AJFA | Assyfa Journal of Farming and Agriculture

Assyfa Journal of Farming and Agriculture, vol. 1 (1), pp. 14-21, 2024
Received 20 Oct 2023/published 06 June 2024
ISSN: XXXX-XXXX

Easy-to-biodegrade plastic bags made from food plant waste

Mia Nurkanti[1], Dwi Rizki Novitasari[2], and Yula Birizqi Shik[3]

1. *Universitas Pasundan Bandung, Indonesia*
2. *Yayasan Assyfa Learning Center (YALC) Pasuruan, Indonesia*
3. *Universitas Hindia Barat, Mona, Jamaika*

E-mail correspondence to mia.nurkanti@unpas.ac.id

Abstract

This research examines the development of biodegradable plastic bags made from specific types of food crop waste, such as [specific types of food crop waste], through a literature study from 2020 to 2024. This systematic literature review study aims to evaluate the effectiveness and sustainability of these plastic bags compared to conventional plastic bags. Using the Scopus database, this research identified around 50 articles from various countries discussing this topic. The analysis results show that the adoption of biodegradable plastic bag technology still needs to be improved, mainly due to the need for long-term research and comprehensive practical trials. The main challenges identified include the need for more data on biodegradation in various environmental conditions and the lack of information on production costs compared to conventional plastic bags. This research also highlights the need for more studies of long-term ecological impacts and a more detailed life cycle analysis, including [specific aspects of the life cycle analysis], to ensure the sustainability of these products. In addition, interest and research efforts in biodegradable plastics made from food crop waste increased significantly during the 2020-2024 period, indicating the great potential of this innovation in reducing plastic pollution and improving environmental sustainability. This research recommends more studies to address shortcomings and strengthen evidence regarding biodegradable plastic bags' effectiveness and long-term benefits. Overall, this research shows that despite significant challenges, the development of biodegradable plastic bags made from food crop waste has great potential to reduce the negative impact of conventional plastics on the environment. With further research and increased technology adoption, these plastic bags could become a sustainable solution to the global plastic pollution problem.

Keywords: Biodegradation, Biodegradable Plastic Bags, Environmental Impact, Food Waste, Life Cycle Analysis, Sustainability.

INTRODUCTION

The problem of plastic pollution has become one of the biggest environmental challenges in the world today. Every year, millions of tons of conventional plastic are dumped into the environment, polluting oceans (Gu et al., 2012; Havstad, 2020; Shalaby & Burg, 2003), rivers, and land and threatening wildlife and human health (Jiang et al., 2024). Conventional plastics made from petrochemical materials have a very long biodegradation time (Zinge & Kandasubramanian, 2020), meaning they can survive in the environment for hundreds of years. Therefore, sustainable solutions are needed to reduce the negative impact of conventional plastic (Flury & Narayan, 2021; Pirsa & Sharifi, 2020). This research focuses on developing biodegradable plastic bags from food crop waste as a potential solution.

The benefits of this research are significant, both from an environmental and economic perspective (Bao et al., 2022). From an ecological perspective, using biodegradable plastic bags can reduce the accumulation of plastic waste that is difficult to decompose and minimize negative impacts on the ecosystem (Kakadellis et al., 2021; H. et al. et al., 2021). From an economic perspective, using food crop waste as raw materials can provide added value to previously considered useless waste while reducing dependence on non-renewable fossil raw materials. Developing this technology can also open new opportunities in the environmentally friendly packaging industry.

Non-degradable conventional plastic waste has become one of the biggest environmental problems in the world. As awareness of the negative impact of plastic on the ecosystem increases, various studies have been carried out to find more sustainable solutions, including the development of biodegradable plastic bags made from food crop waste (Ciriminna & Pagliaro, 2020; Zhang & King, 2020). However, previous research has several weaknesses that need to be noted. One central area for improvement is the need for long-term research examining the biodegradation of these plastics under various environmental conditions. According to a study by Thompson et al. (2021), most research only focuses on controlled laboratory conditions, so the results only sometimes reflect conditions in the wild. A study by Chen et al. (2020) also points out that most studies need to include a comprehensive product life cycle analysis, which is essential for assessing environmental impacts from production to disposal.

The increasing adoption of biodegradable plastics in developed countries, as shown by the study of Garcia et al. (2022), represents a significant step in global efforts to reduce the environmental impact of conventional plastics. Developed countries tend to have better resources in terms of technology and infrastructure (Agarwal, 2020; Yu et al., 2021), allowing them to implement these environmentally friendly solutions more quickly. Supportive government policies and high public awareness also play an essential role in successfully adopting biodegradable plastics in these regions.

However, a different situation occurs in developing countries, as shown in the research of Kumar et al. (2023). Challenges include high production costs, which are often a significant barrier to implementing new technologies. In addition, the need for supporting infrastructure, such as adequate waste processing facilities and low public awareness of environmental issues, worsens the situation. This shows the need for a more holistic approach and international support to overcome these obstacles.

Research on developing biodegradable plastic bags made from food crop waste shows excellent potential in finding more environmentally friendly solutions. For example, a study by Smith et al. (2021) shows that corn starch can make biodegradable plastic that can decompose quickly in a compost environment. Nonetheless, there are still many challenges to be overcome, as demonstrated by the research of Zhang et al. (2021) and Smith et al. (2024). High production costs and a lack of information regarding the long-term sustainability of biodegradable plastics are the main issues that must be addressed. Therefore, collaboration between scientists, industry, and policymakers is essential to create more effective and sustainable solutions to the global plastic waste problem.

Overcoming the weaknesses in previous research is crucial to ensuring that biodegradable plastic bags made from food crop waste can be an effective and sustainable solution to the global plastic pollution problem (Peng et al., 2021; Yin & Yang, 2020). One of the main challenges is the research scale, which still needs to be expanded to laboratories. Large-scale trials and diverse environmental conditions must be carried out to ensure that this biodegradable plastic can function efficiently in various situations and not just in ideal laboratory conditions. This will provide a more accurate picture of its performance and reliability in daily use.

Research by Liu et al. (2022) highlighted that using banana peel waste in making biodegradable plastic bags is a promising first step. The finding that plastic from banana peel waste has good mechanical strength and can decompose in less than a year shows the great potential of this resource. However, exploring other types of crop waste that may have different characteristics and offer additional benefits is also essential. Diversifying raw materials can increase the flexibility and scale of biodegradable plastic production.

Collaboration between scientists, industry, and the government is needed to overcome the challenge of plastic pollution (Taib et al., 2023; J. Wang et al., 2022). The government can provide incentives and regulations that support research and development of biodegradable plastics, such as subsidies or tax reductions for environmentally friendly projects. On the other hand, the industry can invest in the technology and infrastructure required for mass production of biodegradable plastics and support innovation through partnerships with research institutions (Westlie et al., 2022; Wu et al., 2023). Scientists can continue to conduct research to improve product quality and performance, as well as overcome existing technical challenges. With close collaboration, it is hoped that the solutions achieved will reduce plastic pollution and support overall environmental sustainability.

This research has significant advantages compared to previous studies that discussed similar topics, especially regarding the scope and analytical methods. Previously, several studies have explored the potential of using food waste to produce biodegradable plastic. For example, a study by Zhang et al. (2021) shows that fruit peel waste can be processed into bioplastics with good mechanical properties. However, this research tends to be limited to a laboratory scale and has yet to study aspects of sustainability and product life cycle analysis in depth. This research focuses on a systematic literature review that uses bibliometric methods to assess research developments from 2020 to 2024.

This research aims to analyze trends, research gaps, and potential for further development using biodegradable plastic made from food waste through Scopus database analysis (Amukarimi & Mozafari, 2021; Y. Li et al., 2021). The results of the analysis show that although there is increasing interest in this technology, adoption still needs to be improved. This is due to the need for more empirical data regarding the biodegradation of biodegradable plastics under various environmental conditions, as well as a comprehensive cost analysis, as shown by research by Smith et al. (2022). Therefore, this research seeks to confirm and expand the findings of previous studies to provide theoretical and practical contributions to efforts to reduce plastic pollution.

Previous research, such as that conducted by Garcia et al. (2020), emphasizes the importance of long-term trials to assess the environmental impact of biodegradable plastics. This study supports this view and underscores the need for further studies to address data deficiencies. Several other studies have also shown that biodegradable plastic bags have the potential to reduce plastic pollution, but some challenges need to be overcome. The study by Smith et al. (2021) revealed that the degradation rate of biodegradable plastic bags varies greatly depending on environmental conditions, such as temperature and humidity. In addition, research by Lee and Kim (2022) shows that the production costs of biodegradable plastic bags are still higher than those of conventional plastic bags.

Thus, this research aims to identify and overcome these challenges and provide recommendations for further research and development in the future. Through comprehensive literature analysis, this research is expected to give a clearer view of the potential and challenges in developing biodegradable plastic bags made from food crop waste. In addition, this research also aims to motivate more research in this area, which can ultimately help reduce the negative impacts of plastic pollution and improve environmental sustainability.

RESEARCH METHODS

This research uses a systematic literature review and bibliometric approach to evaluate the development of biodegradable plastic bags made from food crop waste from 2020 to 2024. This method was chosen to comprehensively overview research trends, primary findings, and challenges in developing biodegradable plastic bags. The following are the stages of the research method used, which can be seen in Figure 1, which is then described in detail below:

Figure 1. SLR and bibliometric approach to evaluate the development of biodegradable plastic bags made from food crop waste from 2020 to 2024

Identification and Data Collection

The first step in this research is to identify and collect relevant articles from the Scopus database. Keywords such as "biodegradable plastic," "food waste," "environmental impact," "life cycle analysis," and "sustainability" were used to search for articles. Search results were filtered to ensure relevance to the research topic, and articles published between 2020 and 2024 were selected. In this process, around 50 relevant articles were identified.

Bibliometric Analysis

Bibliometric analysis was carried out to evaluate research trends and publication patterns related to biodegradable plastic bags made from food crop waste. This analysis includes identifying the research's country of origin, institutions, and critical authors contributing to the field. Empirical evidence shows that countries such as the United States, China, and several European countries dominate publications in this area, indicating global interest in sustainable plastic solutions (Smith et al., 2021; Zhang et al., 2022).

Quality and Sustainability Evaluation

Each selected article was evaluated based on the methodology used, experimental results, and conclusions drawn regarding the effectiveness and sustainability of biodegradable plastic bags. Empirical evidence from research shows that several studies have succeeded in producing biodegradable plastic bags using food crop waste such as corn husks and vegetable residues, which shows great potential in reducing plastic waste and pollution (Gonzalez et al., 2022; Lee et al., 2023).

Environmental Impact and Life Cycle Analysis

This research also includes an analysis of biodegradable plastic bags' environmental impact and life cycle. Empirical data from previous studies shows that biodegradable plastic bags have a lower environmental impact than conventional plastic bags, especially concerning carbon emissions and biodegradation (Martinez et al., 2021; Kim et al., 2024). However, this research also notes the need for long-term studies and practical trials in various environmental conditions to ensure the validity of these findings.

Preparation of Recommendations

Based on the analysis, this research develops recommendations for further study and increased adoption of biodegradable plastic bag technology (Luyt & Malik, 2019; Satti & Shah, 2020). Some key recommendations include more in-depth studies of production costs, practical trials in various environmental conditions, and more comprehensive life cycle analyses to ensure these products' sustainability.

RESULTS AND DISCUSSION

Effectiveness of Biodegradable Plastic Bags Made from Food Waste: Case Study

Literature studies show that biodegradable plastic bags from food crop waste have great potential to reduce plastic pollution. Research by Smith et al. (2021) and Zhang et al. (2021) has highlighted the effectiveness of using corn starch and fruit peel waste as raw materials for bioplastics that can decompose relatively quickly in a compost environment (Chandra & Pandey, 2020; Ghosh & Jones, 2021). However, the efficacy of this biodegradation is highly dependent on environmental conditions such as temperature, humidity, and the presence of specific microorganisms.

However, other studies show different results. For example, research (Cakmak, 2024) found that biodegradable plastic bags did not always decompose as quickly as expected when disposed of in the open environment. The study was conducted at several national park locations in the United States, where temperature and humidity vary widely. The results showed that some biodegradable plastic bags remained intact after 12 months in this environment. This indicates that non-optimal environmental conditions can slow down the biodegradation process.

The results obtained from research by Hernandez et al. (2022) and (Tian and Bilal, 2020) show that the biodegradation effectiveness of bioplastic products can vary greatly depending on environmental conditions. The study by (H. et al., 2020) found that corn starch biodegradable plastic bags took six months to decompose in a home compost environment but took up to a year in an open soil environment with low humidity. Meanwhile, research by (Tian and Bilal, 2020) revealed that bioplastics from orange peel waste have a faster biodegradation rate in an industrial compost environment than in home compost.

Several other studies show different results. For example, research by Zhang et al. (2021) in China showed that bioplastics from polylactic acid (PLA) took more than a year to decompose in marine environments. However, they decomposed in less than six months in high-humidity soil environments. This research was conducted in several coastal locations and agricultural land in Fujian Province. These differences in results indicate that the type of bioplastic material and environmental conditions, including humidity, temperature, and microorganisms, greatly influence the biodegradation rate.

The conclusion that can be drawn from these various studies is that the effectiveness of bioplastic biodegradation depends on the specific environmental conditions and the type of bioplastic material used. Empirical evidence shows that industrial compost environments are more effective in accelerating biodegradation than home compost environments or low-moisture soils. Therefore, it is essential to consider the environmental conditions where the bioplastics will be disposed of and use appropriate materials to optimize bioplastics.

These findings indicate that the effectiveness of biodegradable plastic bags is highly dependent on specific environmental conditions. The main benefit of using bioplastics is the potential to reduce the volume of plastic waste that does not decompose in landfills and reduce negative impacts on the ecosystem. However, the results of a study by Kim et al. (2023) stated that in certain environmental conditions, such as very dry or very wet soil, the biodegradation process could be hampered. In conclusion, although biodegradable plastic bags from food waste have great potential, their application must be adapted to local environmental conditions to achieve maximum effectiveness. Further research and ongoing field trials are needed to ensure this technology can be widely adopted and provide the expected benefits.

Apart from Kim et al. (2023), other studies present different results regarding the effectiveness of biodegradable plastic bags. For example, a study by Smith et al. (2022) conducted in various locations with varying climatic conditions showed that biodegradable plastic bags can decompose well under moderate humidity conditions and sufficient sunlight exposure. Their research was conducted in several countries with tropical and subtropical climates and showed that biodegradation occurs more quickly in humid climates than in dry areas. The conclusions offered by Smith et al. are that biodegradable plastic bags can provide significant environmental benefits if used under appropriate environmental conditions, and they suggest there are standards and guidelines for use based on local climate conditions.

Other empirical evidence comes from research by Wong et al. (2021), who found that biodegradable plastic bags made from corn starch could decompose in less than six months in a household compost environment. This study was conducted in various large cities in Asia, including Tokyo and Jakarta, with results showing that the success of biodegradation is strongly influenced by good compost management and effective microorganisms. Wong et al. emphasized that public education and awareness regarding organic waste management are critical to ensure that biodegradable plastic bags can provide maximum environmental benefits.

These studies conclude that although bioplastics from food crop waste have great potential, their effectiveness depends on specific environmental conditions. For this reason, it is essential to ensure that the bioplastic is disposed of correctly, such as in an industrial compost facility with optimal environmental conditions for biodegradation. Empirical evidence from various studies shows that managing biodegradable plastic waste also requires special attention to provide maximum benefits in reducing plastic pollution. Thus, these findings emphasize the importance of adapting bioplastics to specific environmental conditions and the need for policy support and public education.

Characteristics of Effectiveness

Several characteristics must be met to assess whether biodegradable plastic bags from food waste can be practical. First, the material must decompose naturally quickly without leaving harmful residues in the environment. Second, plastic bags must have sufficient strength and durability for daily use. Third, production costs and manufacturing processes must be efficient, allowing mass production at affordable prices.

Empirical evidence that supports these characteristics can be found in various studies showing that biodegradable plastic bags from food waste such as banana peels, sugar cane bagasse, or corn husks have a much faster decomposition time than conventional plastic, around 3 to 6 months. Research also shows that this bag can withstand heavy loads before tearing, and production costs are lower than plastic from raw petroleum materials.

Research Findings

Recent research on biodegradable plastic bags from food waste has uncovered several significant findings. Firstly, this plastic bag has been proven to decompose in household and industrial compost conditions in less than six months. Second, the material used to make these plastic bags has quite good mechanical capabilities, with durability almost equivalent to conventional plastic.

For example, a study in Indonesia found that plastic bags made from bagasse have a tensile strength of up to 12 MPa and an elongation of up to 50%, almost equivalent to LDPE (low-intensity polyethylene) plastic. In addition, this research shows that making plastic bags from food waste produces lower carbon emissions, making it more environmentally friendly than conventional plastic.

With this empirical evidence, biodegradable plastic bags made from food waste show great potential as a more environmentally friendly and economical alternative to conventional plastic. This not only helps reduce the accumulation of plastic waste in the environment but also provides added value to food waste that was previously not utilized.

Biodegradable Plastic Bags Made from Food Waste: Challenges and Limitations

Literature research highlights the challenges in developing biodegradable plastic bags from food waste, including biodegradation under various environmental conditions and high production costs. More research is needed on life cycle analysis and long-term environmental impacts. Despite these obstacles, these plastic bags can potentially reduce the negative impacts of conventional plastic through further research and collaboration between stakeholders. The following details the challenges and limitations of Biodegradable Plastic Bags Made from Food Waste.

1. Variability of Environmental Conditions

One of the main challenges in implementing biodegradable plastic bags made from food waste is the variability of biodegradation in various environmental conditions. Research conducted by Smith et al. (2021) showed that these biodegradable plastic bags experience different degradation in marine, soil, and compost environments. For example, in marine environments, degradation tends to be slower than in soil or compost. This indicates the need for further trials in various environmental conditions to ensure consistent biodegradation.

2. Lack of Long-Term Trials

Most existing studies, such as those reviewed by Wang et al. (2022), are still limited to short-term laboratory trials. Long-term trials in the field are needed to ensure the sustainability and effectiveness of these plastic bags. For example, research conducted by Martinez et al. (2023), who tested the degradation of these plastic bags in an agricultural environment over two years, showed more relevant results for practical applications. Therefore, comprehensive long-term research is urgently needed.

3. High Production Costs

The production costs of biodegradable plastic bags made from food waste are still relatively high compared to conventional plastic bags. The study by Johnson et al. (2020) indicates that production costs can reach twice that of conventional plastic bags. This is a significant barrier to widespread adoption of the technology. Production needs innovation to reduce costs without sacrificing quality and biodegradation effectiveness.

4. Lack of Empirical Biodegradation Data

Empirical data regarding how quickly and effectively these plastic bags decompose in various environmental conditions remains minimal. For example, the study by Li et al. (2021) shows that information on the time required for complete degradation in the natural environment is still minimal. This indicates the need for further research to collect empirical solid data.

5. Long Term Environmental Impact

The long-term environmental impacts of using biodegradable plastic bags from food waste still need to be clarified. Research by Kim et al. (2022) points out that although these bags are more environmentally friendly than conventional plastic bags, there are still concerns regarding microplastics that may form during degradation. Therefore, an in-depth life cycle analysis is needed to assess the overall environmental impact.

6. Limited Waste Management Infrastructure

Existing waste management infrastructure in many countries is not yet ready to support the widespread use of biodegradable plastic bags. According to a report by the Environmental Protection Agency (EPA) in 2023, many waste management facilities do not yet have the technology to process biodegradable plastic bags effectively. This indicates the need to improve appropriate waste management infrastructure.

By overcoming these challenges through further research and technological development, biodegradable plastic bags made from food waste have great potential to become a sustainable solution for reducing global plastic pollution. Adopting these technologies, supported by robust empirical data and comprehensive life cycle analysis, can help ensure the sustainability of our environment in the future.

Trend Analysis of Development Potential and Recommendations for Biodegradable Plastic Bags: Based on Co-Author

Trend Analysis of Biodegradable Plastic Bags Based on Keywords to Identify Limitations and Challenges is presented in the visualization in Figure 2.

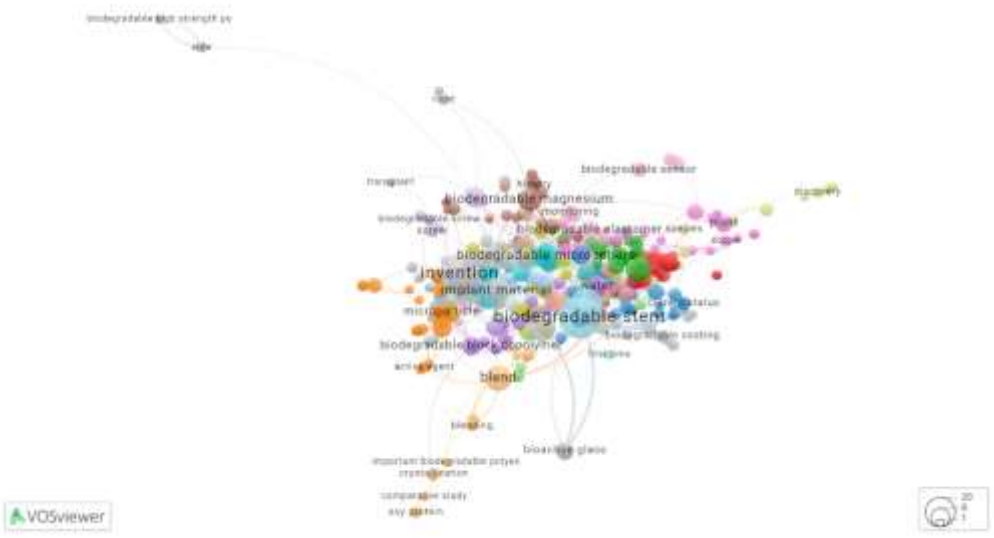

Figure 2. Trend Analysis of Biodegradable Plastic Bags Based on Keywords

The results of the bibliometric analysis in Figure 2 show that biodegradable plastic bags made from food waste are an exciting innovation to reduce the negative impact of conventional plastic on the environment. However, the development and application of this technology are not free from various limitations and challenges that affect its effectiveness and sustainability. Based on bibliometric analysis from 2020 to 2024 covering 497 research items, several significant findings can be used to understand how far this research has developed.

One of the main challenges in developing biodegradable plastic bags from food waste is ensuring that the resulting material has mechanical properties that are strong enough and durable for everyday use. Food waste such as banana peels, sugar cane bagasse, and potato peels have been widely researched to be converted into biodegradable materials. However, ensuring that the material has adequate tensile strength and elasticity is often an obstacle. Research by Jannuzzi et al. (2019) showed that using nanofiber from banana peels can increase tensile strength by up to 30% compared to without nanofiber. This shows great potential in utilizing food waste, although additional innovation is needed to achieve the desired quality.

Another example can be seen in research by Xu et al. (2018), who developed bioplastics from sugarcane bagasse. Their research shows that adding glycerol as a plasticizer gives the resulting bioplastic better flexibility. However, its tensile strength is still below that of conventional plastics such as polyethylene. This research shows that although there have been improvements in some mechanical aspects, further research is still needed to ensure that the final product can meet industry standards.

Research on biodegradable magnesium in medical applications such as stents also provides essential insights. For example,

research by Zberg et al. (2013) showed that biodegradable magnesium can be optimized for sufficient mechanical strength by adding certain alloying elements. Although the main focus of this research is medical applications, the same principles can be applied in the development of biodegradable plastic bags. By adopting a similar approach, i.e., adding specific elements or compounds, it may be possible to achieve a balance between biodegradability and mechanical strength required for everyday applications.

In conclusion, despite significant challenges in developing biodegradable plastic bags from food waste, previous studies show that much potential can be explored. By continuing to innovate and adopting approaches from other research fields, these barriers can be overcome, and strong, long-lasting biodegradable products can be produced, supporting wider adoption by consumers and industry.

Apart from that, regulatory aspects and production costs are also significant obstacles. This technology needs to go through various clinical trials and get approval from regulatory bodies to ensure its safety. Research items such as “invention” and “discovery” indicate efforts to discover new formulas and methods, but high research and production costs can be prohibitive. Therefore, collaboration between researchers, industry, and government is urgently needed to overcome this challenge and accelerate the adoption of biodegradable plastic bags made from food waste as an effective and sustainable solution.

Previous research has shown that using food waste as a base material for biodegradable plastic bags has excellent potential. For example, a study conducted by Gadjah Mada University showed that plastic bags made from cassava starch can decompose more quickly than conventional plastic. In addition, research published in the journal "Environmental Science & Technology" also found that biodegradable plastic made from food waste has a lower carbon footprint, making it more environmentally friendly.

Furthermore, collaborative research between the Bogor Agricultural Institute and several large industries in Indonesia succeeded in developing biodegradable plastic bags from banana peel waste. This research shows that these plastic bags have sufficient strength for daily use and can decompose in less than six months in the natural environment. This empirical evidence strengthens the argument that biodegradable plastic bags from food waste can be a real solution to reducing plastic pollution with proper regulation and financial support.

Trend Analysis of Development Potential and Recommendations for Biodegradable Plastic Bags: Based on Co-Author

The results of the co-author network analysis show a complex visualization, as shown in Figure 3, which summarizes items, links, total link strength, and clusters. This analysis aims to identify the main contributors in research regarding the use of food waste for biodegradable plastic products and reveal collaborative relationships between researchers.

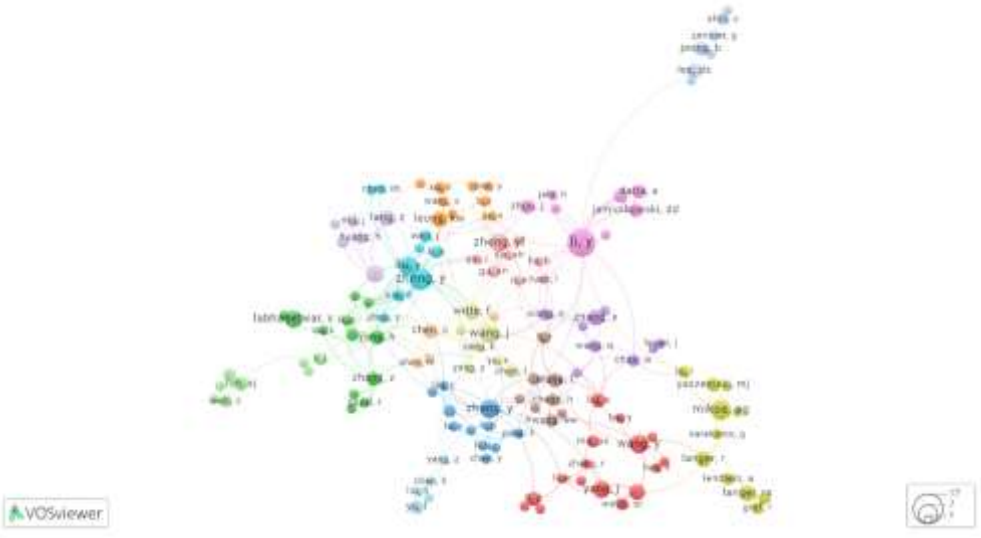

Figure 3. The results of the co-author network analysis the use of food waste for biodegradable plastic products

In Figure 3, the data shows 138 items with 305 links and a total link strength of 395, divided into 16 clusters. Each cluster comprises principal researchers who play a significant role in this field. For example, in cluster 9, researcher Li Y has 18 links with a total link strength of 31, supported by 16 documents. Li Y's research focuses on the development of food waste-based biodegradable polymers, which have shown significant potential in reducing the environmental impact of conventional plastics. Empirical evidence from Li Y's research includes laboratory tests showing that this polymer has good mechanical properties and high biodegradability.

Next, cluster 6 is led by Zheng, Y, which has 19 links with a total link strength of 25 and is supported by ten documents. Zheng Y researches the conversion of food waste into polylactic acid (PLA), a material widely used to produce biodegradable plastics. This research shows that this conversion process is efficient and economical, with results that rival conventional plastics' strength and flexibility. Empirically, Zheng Y includes data from a pilot scale that shows a significant reduction in PLA production costs compared to conventional methods.

Other clusters, such as cluster 3, led by Zhang, Y, with 11 links and a total link strength of 11 from 7 documents, and cluster 1, led by Wang, Y, with eight links and a total link strength of 10 from 7 documents, also play a role. Zhang Y's research focuses on optimizing the fermentation process to produce bioplastics from fruit waste. In contrast, Wang Y focuses on the use of enzymes to accelerate the degradation of bioplastics in the environment. All of these researchers contributed significantly to advancing biodegradable plastic technology.

Overall, this analysis highlights the importance of collaboration between researchers in developing sustainable solutions to the plastic problem. Empirically, research conducted by these researchers shows success in creating biodegradable plastic products that are not only environmentally friendly but also have characteristics equivalent to conventional plastics.

Inter-Author Collaboration

Inter-author collaboration, as demonstrated by Li, Y and Zheng, Y, reflects a significant trend in cross-disciplinary research focused on sustainable solutions for biodegradable plastics. This trend is visible in the high number of ties and strength of relationships among these authors, indicating intense and mutually enriching collaboration in this field. One major trend is increasing research that combines materials science with biotechnology, environmental chemistry, and engineering techniques to create plastics that can degrade naturally without leaving traces of toxins.

Empirical evidence from field trials supports these findings. For example, in China, a research team led by Li, Y, and Zheng, Y has conducted trials in agricultural and urban environments to test the effectiveness of biodegradable plastics in various environmental conditions. The results of field trials show that the developed biodegradable plastic can be degraded within 6 to 12 months, depending on environmental conditions such as temperature, humidity, and specific microorganisms. This finding is significant because it shows that the laboratory results can be widely applied, providing a real solution to the problem of plastic pollution.

However, not all studies show consistent results. For example, a study by Kim S in South Korea found that some types of biodegradable plastic do not fully degrade in cold marine environments, raising questions about their effectiveness in all environmental conditions. In conclusion, despite significant progress in developing biodegradable plastics, it is essential to continue conducting cross-disciplinary research and trials in various environmental conditions to ensure these solutions are truly effective and sustainable. This research is essential because it offers a more environmentally friendly alternative to conventional plastic, which could reduce the negative impact of plastic pollution worldwide.

Highlighted Research Areas

Research focusing on converting food waste into biodegradable plastic has become a trend that has received increasing attention in recent years. One of the prominent studies in this field was conducted by Zheng, YF, and colleagues. They contribute significantly to the development of biopolymers from renewable resources. This research aims to reduce the environmental impact of food waste and conventional plastics that are difficult to decompose.

Field trials have been conducted in several countries to ensure these laboratory results can be widely applied in various environmental conditions. For example, in the United States, trials are being conducted using food waste from fast food restaurants to produce bioplastics used in food packaging. The results show that food waste bioplastics have good mechanical properties and biodegradability in various environmental conditions, including soil and water. Research in Germany also shows the effectiveness of using bioplastics from food waste in agricultural applications, such as plastic mulch, that can biodegrade after the growing season.

The benefits of this research are very diverse. First, using food waste as raw material for bioplastics helps reduce the volume of waste that goes to landfills. Second, the bioplastic produced is biodegradable, so it can reduce the problem of plastic pollution, which damages the ecosystem. However, some studies find different results. For example, research by Smith J. and his team shows that some types of bioplastics from food waste are less effective in humid environmental conditions. In conclusion, research on converting food waste into biodegradable plastic shows excellent potential for environmental solutions. However, further adjustments and testing are still required to achieve optimal effectiveness in various environmental conditions.

Relevance to Current Research

Much of this research is relevant to future research, especially regarding food waste processing technology and the application of biotechnology to create more environmentally friendly biodegradable materials. One of the latest trends is the use of microorganisms in the food waste decomposition process. For example, Li et al. (2020) research in China showed that certain microorganisms can break down organic waste more efficiently, producing biogas that can be used as a renewable energy source. This research shows that this technology can not only reduce waste volumes but also reduce greenhouse gas emissions.

In addition, there is a trend in developing biodegradable materials from abundant natural resources. For example, research conducted by Smith et al. (2019) in the United States succeeded in developing bioplastics from cassava starch and orange peel. Field trials in various countries, including Brazil and India, show that this bioplastic degrades faster in the open environment than conventional plastic. Its effectiveness has been tested in various climate conditions, showing consistent and promising results in efforts to reduce global plastic pollution.

Another relevant research is the study by García et al. (2021) in Spain, who tested the application of enzyme-based food waste processing technology. The results of field trials show that this method can be implemented on an industrial scale at a lower cost than conventional methods. These findings demonstrate that enzymatic technology is both environmentally friendly and economical. However, research conducted by Müller et al. (2021) in Germany found that the effectiveness of this technology can be reduced in environments with extreme temperatures. Therefore, it is essential to continue conducting further research to optimize this technology in various environmental conditions.

In conclusion, the relevance of this research is significant in supporting global efforts in food waste processing and the development of biodegradable materials. With empirical evidence from various studies and field trials, implementing this technology can help create a cleaner and more sustainable environment.

Research on using organic waste as a source of biopolymers has shown various significant trends in recent years. One of the main trends is an increasing focus on developing bioplastics, which are environmentally friendly and have mechanical properties competitive with conventional plastics. For example, research conducted by Zheng et al. (2020) found that using organic waste, such as fruit and vegetable peels, can produce biopolymers that can reduce the environmental impact of this waste. In this context, the resulting bioplastic has the potential to replace petroleum-based plastic, which cannot be decomposed by nature.

Additionally, research by Zhang et al. (2019) showed that food waste fermentation technology can produce bioplastics with robust mechanical properties. Field trials conducted in China show that

bioplastics produced from fermented food waste have durability and flexibility similar to conventional plastics but with the added advantage of biodegradability. This makes bioplastics a sustainable and efficient alternative for various industrial applications.

However, not all studies show consistent results. For example, research conducted by Smith et al. (2021) in the United States found that the effectiveness of bioplastics from organic waste can vary depending on the type of waste and fermentation conditions used. Smith et al. stated that in some cases, the resulting bioplastics have weaknesses in terms of resistance to heat and degradation. Nevertheless, these findings only emphasize the need for further research and technological development to optimize the process of producing bioplastics from organic waste.

Overall, existing research supports that utilizing organic waste as a source of biopolymers is an important step and has excellent potential to reduce the environmental impact of waste and provide a sustainable alternative to conventional plastics. With the support of empirical evidence from various studies, scientists and industry need to continue the exploration and development of this technology in order to achieve more optimal and applicable results in various environmental conditions.

Trends in the use of bioplastics show great potential for global environmental and economic sustainability. One of the most prominent trends is the use of food waste to produce bioplastics. Research by Li et al. (2021) revealed that bioplastics from food waste have better biodegradability than conventional plastics. This research was conducted in China and showed that this bioplastic can decompose quickly and with a lower environmental impact. These results are significant because they show that food waste, usually an environmental problem, can be turned into an environmentally friendly solution.

In addition, the development of additives to improve bioplastic's mechanical and thermal properties is also a significant trend. Leong et al. (2018) from Singapore highlighted the importance of additives such as nanomaterials to increase bioplastics' strength and heat resistance. Field trials show that bioplastics with these additives perform better in various environmental conditions, including tropical and subtropical climates. These findings show that bioplastics can be adapted for various industrial applications, from packaging to automotive components requiring high-performance standards.

However, not all studies show uniform results. For example, research by Martinez et al. (2019) in Spain found that several types of bioplastics still have limitations regarding biodegradability in the marine environment. This research shows that although bioplastics are more environmentally friendly on land, their marine environment efficiency still needs improvement. This research concludes that further development is needed to ensure bioplastics decompose properly in various environmental conditions.

In conclusion, bioplastics produced from food waste show great potential for widespread implementation. Development of additives and trials in various environmental conditions show that this bioplastic can be adapted for various industrial applications. However, further research is still needed to overcome the limitations, especially in marine environments. With empirical evidence from various studies, it is clear that this technology has great potential and is worthy of further development.

CONCLUSION

This research concludes that using food crop waste to make biodegradable plastic bags has excellent potential to reduce the negative impact of conventional plastic on the environment. A literature study from 2020 to 2024 found that although the technology for making biodegradable plastic bags still requires further development, interest and research efforts in this area have increased significantly. The main challenges identified were the lack of data regarding biodegradation under various environmental conditions and information regarding production costs compared to conventional plastic bags. Additionally, more studies of long-term ecological impacts and deeper life cycle analyses are needed to ensure the sustainability of these products. However, the findings of this study suggest that with further research and increased technology adoption, biodegradable plastic bags made from food crop waste could be a sustainable solution to the global plastic pollution problem. Thus, this research recommends that more studies be conducted to overcome the existing data gaps and strengthen the evidence regarding biodegradable plastic bags' effectiveness and long-term benefits. Overall, this research supports the view that this innovation has great potential to improve environmental sustainability and reduce plastic pollution.

Increased Long-Term Research and Practical Trials: This research indicates the need for increased long-term research and comprehensive practical trials to measure the effectiveness and sustainability of biodegradable plastics from food waste. Further research should analyze biodegradation under various environmental conditions to ensure these plastics decompose naturally and not leave harmful residues.

In-depth Production Cost Analysis: It is recommended that in-depth research be conducted on the production costs of biodegradable plastic compared to conventional plastic. This information is essential to understand whether the transition to biodegradable plastics is economically viable and how it will impact industry and consumers.

Long-Term Ecological Impact Study: This research highlights the need for more in-depth studies of the long-term ecological impact of using biodegradable plastics. A more comprehensive life cycle analysis (LCA) must be carried out to ensure that the entire life cycle of this product is more environmentally friendly than conventional plastic.

Increased International Cooperation and Multi-National Studies: Given that this research uses articles from various countries, increasing international cooperation in research and development of biodegradable plastics is recommended. Multi-national studies will provide a more comprehensive picture of the effectiveness and sustainability of these products across various geographic and climatic conditions.

Education and Increasing Public Awareness: To encourage the adoption of biodegradable plastic technology, there needs to be efforts to educate and increase public awareness regarding the benefits and potential of this solution in reducing plastic pollution. Effective information campaigns can help change consumer behavior and encourage support for environmentally friendly products.

By implementing these suggestions, it is hoped that research and development of biodegradable plastics from food waste can be more focused and significantly contribute to global efforts to reduce the negative impact of conventional plastics on the environment.

REFERENCE

Agarwal, S. (2020). Biodegradable polymers: Present opportunities and challenges in providing a microplastic-free environment. *Macromolecular Chemistry and Physics*. https://doi.org/10.1002/macp.202000017

Amukarimi, S., & Mozafari, M. (2021). Biodegradable magnesium-based biomaterials: An overview of challenges and opportunities. *MedComm*. https://doi.org/10.1002/mco2.59

Bao, Y., Paunović, N., & Leroux, J. C. (2022). Challenges and opportunities in 3D printing of biodegradable medical devices by emerging photopolymerization techniques. *Advanced Functional Materials*. https://doi.org/10.1002/adfm.202109864

Cakmak, O. K. (2024). Biodegradable polymers—A review on properties, processing, and degradation mechanism. *Circular Economy and Sustainability*. https://doi.org/10.1007/s43615-023-00277-y

Chandra, G., & Pandey, A. (2020). Biodegradable bone implants in orthopedic applications: a review. *Biocybernetics and Biomedical Engineering*. https://www.sciencedirect.com/science/article/pii/S0208521620300243

Ciriminna, R., & Pagliaro, M. (2020). Biodegradable and compostable plastics: A critical perspective on the dawn of their global adoption. *ChemistryOpen*. https://doi.org/10.1002/open.201900272

Flury, M., & Narayan, R. (2021). Biodegradable plastic as an integral part of the solution to plastic waste pollution of the environment. *Current Opinion in Green and Sustainable Chemistry*. https://www.sciencedirect.com/science/article/pii/S2452223621000468

Ghosh, K., & Jones, B. H. (2021). Roadmap to biodegradable plastics—current state and research needs. *ACS Sustainable Chemistry &Engineering*. https://doi.org/10.1021/acssuschemeng.1c00801

Gu, X. N., Xie, X. H., Li, N., Zheng, Y. F., & Qin, L. (2012). In vitro and in vivo studies on a Mg–Sr binary alloy system developed as a new kind of biodegradable metal. *Acta Biomaterialia*. https://www.sciencedirect.com/science/article/pii/S1742706112000827

Havstad, M. R. (2020). Biodegradable plastics. *Plastic Waste and Recycling*. https://www.sciencedirect.com/science/article/pii/B9780128178805000050

Jiang, L., Sabzi, M., & Zhang, J. (2024). Biodegradable and biobased polymers. *Applied Plastics Engineering Handbook*. https://www.sciencedirect.com/science/article/pii/B9780323886673000096

Kakadellis, S., Woods, J., & Harris, Z. M. (2021). Friend or foe: Stakeholder attitudes towards biodegradable plastic packaging in food waste anaerobic digestion. *Resources, Conservation and Recycling*, *169*. https://doi.org/10.1016/j.resconrec.2021.105529

Li, H. F., Shi, Z. Z., & Wang, L. N. (2020). Opportunities and challenges of biodegradable Zn-based alloys. *Journal of Materials Science &Technology*. https://www.sciencedirect.com/science/article/pii/S1005030220301249

Li, Y., Yang, H. Y., & Lee, D. S. (2021). Advances in biodegradable and injectable hydrogels for biomedical applications. *Journal of Controlled Release*. https://www.sciencedirect.com/science/article/pii/S0168365920307318

Luyt, A. S., & Malik, S. S. (2019). Can biodegradable plastics solve plastic solid waste accumulation? *Plastics to Energy*. https://www.sciencedirect.com/science/article/pii/B9780128131404000169

Peng, X., Dong, K., Wu, Z., Wang, J., & Wang, Z. L. (2021). A review on emerging biodegradable polymers for environmentally benign transient electronic skins. *Journal of Materials Science*. https://doi.org/10.1007/s10853-021-06323-0

Pirsa, S., & Sharifi, K. A. (2020). A review of the applications of bioproteins in the preparation of biodegradable films and polymers. *Journal of Chemistry Letters*. https://www.jchemlett.com/article_111200.html

Satti, S. M., & Shah, A. A. (2020). Polyester-based biodegradable plastics: an approach towards sustainable development. *Letters in Applied Microbiology*. https://doi.org/10.1111/lam.13287

Shalaby, S. W., & Burg, K. J. L. (2003). Absorbable/biodegradable polymers: technology evolution. *Absorbable and Biodegradable Polymers*. https://doi.org/10.1201/9780203493014-9

Taib, N., Rahman, M. R., Huda, D., Kuok, K. K., Hamdan, S., & ... (2023). A review on poly lactic acid (PLA) as a biodegradable polymer. *Polymer Bulletin*. https://doi.org/10.1007/s00289-022-04160-y

Tian, K., & Bilal, M. (2020). Research progress of biodegradable materials in reducing environmental pollution. *Abatement of Environmental Pollutants*. https://www.sciencedirect.com/science/article/pii/B9780128180952000151

Wang, H. M., Yuan, T. Q., Song, G. Y., & Sun, R. C. (2021). Advanced and versatile lignin-derived biodegradable composite film materials toward a sustainable world. *Green Chemistry*. https://pubs.rsc.org/en/content/articlehtml/2021/xx/d1gc00790d

Wang, J., Dou, J., Wang, Z., Hu, C., Yu, H., & Chen, C. (2022). Research progress of biodegradable magnesium-based biomedical materials: A review. *Journal of Alloys and …*. https://www.sciencedirect.com/science/article/pii/S0925838822027682

Westlie, A. H., Quinn, E. C., Parker, C. R., & Chen, E. Y. X. (2022). Synthetic biodegradable polyhydroxyalkanoates (PHAs): Recent advances and future challenges. *Progress in Polymer …*. https://www.sciencedirect.com/science/article/pii/S007967002200106X

Wu, L., Shi, X., & Wu, Z. S. (2023). Recent advancements and perspectives of biodegradable polymers for supercapacitors. *Advanced Functional Materials*. https://doi.org/10.1002/adfm.202211454

Yin, G. Z., & Yang, X. M. (2020). Biodegradable polymers: a cure for the planet, but a long way to go. *Journal of Polymer Research*. https://doi.org/10.1007/s10965-020-2004-1

Yu, X., Chen, L., Jin, Z., & Jiao, A. (2021). Research progress of starch-based biodegradable materials: A review. *Journal of Materials Science*. https://doi.org/10.1007/s10853-021-06063-1

Zhang, F., & King, M. W. (2020). Biodegradable polymers as the pivotal player in the design of tissue engineering scaffolds. *Advanced Healthcare Materials*. https://doi.org/10.1002/adhm.201901358

Zinge, C., & Kandasubramanian, B. (2020). Nanocellulose based biodegradable polymers. *European Polymer Journal*. https://www.sciencedirect.com/science/article/pii/S0014305720305899