Sustain

SHORT COMMUNICATION
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Are Bioplastics a Sustainable Alternative to Single-Use Plastic? A Pilot Project at the University of South Florida

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ABSTRACT

Campaigns to ban single-use plastics have spread globally, increasing awareness about plastic pollution and driving consumer demand for bioplastics alternatives. Consumer perception is that plastics derived from plants are compostable. Biodegradable and compostable products are not the same. Arguably, everything will eventually biodegrade. Compostable, however, signifies that the product will decompose into the soil within a timeframe. A USF pilot research study has launched investigating the efficacy of single-use bioplastics in a home compost environment. The results will provide consumers with green product recommendations, call attention to the interdependence between bioplastics and Industrial Composting Facilities, and encourage behavior supportive of sustainable, reusable alternatives aligned with the SDG's.

Keywords: Bioplastics, Single-use plastics, PLA, Compostable plastics, SDGs.

INTRODUCTION

Single-use plastic pollution is overwhelming the planet. The reduction of single-use plastics is part of many sustainability initiatives around the globe, including the UN Sustainable Development Goals. Although sustainability can be challenging to define, many follow the Brundtland definition, "sustainability focuses on meeting the needs of the present without compromising the ability of future generations to meet their needs." (World Commission on Environmental and Development, 1987). Sustainability has become a buzzword used in trendy marketing campaigns by corporations reliant on consumerism for economic growth. However, the well-being of the environment, ecosystems, and future generations' welfare is not necessarily at the core of these flashy sustainability plans. Greenwash prefixes like "bio-" "eco-", and "plant-based" plastics mislead consumers into justifying purchasing behavior while neglecting to address the underlying need for responsible consumption. The misperception held by consumers is

bioplastics are biodegradable (Choe *et al.*, 2021). For example, polylactic acid (PLA) are plastics derived from plant-based polymers found in corn, cassava, and sugar cane (Oyedeko *et al.*, 2022). Polyhydroxyalkanoate (PHA) are plastics made from canola oil. Both PLA and PHA are derived from renewable bioresources. However, the materials are chemically processed to form a composite with a molecular structure of long-chain polymers nearly identical to fossil fuel-based plastic counterparts (California Organics Recycling Council, 2011). Specifically, in the food industry, these bioplastic products are manufactured into durable cutlery, plates, cups, and straws matching in color, size, and weight as traditional plastics, making it difficult for end-users to differentiate, resulting in contamination of waste streams. In most cases, bioplastics and single-use petro based plastics have a cradle-to-grave lifecycle that is not truly sustainable (Folino *et al.*, 2023).

Since many bioplastics are engineered to perform the same as conventional single-use plastics, some bioplastics can remain structurally intact for hundreds of years in the environment (California Organics Recycling Council, 2011). Theoretically, products advertised as 100% biodegradable should completely decompose in soil or water within one year of disposal (EPA, n/d). Whereas compostable plastics imply, the product will biodegrade at a rate consistent with other compostable material in less than six months, returning to the soil, leaving no visible trace or toxic residue (California Organics Recycling Council, 2011). In the United States, the labeling of compostable plastics must meet the American Society for Testing and Materials (ASTM) standard specification D6400 and 6868 designations that the bioplastics are designed to be composted aerobically in the high temperatures found in municipal or industrial facilities (ASTM, 2019). The Biodegradable Products Institute (BPI) is a non-profit with the most extensive certification program in North America. BPI is considered the gold standard of compostable certifications and stipulates that bioplastic products biodegrade within 180 days in an industrial composting facility to be certified (BPI, 2021). Similarly, the European Bioplastics seedling logo verifies that the products meet the European Standard EN 134323 by two reputable accreditations, DIN CERTCO and TUV AUSTRIA, mark products for municipal composting only (European Bioplastics, 2018). The European Bioplastics has declared that products certified with the Seedling Logo are no longer allowed to contain any trace amounts of PFAS in response to address the rising public concern over poly-fluoroalkyl substances (PFAS) in food packaging (European Bioplastics, 2021).

Unfortunately, most cities throughout the U.S. lack the commercial composting infrastructure to manage the end of life for the bioplastics waste (Sustainable

Packaging Coalition, 2021). As a result, bioplastics often face a similar fate as conventional plastics are buried in landfills or incinerated, missing the opportunity to decompose into healthy soil used in food production (Briassoulis, Pikasi, & Hiskakis, 2019). Alternatively, compostable products designed less rigid like thin bio bags are more likely to decompose in environmental conditions found in a typical backyard compost. Although, the U.S. has not established a standard specification for home compost certification, nor has the EU. However, Australia and New Zealand have developed the Australian Standard AS 5810-2010 accreditation for bioplastics suitable to decompose in a home compost. The verification logo that identifies bioplastics suitable helps differentiate packaging materials as biodegradable and compostable so that they can decompose into humus, a valuable resource for the circular economy (Australasian Bioplastics Association, n/d).

RESEARCH DESIGN

A USF pilot research study launched in the Fall of 2021 by this author investigates the efficacy of biodegradable single-use compostable plastics in a typical backyard compost environment at the Rosebud Continuum Sustainability Education Center. The goal is to collect data, analyze results, and provide consumers and other key stakeholders with sustainable product recommendations. In addition, the project aims to raise awareness about the interdependence between bioplastics and Industrial Composting Facilities and encourage behavior supportive of earth-friendly reusable alternatives. The research findings will inform, inspire, and create adaptative solutions to eliminate single-use plastic through a systems thinking nexus approach aligned with the United Nations Sustainable Development Goals. The recommendations will be distributed to organizations that support eliminating single-use plastic, such as Ocean Allies, Keep Pinellas Beautiful, Visit St. Pete Clearwater, and the Florida Restaurant & Lodging Associations. Moreover, the research will be shared with local municipalities and the Tampa Bay Regional Planning Council to advocate for new infrastructure to channel waste streams to industrial composting facilities.

METHODOLOGY

The research design adopts a mixed-methods approach to simulate the environmental conditions in a typical backyard compost to study the decomposition rate of multiple types of PLA and PHA used in the food service industry. The purpose of the study will document a variety of brands divided into three separate test groups per **Table 1.** The brand comparison Group 1 will test identical products by three manufacturers

shredded and covered with compost. The controlled study Group 2 will study how these products behave in the natural environment as litter compost free. The randomized study Group 3 will investigate whether adding digestate from the on-site anaerobic digester will help to accelerate the decomposing process of the shredded bioplastics covered with compost. The research will reflect primary fieldwork and will be compared to secondary data for comparative analysis. Weekly observations will collect quantitative data to measure the weight of materials added, the temperature of the compost, weather conditions, and the amount of turning the pile. A compost thermometer will test the temperature of the compost. Materials added to the compost are weighed using a scale to track the amount of food waste (nitrogen), yard waste mulch (carbon), water, digestate, and bioplastics. The digestate will test for the pH, N, P, NH_4 levels. The qualitative data examining other case study research will be reviewed to identify correlations in the process of observation. The interdisciplinary approach of the pilot project aims to generate awareness of bioplastics and extinguish misconceptions consumers have about the feasibility of plant-based products that can biodegrade in any environment.

Sample ID		Product	Brand	Composite	Certified	Color	Condition	Compost Type
Group 1 - Rows 1 and 2 - Product brand comparsion								
GIA	GIA-01	Straw	EcoProducts	PLA	compostable	clear	shredded	compost pile
	GIA-02	Fork	Auburn Supply	PLA - wood	compostable	natural	shredded	compost pile
	GIA-03	Cup	Greenware	PLA7 (16)	compostable	clear	shredded	compost pile
GIB	GIB-04	Straw	Phade	PHA - Canola Oil	marine, home, industrial	clear	shredded	compost pile
	GIB-05	Fork	World Centric	PLA	compostable	white	shredded	compost pile
	GIB-06	Cup	World Centric	PLA	compostable	clear	shredded	compost pile
GIC	GIC-07	Straw	Stalk Market	PLA	compostable	clear	shredded	compost pile
	GIC-08	Fork	Jaya	PLA	compostable	black	shredded	compost pile
	GIC-09	Cup	Jaya	PLA	compostable	clear	shredded	compost pile
Group 2 - Rows 3 and 4 - GIIA : Control group full size "litter" compost free								
GIIA	GIIA-011	BioBags	Beyond Green	PLA	marine, home, industrial	green	full size	compost free
	GIIA-012	Knife	Auburn Supply	PLA - wood	compostable	natural	full size	compost free
	GIIA-013	Cup	Greenware	PLA7 (16)	compostable	clear	full size	compost free
	GIIA-014	Straw	EcoProducts	PLA	compostable	clear	full size	compost free
	GIIA-015	Straw	Phade	PHA - Canola Oil	marine, home, industrial	clear	full size	compost free
	GIIA-016	Cup	Fabri-Kal Greenware	PLA	compostable	clear	full size	compost free
Group 3 - Rows 3 and 4 - GIIIB & GIIIC : Randomized group compost using anaerobic digestate								
GIIIB	GIIIB-017	BioBags	Beyond Green	PLA	marine, home, industrial	green	full size w/ dog poop	compost w/digestate
	GIIIB-018	Spoon	Jaya	PLA	compostable	black	shredded	compost w/digestate
	GIIIB-019	Straw	EcoProducts	PLA	compostable	clear	shredded	compost w/digestate
GIIIC	GIIIC-020	BioBags	Beyond Green	PLA	marine, home, industrial	green	shredded	compost w/digestate
	GIIIC-021	Plate	World Centric	PLA	compostable	natural	shredded	compost w/digestate
	GIIIC-022	Cup	Fabri-Kal	PLA	compostable	clear	shredded	compost w/digestate
	GIIIC-023	Knife	Jaya	PLA	compostable	black	shredded	compost w/digestate

Table 1: Product Inventory

Source: The author's research analysis of product composition, certification, color condition, and compost type are separated into three groups: brand comparison, controlled group, and randomized group.

SCOPE

The scope of the study will investigate the rate of composability of identical items made by multiple manufacturer identical conditions in direct sunlight. The food service bioplastic items include straws, cutlery, bio bags, cups, and plates. **Figures 1 and 2** show that the compost design consists of four windows 10 feet long by 3 feet wide. Each row contains 3 feet wide dividers to control test specifications. Group 1 will consist of rows one and two to test similar products by three different brands that will be shredded using handheld scissors, and one of each product will be deposited in each 3 x 3 section. A mixture of food waste (green) and dry mulch (brown) plus water as needed will be added to the piles weekly. Group 2 will consist of rows three and four, known as the controlled group

2, with the bioplastics deposited in the 3' x 3' full size like "litter" exposure to full sun, rain without any compost. Group 3 will be placed in sections b and c in rows three and four, consisting of shredded bioplastics that receive the same compost mixture of food waste, dry mulch, and water plus biodigester digestate. The piles will be covered with dark permeable fabric to aid in raising the temperature required for decomposing while also providing the aerobic conditions suitable for the microbes to break down the bioplastics. The controlled group 2 will be the exception. The piles for groups 1 and 3 will be flipped over from one row to the adjacent row to aid the decomposition weekly. Data collected will be annotated once a week for one year to account for ambient temperature, compost temperature, compost moisture, the weight of compost or digestate added, and the decomposition rate of each group according to the sample id. A quarterly soil test will be completed at the start and finish.

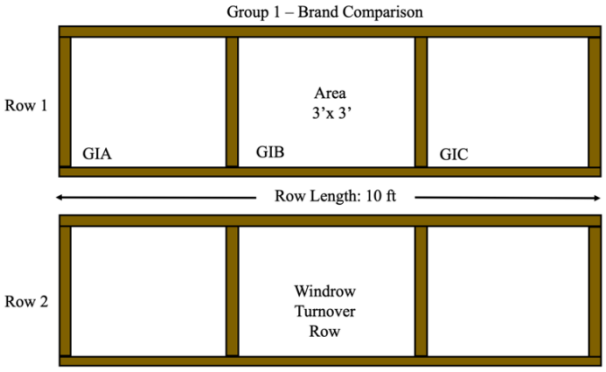

Figure 1

Source: Group 1 Brand comparison for windrows row 1 and 2.

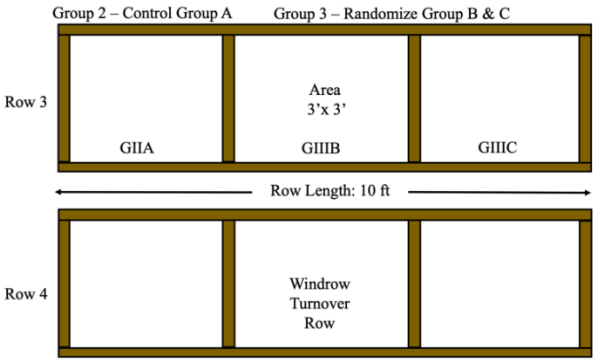

Figure 2

Source: Group 2 Control group A and Group 3 randomized group B and C windrows.

CONCLUSION

Eco-friendly products are not guaranteed to be earth-friendly. The end-of-life management of bioplastics is essential for the future of the circular economy. A paradigm shift towards reducing consumption, reusing the products we already have, and designing better solutions for the existing plastics (Ellen MacArthur Foundation, n/d). Worth mentioning that bio-plastics derived from biomass that could be used to feed the world or as feedstock for livestock make bioplastics a controversial topic due to food security issues and the rapid growth of the population. In addition, the potential impact caused by land-use change for the bio-economy needs to be addressed through nexus thinking with an equal value of Food, Energy, Water and

how that translates to the environment and socio-economic impacts.

Furthermore, the cost of bioplastics derived from biowaste resin material must reach scale to be a viable solution in the food service industry. Therefore, SDG 12 responsible consumption must be the north star for decision-makers for a sustainable future (UN, n/d). And while I am curious to find out whether the digestate from the biodigester will play a role in the decomposition rate, I expect the results will prove that the bio bags and maybe the marine grade straws will decompose in one year.

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