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FROM CONVENTIONAL TO SUSTAINABLE: A COMPREHENSIVE REVIEW ON THE TRANSITION FROM CONVENTIONAL PLASTICS TO BIOPLASTICS DERIVED FROM ORGANIC WASTES

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ABSTRACT

Sustainable solutions are desperately needed as awareness of plastic pollution and its negative effects on the environment grows on a worldwide scale. Bioplastics, which are made from biological waste, present a viable answer to this problem. In this analysis, the potential for bioplastics to replace conventional plastics as a sustainable material is examined. Bioplastics are made from a variety of organic waste sources. The study focuses on current developments in the manufacturing of bioplastics, covering several methods for converting waste into bioplastics and the characterisation of the resultant biopolymers. Bioplastics' prospective uses, biodegradability, and environmental advantages are also covered. Additionally, the difficulties and potential benefits of using organic waste for the creation of bioplastics are discussed, providing additional research and development insights.

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Keywords: Waste management, Plastic pollution, Challenges, Bioplastic, Biodegradable, Environment.

INTRODUCTION

Plastics have revolutionized several sectors and consumer goods, becoming an essential component of contemporary life. However, the widespread usage of traditional plastics made from fossil fuels has led to serious environmental issues, mostly because they are not biodegradable and remain in the environment for an extended period of time. Bioplastics have come to light as a viable solution to these problems, with the potential to have less of an adverse effect on the environment and to be more sustainable. This comparative research seeks to examine the fundamental distinctions between conventional plastics and bioplastics, illuminating their creation, characteristics, effects on the environment, and prospective uses. We can learn a lot about how various plastics contribute to the development of a more environmentally friendly and sustainable future by knowing the advantages and disadvantages of each substance. The inappropriate disposal of organic waste places a heavy strain on the ecosystem, including soil degradation and greenhouse gas emissions. In order to solve this problem, researchers are focusing on using organic waste to create bioplastics. Many forms of organic waste have been investigated for their potential in the creation of bioplastics, including wastewater sludge, food scraps, and agricultural leftovers.

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Table 1: Overview of various raw materials/resources used in the production of bioplastics.

S.NO	RESOURCES/RAW MATERIALS	BIOPOLYMER TYPE
1.	Corn, Potato, Rice, Wheat, Cassava	Starch based bioplastic(5)
2.	Sugarcane, Corn	Polylactic acid [PLA]
3.	Sugarcane, Corn, Vegetable matter	Polyhydroxyalkanoates [PHA]
4.	Corn, Vegetable oils	Polybutylene adipate terephthalate [PBAT]
5.	Potato, Sugarcane, Corn, Cassava	Polybutylene succinate [PHS]
6.	Microorganisms, mostly bacteria	Polyhydroxybutyrate [PHB]
7.	Crude oil derivatives	Polycaprolactone [PCL]
8.	Vegetable waste, Sugarcane, Corn	Polyethylene terephthalate [Bio-PET]

METHODOLOGY

Fermentation is a popular technique for creating bioplastics from organic waste. In this process, microorganisms convert the organic material into biopolymers like polyhydroxyalkanoates (PHA) and polylactic acid (PLA), among others(6). Low manufacturing costs, great biodegradability, and flexibility in polymer characteristics are only a few benefits of fermentation. In order to increase the efficiency of the conversion process, researchers have also looked at the use of enzyme-catalysed methods to transform certain organic waste components into bioplastics.(7) The manufacture of bioplastics comprises a number of processes, each with benefits and drawbacks as of my most recent update in November 2022——"(8). Bioplastics are more ecologically friendly than conventional plastics made of petroleum since they are made from renewable resources including plants, microbes, and algae. Here are some typical techniques for creating bioplastics.

Starch-based Bioplastics

These bioplastics main source of feedstock is starch, a carbohydrate found in plants including corn, potatoes, and cassava. Starch from the crops is extracted, processed, and then turned into bioplastic products. Although biodegradable, starch-based bioplastics have drawbacks in terms of their ability to withstand water and their mechanical characteristics—(5).

Polylactic acid Bioplastics

Popular bioplastic which is known as PLA is created by fermenting plant sugars, typically from maize or sugarcane. Lactic acid is created by dissolving the sugars, and after being polymerized, it becomes PLA.–(9) In a variety of applications, PLA bioplastics can take the place of conventional petroleum-based plastics due to their excellent transparency and biodegradability.

Polyhydroxyalkanoates [PHA] Bioplastics

PHA bioplastics are created by certain bacteria through the microbial fermentation of organic resources like sugars or plant oils. These raw materials are transformed by the bacteria into PHA, a biodegradable and adaptable bioplastic(10). Depending on the particular monomer makeup, PHA is renowned for having a wide variety of characteristics.

Polyhydroxybutyrate [PHB] Bioplastics

A particular kind of PHA bioplastic known as PHB is created when bacteria digest carbohydrates or other carbon sources. PHB is appropriate for a variety of applications since it has qualities that are comparable to those of conventional polypropylene. However, compared to other bioplastics, its manufacture might be more expensive(11).

Polyethylene Bioplastics

Although it is made from renewable resources, such as sugarcane ethanol, Bio-PE is a bioplastic that is chemically identical to conventional polyethylene.(11) A drop-in bioplastic that may be utilized in the current infrastructure for the manufacturing of polyethylene is produced by the polymerization of ethylene generated from sugarcane.

Polybutylene succinate [PHS] Bioplastics

The polymerization of succinic acid and 1, 4-butanediol, both are derived from renewable resources, results in PBS. The PBS bioplastics are versatile and have strong mechanical characteristics.

PROPERTIES OF BIOPLOYMER

1. **Renewable Source:** Bioplastics are produced using renewable natural resources including potato, sugarcane, maize starch(12), and even garbage. The replenishment of these resources is necessary for their production, which lessens the need on fossil fuels.
2. **Biodegradability:** Bioplastics' capacity to decay, or to be spontaneously converted by microbes into innocuous substances like water, carbon dioxide, and biomass, is one of its important characteristics. This lessens trash and environmental contamination(13).

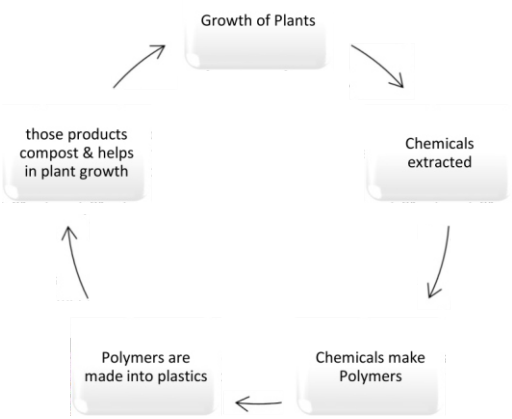
3. **Versatility:** Bioplastics may be developed to have a broad variety of physical qualities, making them appropriate for a number of applications including textiles, medical devices, disposable cutlery, agricultural films(14), and packaging.
4. **Smaller Carbon Footprint:** Bioplastics usually have a smaller carbon footprint than traditional plastics because they produce less greenhouse gases during manufacture, especially when they come from renewable feed stocks.
5. **Non-Toxic:** The majority of bioplastics are non-toxic and don't produce dangerous chemicals when used or thrown away. They are suitable for medical and food packing because of this quality(15).
6. **Bio-based Content:** Bioplastics are categorized according to how much of renewable raw materials were utilized during manufacture, which is known as their bio-based content. A higher percentage of bio-based materials have a better effect on sustainability(16).
7. **Mechanical Strength:** Bioplastics can have strong mechanical strength and durability, enabling them to survive certain stress conditions and function suitably in a variety of applications, depending on their kind and composition.
8. **Water Resistance:** For some applications where moisture contact is a problem, bioplastics that demonstrate water resistance are required.
9. **Compostability:** Under certain circumstances, some bioplastics may be composted(17), which means they decompose into compost, a useful source of nutrients for plants.
10. **Cost and Scalability of manufacture:** The affordability and scalability of the manufacture of bioplastics are key determinants of their broad adoption. Their costs are anticipated to decrease as technology develops and production quantities rise.

Table 2: Outlining the solubility, biodegradability, applications of bioplastics from various resources.

S. NO	Raw materials	Type of Bioplastic	Solubility	Biodegradable	Application
1.	Corn starch	PLA	Hot water	Yes	Packaging industry
2.	Potato starch	TPS [Thermoplastic starch]	Hot water	Yes	Single use items
3.	Sugarcane	Polyhydroxy alkanoates	Insoluble in water	Yes	Used in packaging
4.	Wheat straw	Wheat straw bioplastics	Insoluble in water	Yes	Used in agricultural films & disposable products.
5.	Cassava	Cassava based bioplastics	Soluble in water	Yes	Various applications

In general, bioplastics are very promising as they are long-lasting substitute for traditional plastics, and also helps to create a cleaner and greener future. But it's crucial to weigh their advantages against thorough evaluation of their particular uses, end-of-life care, and potential environmental effects over the course of their life cycles,

LIFE CYCLE OF BIOPLASTICS



SPECTRAL CHARACTERISATIONS

To guarantee that bioplastics made from organic waste are suitable for various uses, it is essential to characterize them. Studies have demonstrated that by modifying fermentation conditions and waste content, it is possible to control the characteristics of biopolymers and produce bioplastics with the necessary mechanical, thermal, and barrier qualities. Because they lessen the need for fossil fuels and prevent the build-up of conventional plastics in the environment, bioplastics made from organic waste have a significant positive impact on the environment. Under the right circumstances, these bioplastics also exhibit high biodegradability, reducing the possibility of long-lasting contamination.

High-resolution imaging of the bioplastic surface using **SEM(19)** reveals its topography, porosity, and shape. This method makes it easier to comprehend how processing variables affect the surface properties of the finished product. Bioplastics' chemical composition and structural traits may be ascertained using **FTIR(20)**, which recognizes molecular vibrations and functional groups. In order to evaluate the optical characteristics and transparency of the materials, **UV-Visible spectroscopy** examines the absorption of light by bioplastics in the ultraviolet and visible spectrums. **Raman spectroscopy** aids in the characterisation and evaluation of materials by providing data on molecular vibrations, crystallinity, and phase transitions in bioplastics. By examining how bioplastic molecules interact with magnetic fields, **NMR** spectroscopy can shed light on the chain structure, degree of polymerization, and type of polymerization.

CONCLUSION

In creating bioplastics from organic waste is a possible solution to the problems associated with waste management and plastic pollution. A circular economy, in which trash is used as a valuable resource, may be created by integrating sustainable waste-to-bioplastic technologies, minimizing the total environmental effect. Realizing the full potential of bioplastics made from organic waste would depend heavily on on-going study and collaboration between academics, business, and policymakers. Despite the enormous advancements made in the creation of bioplastics from organic waste, several obstacles still exist. For widespread deployment, problems with scalability, trash collection, and conversion process optimization must be resolved. Additionally, economic aspects like the cost-effectiveness of producing bioplastics in comparison to traditional plastics must be carefully considered.

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REFERENCES

1. **Vethaak AD, Leslie HA.** Plastic Debris is a Human Health Issue. *Environ Sci Technol*. 2016 Jul 5;50(13):6825–6.
2. **Vinci G, Ruggieri R, Billi A, Pagnozzi C, Di Loreto MV, Ruggeri M.** Sustainable management of organic waste and recycling for bioplastics: A lca approach for the italian case study. *Sustain*. 2021 Jun 1;13(11).
3. **RameshKumar S, Shaiju P, O'Connor KE, P RB. B**io-based and biodegradable polymers - State-of-the-art, challenges and emerging trends. *Curr Opin Green Sustain Chem*. 2020 Feb 1;21:75–81.
4. **Bhatia SK, Otari S V., Jeon JM, Gurav R, Choi YK, Bhatia RK, *et al*.** Biowaste-to-bioplastic (polyhydroxyalkanoates): Conversion technologies, strategies, challenges, and perspective. *Bioresour Technol*. 2021 Apr 1;326:124733.
5. **Shafqat A, Al-Zaqri N, Tahir A, Alsalme A.** Synthesis and characterization of starch based bioplatics using varying plant-based ingredients, plasticizers and natural fillers. *Saudi J Biol Sci.* 2021 Mar 1;28(3):1739–49.
6. **Emadian SM, Onay TT, Demirel B.** Biodegradation of bioplastics in natural environments. *Waste Manag*. 2017 Jan 1;59:526–36.
7. **Avérous L, Pollet E.** Biodegradable Polymers. Green Energy Technol. 2012;50:13–39.
8. **Rosenboom JG, Langer R, Traverso G.** Bioplastics for a circular economy. Vol. 7, Nature Reviews Materials. 2022.
9. **Jõgi K, Bhat R.** Valorization of food processing wastes and by-products for bioplastic production. Sustain Chem Pharm. 2020 Dec 1;18:100326.
10. **Fra-Vázquez A, Palmeiro-Sánchez T, Del Río AáV, Mosquera-Corral A.** Transformation of organic contamination from wastewater into bioplastics (polyhydroxyalkanoate) by microorganisms. In: Wastewater Treatment Residues as Resources for Biorefinery Products and Biofuels. 2019.
11. **Price S, Kuzhiumparambil U, Pernice M, Ralph PJ.** Cyanobacterial polyhydroxybutyrate for sustainable bioplastic production: Critical review and perspectives. *J Environ Chem Eng.* 2020 Aug 1;8(4):104007.

12. **Chel-Guerrero L, Barbosa-Martín E, Martínez-Antonio A, González-Mondragón E, Betancur-Ancona D.** Some physicochemical and rheological properties of starch isolated from avocado seeds. *Int J Biol Macromol*. 2016;86.
13. **Atiwesh G, Mikhael A, Parrish CC, Banoub J, Le TAT.** Environmental impact of bioplastic use: A review. *Heliyon*. 2021;7(9).
14. **Prosperi M, Sisto R, Lombardi M, Zhu X.** Production of bioplastics for agricultural purposes: A supply chain study. Rivista di Studi sulla Sostenibilita. 2018.
15. **Khorami M, Arti H, Ghasemi M, Fakoor M, Moosavi S, Heidari S, et al.** Biodegradable plastic production from fruit waste material and its sustainable use for green applications. *Int J Pharm Res Allied Sci*. 2016;5(2).
16. **Coppola G, Gaudio MT, Lopresto CG, Calabro V, Curcio S, Chakraborty S.** Bioplastic from Renewable Biomass: A Facile Solution for a Greener Environment. *Earth Syst Environ* [Internet]. 2021;5(2):231–51. Available from: https://doi.org/10.1007/s41748-021-00208-7
17. **Pantaloni D, Rudolph AL, Shah DU, Baley C, Bourmaud A.** Interfacial and mechanical characterisation of biodegradable polymer-flax fibre composites. *Compos Sci Technol*. 2021;201.
18. **Ruggero F, Gori R, Lubello C.** Methodologies to assess biodegradation of bioplastics during aerobic composting and anaerobic digestion: A review. Vol. 37, Waste Management and Research. 2019.
19. **Hidayani TR, Iftari W, Salim E.** Comparison reflux and melt blending method in preparation of biodegradable plastic from high density polyethylene (HDPE) plastic waste and starch from palm oil empty fruit bunch. In: AIP Conference Proceedings. 2020.
20. **Hafeez MA, Maan AA, Butt MS, Zia MA.** Development and characterization of biodegradable food packaging films from food industrial wastes. *Pakistan J Agric Sci*. 2021;58(2).