ASEAN Journal for Science and Engineering in Materials

Journal homepage: https://ejournal.bumipublikasinusantara.id/index.php/ajsem

# Sustainable Packaging: Bioplastics as a Low-Carbon Future Step for the Sustainable Development Goals (SDGs)

*Jumharijah Basnur*[*]*, Muhammad Fakhri Ferdian Putra, Shabrina Vee Amelia Jayusman, Z. Zulhilmi*

Program Studi Pendidikan Teknologi Agroindustri, Fakultas Pendidikan Teknologi dan Kejuruan, Universitas Pendidikan Indonesia, Indonesia

Correspondence: E-mail: jbasnur@gmail.com

## ABSTRACT

In recent years, the issue of desirability or sustainability has dominated the global conversation. This research focuses on designing solutions to environmentally detrimental carbon footprints, contributing to achieving SDGs climate action with a focus on sustainable packaging. Through a qualitative approach and methodological literature study, we analyzed that the use of sustainable packaging uses fewer raw materials and is more energy efficient, such as recycled plastic (bioplastic) and alternative materials that require less energy in their production. The results of this research show that the use of bioplastics has a real impact on the carbon footprint. Natural bioplastic materials can be degraded because the molecular structure of the raw material is crystalline so it is more fragile and more easily degraded than conventional plastic. Sustainable Packaging is an important future step towards low carbon.



## ARTICLE INFO

***Article History:***
*Submitted/Received 01 Sep 2023*
*First Revised 10 Oct 2023*
*Accepted 10 Dec 2023*
*First Available online 12 Dec 2023*
*Publication Date 01 Mar 2024*

***Keyword:***
*Alternative materials,*
*Bioplastic,*
*Carbon footprint,*
*SDGs,*
*Sustainable packaging.*

## 1. INTRODUCTION

The problem of high carbon emissions is a global challenge that requires an immediate solution. solution. Improved energy efficiency and reduced energy demand are expected to account for more than 50% of global carbon emission reductions in the coming decades (Brown, 2022). The packaging industry, currently still closely linked to the use of oil-based plastics, is facing serious problems. oil-based plastics face serious problems. These plastics are difficult to degrade and have a negative impact on the environment, including high levels of carbon emissions (Smith & Johnson, 2020). Therefore, alternative and sustainable solutions are crucial to replace the use of conventional plastics the use of conventional plastics.

Sustainable packaging, better known as sustainable packaging, is a major focus in efforts to reduce the environmental impact and carbon emissions generated by the packaging industry. According to Li and Thompson (2020), increasing resource efficiency and reducing environmental impact are the main elements of sustainable packaging. Sustainable Packaging is not just a trend but an urgent need to reduce the environmental impact and carbon emissions generated by the packaging industry. The main goal of sustainable packaging is to reduce environmental impact and increase resource efficiency. One of the most promising solutions in this context is the use of bioplastics. Bioplastics, which are made from natural materials such as cornstarch, sugarcane, and potato starch, offer a biodegradable solution that leaves no hazardous waste behind (Adams & White, 2018). The use of bioplastics as a step towards a low-carbon future is highly relevant to the Sustainable Development Goals (SDGs) that aim to reduce carbon emissions and increase sustainability.

The use of bioplastics can make a significant contribution to supporting Goal 12 on responsible production and consumption and Goal 13 on climate action, creating crucial synergies in achieving these goals (Green, 2020). According to Ramadhani *et al.* (2022), bioplastics are suitable for producing food and beverage containers. Bioplastics can be used as a substitute for conventional plastics because they are biodegradable and environmentally friendly. Bioplastics have great potential to be sold well and target the right market. Bioplastics can help reduce plastic waste and become a substitute for conventional plastics that are currently widely available in the market. Bioplastics can be used to replace various daily activity products, such as disposable household appliances and kitchen utensils. Bioplastics are also effectively used in the food and beverage industry. This industry is known for its large packaging waste and high levels of carbon emissions. The use of bioplastics in food and beverage packaging can reduce waste and carbon emissions while increasing resource efficiency (Turner, 2021). Mitchell (2022) also confirmed that bioplastics are safe to use in food packaging and can maintain food quality. The protective properties of bioplastics, which are determined by their mechanical and physical properties, help to estimate the shelf life of the product and the type of food suitable for packaging.

This research has the main objective to explore the crucial role of bioplastics as a solution in sustainable packaging, especially in reducing carbon emissions and achieving the SDGs. By focusing on the contribution of bioplastics to the reduction of environmental impacts and carbon emissions in the context of the packaging industry, it is hoped that the research results will provide a deeper understanding and sustainable solutions to this global challenge. provide a deeper understanding and sustainable solutions to this global challenge. Through this approach, it is hoped that a solid foundation can be established for the transformation towards more sustainable and environmentally friendly packaging practices globally.

DOI:
p-ISSN : 2828-920X e-ISSN: 2828-9951

## 2. METHODS

A research method that can be used in research on sustainable packaging, which includes the use of fewer and more energy-efficient raw materials, such as recycled plastics (bioplastics) and alternative materials that require less energy in production, is a literature study (Geyer *et al*., 2017). This method involves collecting and analyzing data from written sources such as journals, books, articles, and other documents (Nurhalimah, *et al.,* 2023). In the literature study, researchers can collect information about sustainable packaging, recycled materials, bioplastics, and other alternative materials that can be used in the production of environmentally friendly packaging (Narancic & O'Connor, 2017). An in-depth analysis of the literature will enable a better understanding of the sustainability impacts of each type of material, including the raw material and energy use aspects of its life cycle. Furthermore, the research will mine data from case studies, experiments, and related research projects to identify best practices in achieving raw material reduction and energy efficiency in packaging production. Researchers can use the literature study method to gather information on examples of green packaging innovations and develop their research further (Lebreton *et al*., 2017).

## 3. RESULTS AND DISCUSSION

### 3.1. Sustainable Packaging

Sustainable Packaging means the use of packaging materials that are designed, made, and used in a way that does not harm the environment. It is considered a sustainable solution for paper packaging in the future (Yonanda *et al., 2022*). Paper packaging unlike plastic or other non-biodegradable materials, is derived from trees, renewable resources, and organic and biodegradable materials. and biodegradable. Meanwhile, according to Anggalih (2022), the definition of sustainable packaging is the development and use of packaging whose purpose is to produce a sustainable system. The number of people who care about the environment increases significantly every year. So, many manufacturers who see the opportunity of this new market segment are starting to realize that sustainability is very important for the survival of the environment. are beginning to realize that sustainability is critical to the long-term viability of resources and the company's ability to meet market needs. The production of paper packaging generally requires less energy than plastics, and advances in sustainable forestry practices and the use of recycled content help to preserve natural resources and protect ecosystems.

To accelerate the transition towards sustainable packaging, various stakeholders must cooperate and work with each other. For example, the Future of Positive Packaging Program brings together social entrepreneurs, companies, and researchers to create solutions that have a positive environmental and social impact. environment and social impact. By working together, companies, governments, and research institutions can develop innovative packaging solutions that align with the SDGs and help create a more sustainable future. Packaging has a huge impact on the environment (Alfarizi, 2023).

### 3.2. Bioplastics

This research refers to the use of bioplastics as the use of environmentally friendly packaging. Research conducted by Intandiana *et al.* (2019) showed that bioplastics are used as a substitute for plastic because this material is made from biopolymers that are degraded by microorganisms. The biopolymer used here is starch which is easily found in Indonesia. based on this research, it is found that the addition of cellulose can increase the danceability

DOI:
p-ISSN : 2828-920X e-ISSN: 2828-9951

of bioplastics with a cellulose content of 10%, 14.3 Mpa, and a stretch value of 1.45%. In addition, according to the contact angle, the addition of cellulose has a contact angle value of 58.6˚. This is evidence that the addition of a lot of cellulose content shows high wettability or hydrophilicity.

In addition, in terms of manufacturing materials also need to be considered. The material for making environmentally friendly packaging is an important part because it will be a form of public concern for the environment. One of them is research conducted by Erviana *et al.* (2022), explaining that the use of foam can be used as a substitute for styrofoam. Biofoam is a material produced by starch and fiber in this study, namely peanut shells and rice husks. Every year the rice harvest is carried out 3 times while peanuts only harvest 2 times per year and every processing always leaves waste. For peanuts, the waste obtained per year is 40% and rice husk waste is 90% which is still underutilized and only piled up and even burned, resulting in environmental and air pollution.

According to Dermawan (2020), bioplastics are plastics that can be used like ordinary plastics, but after use, will be destroyed by microorganisms and produce water and carbon dioxide gas. carbon dioxide. Bioplastics are environmentally friendly plastics that can be decomposed by microorganisms (Sari et al., 2019). that can be decomposed by microorganisms. Most or completely made from renewable raw materials. Indonesia has shown its commitment to reduce plastic pollution and encourage sustainable packaging. The National Action Plan for the Management of the Country's Plastic Waste aims to increase the use of recycled materials and reduce single-use plastics. Bioplastics can be incorporated into this plan as it offers a more environmentally friendly packaging material option. Packaging has a huge impact on the environment. Consider some incredible statistics:

(i) Biodegradable bio-based plastics: These plastics are derived from resources, such as agricultural waste, and degrade faster than traditional plastics.
(ii) Flexikeg x Perrier: This collaboration aims to make beverages such as water available in a more sustainable way by using bioplastic materials.

Thus, bioplastics can help achieve the SDGs and reduce the environmental impact of packaging. packaging. To achieve these goals, various stakeholders must work together and work together to drive the development and implementation of sustainable packaging solutions, such as bioplastics.

### 3.3. Components of Bioplastics

There are several types of bioplastic components. Hydrocolloids used in bioplastic production are proteins and carbohydrates. The film is formed from carbohydrates which can be starch, gum (alginate, pectin, and gum arabic), and chemically modified starch. Protein-based film formation can use casein, soy protein, wheat gluten, and corn protein. Hydrocolloid-based membranes are particularly suitable as barriers to the transfer of oxygen, carbon dioxide, and fats. This type of film has excellent mechanical properties making it suitable for improving the membrane structure so that it does not disintegrate easily.

This method combines zein (base material) with 30% (v/v) water or ethanol with 20% (v/v) water. Next, materials used to make plastics, such as lipids or glycerin, are incorporated and heated for ten minutes at fifty degrees Celsius. Pouring 10 milliliters of the mixture onto a smooth polyethylene plate surface performing molding on the casting. The material was kept for five hours at a temperature of 30-45 degrees Celsius. The formed film is released from the surface of the mold, then dried, and then stored.

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p-ISSN : 2828-920X e-ISSN: 2828-9951

This bioplastic was made with the base material, casein, using an extruder mold through several steps: mixing the base material with acetone or ethanol-water, adding the ethanol-water, adding plastics, molding, and drying the film.

### 3.4. Plastic Waste Reduction for the Future

Carbon footprint is the amount of greenhouse gas emissions that individuals produce in their daily lives. carbon footprint is the amount of greenhouse gas emissions that individuals produce daily. Carbon footprint is the total carbon dioxide (CO2) emissions associated with all human activities or other entities, such as buildings or countries. such as buildings or countries. According to the Encyclopaedia Britannica website, carbon footprint also includes emissions from burning fossil fuels in manufacturing as well as transportation. Reduction of the use of plastic bags with an additional fee provides awareness to the public to reduce the use of plastic as a tool for transportation. awareness to the public to reduce the use of plastic as a tool to carry groceries. So environmentally friendly packaging is needed to minimize the use of plastic in the community society. Research written by Handayani (2022) provides a solution to the use of plastic waste that is very much in souvenirs. This research created innovative packaging products with workshops and presentations to introduce packaging materials. This research provides meaning that the packaging design of a product is very dependent on the aesthetics of the packaging. Attractive packaging can increase the marketability of a product. product. Not only that, the use of environmentally friendly packaging is also an added value in the sales level of a product. This is because currently, many people pay attention to the use of plastic which makes the earth bad in the future.

This research refers to the use of bioplastics as the use of environmentally friendly packaging. Research conducted by Intandiana *et al*. (2019) reported that bioplastics are used as a substitute for plastic because this material is made from biopolymers that are degraded by microorganisms. microorganisms. The biopolymer used here is starch which is easily found in Indonesia. based on this research, it was found that the addition of starch to the bioplastic is more effective. This research found that the addition of cellulose can increase the danceability of bioplastics with a cellulose content of 10%, 14.3. 10% cellulose, 14.3 MPa, and a stretch value of 1.45%. In addition, according to the contact angle, the addition of cellulose has a contact angle value of 58.6˚. This is evidence that the addition of cellulose content shows high wettability or hydrophilicity.

Not only based on cassava starch but bioplastics can also be produced from palm starch and glucomannan. Bioplastics with this component were carried out by Purnavita *et al*. (2020), stating that in the addition of 0 ml glycerol (without glycerol), bioplastic composites with a ratio of glucomana: palm starch of 1: 1 produced the highest water resistance value, the plastic morphology was quite good and the tensile strength value was quite high, but the tensile elongation value was low. Whereas in the experiment with the addition of 10 ml glycerol, the bioplastic composite with a glucomannan: palm starch ratio of 1:1 produced the highest tensile elongation value and good morphological results, but the tensile strength and water resistance values were low. Composite composition

The recommended bioplastic composite composition is a glucomannan: palm starch ratio of 1:1 with the addition of glycerol less than 10 ml. The addition of glycerol to the ratio of glucomannan and aren palm starch has the effect of reducing the water resistance compared to that without the addition of glycerol. to water compared to without the addition of glycerol, because the plasticizer glycerol stretches the bonds between amylose molecules so that there is a possibility of gaps and water can enter. Purnavita *et al*. (2020), mentioned that an increase in film solubility can be significantly achieved by the addition of glycerol. This

DOI:
p-ISSN : 2828-920X e-ISSN: 2828-9951

phenomenon occurs due to the hydrophilic nature of glycerol, which makes it easily soluble in water, and the impact is a decrease in the resistance of bioplastics to water exposure.

Research conducted by Ningsih *et al.* (2019), states that the addition of CMC to the synthesis of bioplastics from nagara yam starch affects the characteristics of the bioplastics produced, namely increasing the value of thickness, water absorption, tensile strength, elongation, and reducing resistance, and water vapor transmission. Based on the tensile strength data and water vapor transmission rate obtained, the addition of the optimum CMC concentration is 9% CMC. The optimum CMC concentration was 9% CMC (w/b) with the highest tensile strength value and the lowest water vapor transmission of 0.5281 N/mm2 and 6.370 g/m2/day. This indicates that the addition of CMC makes the molecular structure amorphous. In amorphous molecular structures, the chains are branched but not tightly arranged so that the distance between molecules becomes longer and the strength of molecular bonds is weakened. the molecular bonding strength is weakened. The weakening of the molecular bond strength in this film causes the lower force needed to break the film. The increase in elongation value is because CMC has a high gel strength.

### 3.5. Bioplastics as Support for Achieving the SDGs

To achieve the SDGs and reduce their carbon footprint, companies, and countries must commit to sustainable packaging and low-carbon development. This requires cooperation, innovation, and a comprehensive approach to addressing the environmental impacts of packaging materials and waste management. By prioritizing sustainable packaging, companies, and countries can build a more sustainable and resilient future that aligns with global efforts in line with global efforts.

Sustainable packaging means the use of packaging materials that are designed, made, and used in a way that does not harm the environment. It is considered a sustainable solution for paper packaging in the future. Paper packaging unlike plastic or other non-biodegradable materials, comes from trees, renewable resources, and organic and biodegradable materials. Paper production generally requires less energy than plastics, and advances in sustainable forestry practices and the use of recycled content help to preserve natural resources and protect ecosystems (Anggalih, 2022).

The reduction in the use of plastic bags with additional fees provides awareness to the public to reduce the use of plastic as a tool to carry groceries. So environmentally friendly packaging is needed to minimize the use of plastic in society. The research was written by Handayani (2022), which provides solutions to the use of plastic waste that is very much in souvenirs. This research creates innovative packaging products with workshops and presentations to introduce packaging materials. This research provides meaning that the packaging design of a product is very dependent on the aesthetics of the packaging. Attractive packaging can increase the selling power of a product. Not only that, the use of environmentally friendly packaging is also an added value in the sales level of a product. become an added value in the sales level of a product. This is because nowadays people already pay a lot of attention to the use of plastic which makes the earth not good in the future in the future.

## 4. CONCLUSION

In the context of sustainable packaging and reduced environmental impact, the use of paper-based packaging and bioplastics has become a major focus as they are derived from renewable resources and can be recycled. Bioplastics offer an attractive solution, but further research is needed to understand their full impact on the environment, and the sustainable

DOI:
p-ISSN : 2828-920X e-ISSN: 2828-9951

availability of raw materials, paper, and bioplastics plays a key role in achieving sustainable development goals.

## 5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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DOI:
p-ISSN : 2828-920X e-ISSN: 2828-9951