large accumulations in oceans and coastlines. Plastic enters the ocean through land and sea, each accounting for 80% and 20% of total garbage, respectively. Litter enters the marine environment mainly through land and rivers, with an estimated 1.15 to 2.41 million tons of plastic entering the ocean from rivers alone each year.

The key problem with plastics is their non-biodegradability. Traditional plastics, such as polyethylene and polystyrene, are made from synthetic polymers that do not break down naturally. Although plastics break down into smaller pieces over time, they do not fully biodegrade, resulting in long-term accumulation in the marine environment, thereby harming marine ecosystems. Some plastics, such as microplastics, are small enough to be ingested by marine animals, causing harm to organisms and ecosystems. Microplastics also affect human health. The WHO report on microplastics in drinking water (plastic particles smaller than 5 mm are called microplastics) indicates that the presence of microplastics has been detected in drinking water and the wider environment, and also indicates that microplastics pose a long-term risk to human health as they have been detected in human food and drinking water (Nikiema et al., 2020, as cited in Nikiema and Asiedu, 2022) *[2]*.

Another major factor contributing to this problem is the lack of effective waste management systems, which are lacking in many parts of the world, especially in developing countries, which has greatly exacerbated marine plastic pollution. Tibbetts (2015) *[3]* mentioned that the generation of marine debris is closely related to the geographical location of the country. Several of the top 20 countries are developing countries with relatively long coastlines. The main influencing factor is the lack of urban service management for rapid development. Many regions lack the infrastructure to properly collect, process and dispose of plastic waste, which leads to plastic waste flowing into rivers and eventually into the ocean. Even in developed countries, the recycling rate of plastics is still very low, and only a small part of plastic waste is effectively recycled.

Economic factors are also one of the reasons why plastic pollution persists. Traditional plastics are cheap to produce and are the preferred material for many industries, especially food packaging. In contrast, edible plastics are currently more expensive to manufacture due to the high cost of raw materials and production processes. This cost difference makes it difficult for edible plastics to compete with traditional plastics in the market. Edible plastics are biodegradable and environmentally friendly. The use of many biopolymer materials can be very effective in reducing global plastic debris.

Finally, consumers lack awareness and education about the impact of plastic waste on the environment. Although public awareness of plastic pollution has increased in recent years, many consumers are still unaware of the potential benefits of switching to biodegradable alternatives such as edible plastics. This lack of awareness is exacerbated by concerns about the safety, durability and functionality of edible plastics. At the same time, consumers' excessive consumption patterns of plastic products generate a large amount of waste.

2. Advantages of edible plastics

The main problem with marine plastic pollution is the staggering amount of trash that enters the ocean. One of the biggest challenges in addressing plastic pollution is the lack of viable alternatives. While recycling programs already exist, they are often insufficient to handle the large amounts of plastic waste generated globally. In addition, many plastics cannot be recycled due to pollution or the cost of the recycling process.

Compared to edible plastics, traditional plastics have a long lifespan, which means that these materials can remain in the environment for hundreds of years. Traditional plastics enter deeper marine environments, where they degrade more slowly due to environmental factors such as temperature and oxygen, causing long-term damage. Marine species, including fish, seabirds, and

mammals, often mistakenly ingest plastic particles, leading to starvation, injury, or death. Edible plastics offer a potential solution to the specific problem of marine plastic pollution. When edible plastics are used for packaging or food containers, the risk of environmental pollution is effectively reduced. Despite increased awareness of these issues, the consumption of disposable plastics continues to rise due to convenience and cost factors.

Edible plastics can be made from natural renewable resources, such as starch, protein, lipids, and cellulose, which are abundant and biodegradable, with low environmental impact, in stark contrast to traditional plastic raw materials. The production of edible plastics can promote a sustainable manufacturing industry and reduce dependence on non-renewable resources. At the same time, edible plastics are designed to meet food safety standards and the packaging itself has potential health benefits. The development of edible plastics can provide consumers with healthier and more environmentally friendly alternatives.

Based on the above analysis, edible plastics made from biodegradable and renewable resources have become a potential solution to reduce the harmful effects of disposable plastics. Edible plastics are biodegradable and, in some cases, consumable, making them an innovative alternative to traditional plastics. Companies such as Notpla and Evoware are at the forefront of this innovation, using materials such as seaweed and other natural resources to create sustainable packaging solutions. However, despite the bright prospects of edible plastics, they face significant challenges in production scalability, consumer acceptance, and regulatory frameworks.

Therefore, edible plastics have the potential to provide a sustainable solution to one of the most pressing environmental issues of our time - marine plastic pollution. The emergence of edible plastics provides an innovative way to mitigate these risks because it provides a biodegradable alternative to traditional plastics. Edible materials are biodegradable and environmentally friendly, and the use of many biopolymer materials can be very effective in reducing global plastic debris.

3. Potential and Challenges of Edible Plastics

In a global context, consumer behavior is increasingly influenced by environmental issues, and many consumers are now looking for sustainable alternatives to plastics, and edible plastics provide an opportunity to meet this demand. Although edible plastics are a relatively new concept, there is growing interest in their potential to reduce plastic pollution. A comprehensive analysis of the challenges and opportunities associated with edible plastics, while focusing on stakeholders' attitudes toward edible plastics, can provide an important reference for future research in this field.

Edible plastics offer a potential solution to marine plastic pollution, but they face several major challenges. First, the current cost of producing edible plastics is much higher than traditional plastics (Nikiema and Asiedu, 2022) *[2]*. This is mainly due to the use of natural, biodegradable materials, which are more expensive to procure and process. Second, edible plastics are generally less durable than traditional plastics, which limits their use in certain applications. On the other hand, edible plastics need to maintain their strength and integrity during production, transportation, and storage, while also being able to degrade or dissolve after being discarded or eaten. This balancing act poses significant technical challenges.

At the same time, consumer acceptance and consumption patterns remain a major obstacle. Many consumers are not aware of edible plastics or are reluctant to accept new products due to concerns about safety, functionality, and price. Overcoming these challenges will require significant efforts in research and development, as well as public education campaigns to raise awareness of the benefits of edible plastics.

Younger consumers are generally environmentally conscious and recognize the environmental benefits of edible packaging. In comparison, consumers over 50 years old are more skeptical of edible plastics and believe that changing this dilemma is not a matter of personal behavior. Consumers pay

more attention to the durability and safety of products than environmental benefits. Consumers need to believe that the performance of edible plastics is comparable to that of traditional plastics to increase acceptance and usage among the general public and expand the consumer market.

In addition, the role of government policies, community actions and environmental organizations in promoting sustainable alternatives cannot be ignored. Policymakers play a vital role in shaping the biodegradable packaging market by enacting regulations that limit the use of disposable plastics and encourage the adoption of environmentally friendly materials. The enactment of laws banning the use of disposable plastics and government encouragement of the use of biodegradable packaging such as edible plastics are more conducive to improving the transformation of consumer habits and the worsening of plastic pollution. Most current research focuses on technological innovation; at the same time, this study provides practical solutions for companies, policymakers and consumers. By assessing the feasibility of edible plastics, it will help to continue efforts to reduce marine plastic pollution and move towards a more sustainable future.

Finally, since edible plastics are designed for consumption, they must comply with national food safety regulations to ensure that they are non-toxic and safe to eat. The regulatory framework for edible plastics is still in its early stages and governments need time to develop clear guidelines and standards. In addition, since different countries have different safety and labeling requirements, there may be challenges in approving the use of edible plastics for food packaging.

4. Recommendations for the promotion of edible plastics

To address the challenges facing edible plastics, a multi-pronged approach is needed. The first and most important solution is to invest in technological innovation. By improving the production process of edible plastics, manufacturers can reduce costs and focus on improving the durability and flexibility of edible plastics while ensuring that they are biodegradable and safe to eat. New materials such as seaweed-derived polymers can provide sustainable alternatives to current edible plastics. For example, advances in materials science, Wang et al. (2021)*[4]*studied degradable polymers in seawater through innovative designs. This research is discussed as having the potential to replace commodity polymers, which, although challenging, may play an important role in solving the plastic waste problem.

Government policies and regulations will also play a key role in promoting the adoption of edible plastics. Governments can support the edible plastics industry by implementing policies that encourage the use of biodegradable materials, including providing research grants, subsidies and tax incentives to companies engaged in edible plastic technology research, and establishing a favorable regulatory framework to promote the approval and use of edible plastics in food packaging, helping the market shift to more environmentally friendly solutions. In addition, stricter regulation of single-use plastics, coupled with clear standards for the use and disposal of biodegradable materials, could create a more favorable market environment for edible plastics. The EU (2015) *[3]* directive requiring consumers to be charged for plastic bags after December 2018 has eliminated consumer ignorance about plastic pollution. Policies that promote composting and other forms of sustainable waste management are also necessary to ensure that edible plastics degrade as expected.

Consumer education and awareness campaigns are another important part of the solution. Many consumers are unfamiliar with edible plastics or do not fully understand their environmental benefits. Public awareness campaigns that highlight the benefits of edible plastics, such as their ability to reduce marine plastic pollution, can help change consumer perceptions and encourage more people to choose these sustainable alternatives. In addition to general awareness campaigns, companies should also clearly label their products to indicate that they are biodegradable or edible, which will help consumers make informed choices.

Collaboration between companies and environmental organizations can also help promote edible

plastics. By working with environmental organizations, companies can leverage the expertise and advocacy power of these organizations to raise awareness of the benefits of edible plastics. These partnerships can also help drive policy changes that support sustainable packaging. For example, environmental groups could work with businesses to lobby governments to introduce regulations that favor biodegradable materials or promote public education campaigns about plastic pollution.

Another important solution is to develop waste management infrastructure that supports the disposal of biodegradable materials. In areas where composting facilities are available, edible plastics can break down quickly and safely, but in areas without such infrastructure, these materials may end up in landfills, undermining their environmental benefits. Governments and private companies should invest in expanding composting facilities and other forms of sustainable waste management to ensure that biodegradable materials such as edible plastics can be properly disposed of.

Finally, consumer incentives can help encourage the use of edible plastics. Governments and businesses can work together to develop programs that reward consumers for choosing sustainable packaging. For example, retailers could offer discounts to customers who purchase products with edible packaging, or governments could provide rebates to consumers who choose biodegradable materials. These incentives would help offset the high cost of edible plastics and make them more attractive to price-sensitive consumers.

5. Conclusion

In summary, edible plastics are a promising solution to the problem of marine plastic pollution, providing a biodegradable and environmentally friendly alternative to traditional plastics. By providing a biodegradable, safe and sustainable alternative to traditional plastics, edible plastics have the potential to revolutionize the packaging industry and reduce the environmental impact of single-use plastics. However, significant challenges remain, including high production costs, durability issues, consumer skepticism and government regulation. Addressing these challenges requires a combination of technological innovation, government policy support and consumer education. Environmental organizations play a vital role in advocating for sustainable materials, and governments also need to introduce stronger regulations to promote the use of biodegradable materials. At the same time, companies must continue to invest in research and development to improve the performance and cost-effectiveness of edible plastics. Collaboration between companies and environmental organizations and public awareness campaigns will also play a key role in increasing consumer acceptance of edible plastics. Ultimately, the success of edible plastics in addressing the problem of marine plastic pollution depends on collaboration between governments, companies and consumers. By working together to overcome current barriers, edible plastics have the potential to significantly reduce the amount of plastic waste entering the ocean and contribute to a more sustainable future.

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