The Ripe Type of Plastic: Developing Bio-Based Plastics from Food Waste

Kareena Kanumury

Introduction / Why it matters

Plastic usage, especially single-use plastics, has increased tremendously in the past years and is a significant contributor to waste in landfills. Companies have traditionally turned to bioplastics to combat plastic waste in landfills as a potential solution. However, the production of bioplastics often incorporates toxic chemicals, and their decomposition often produces toxic byproducts.

Bio-based plastics are a potential solution to the shortcomings of traditionally used bioplastics. Bio-based plastics differ in that they are solely derived from organic products, compostable, and are generally not harmful to the environment.

PROCEDURE OVERVIEW

DEVELOPMENT

Due to the prevalence of food-waste in landfills, this project focused on repurposing commonly found waste products. The bio-based plastics incorporated food-waste such as potatos, avocados, bread, and milk.

TESTING

Heat test

The bio-based plastics were placed in the oven and the amount of time it took for each bio-based plastic to change structure was recorded.

Water Absorption

The bio-based plastics were submerged in water, and the water absorbtion of each plastic was recorded.

ENVIRONMENTAL APPLICATIONS

To assess the impact the plastics have on the environment, samples of each bio-based plastic were placed in plants, and the growth along with observations of the plants were recorded.

DATA + STATISTICS

Following data collection, a T-test will be used to compare the control group to the experimental groups.

Procedures

In order to develop the food waste derived bio-based plastics the following steps were carried out for each of the bio-based plastics.

Potato Starch:

1. Combine potato starch, acetic acid, water, glycerol, and food coloring and stir contents for approximately 30 seconds
2. Heat contents on a low flame and add vegetable oil. While heating add the potato starch into pot.
3. Stir until the texture turns from a liquid to a thick, stretchy, sticky substance
4. Allow contents to cool for 24 hours until the plastic is dry

Milk:

1. Combine refrigerated 2% milk, vinegar and glycerin
2. Heat the contents on a medium flame and once they are at a boil add vinegar once more
3. Once the milk has curdled strain the contents into a separate container
4. Using paper towels press the solidified contents to drain the excess liquid
5. Leave the contents to cool for 12 hours until the plastic is dry

Bread:

1. Dehydrate bread in the oven for about 30 min
2. Blend the bread into a fine powder
3. In a pot, heat and combine water and gelatin and later add in glycerol, and the bread powder and stir until well combined
4. Pour mixture into a mold and weight 12 hours to dry

Avocado Pits:

1. Separate avocado pits and dry them for 72 hours
2. Cut each pit, blend . dehydrate, and blend the mixture until the pits turn into a fine powder
3. In a pot, heat and combine water, gelatin, guclerol and then add the avocado mixture and stir until well combined
4. Leave to dry for 48 hours

Disclaimer: specific quantities are listed in the logbook

Testing Overview

The following tests served to compare the four bio-based plastics, the commercially available bio-plastic and plastic.

Heat

The heat test assessed the amount of time it took for each plastic group to change structure after being exposed to 350 degrees Fahrenheit.

Water Absorption

The water absorption test measured the amount of water each plastic could hold.

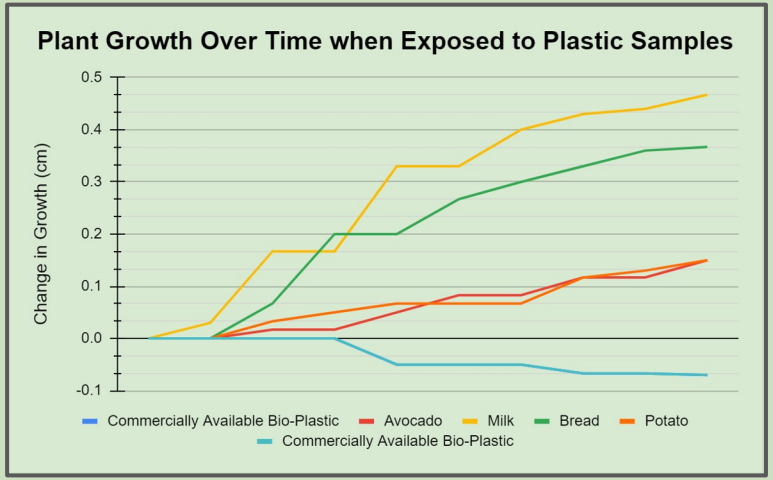
Plant Growth

The plant growth test aimed to understand the effect each plastic had on plant growth. Each type of plastic was placed beside a plant and observations about the plant's health and height were recorded.

Summary of Data

Water Absorption Test

Type of Plastic	Average Percent% Water Absorbed of each Plastic
Commercial Bioplastic	231.167%
Avocado Bio-Based Plastic	158.913%
Milk Bio-Based Plastic	133.023%
Potato Starch Bio-Based Plastic	136.71%
Bread Bio-Based Plastic	171.263%



Heat Test

Type of Plastic	Time in Minutes for Visible Structural Changes
Commercial Bioplastic	1 min 27 seconds
Avocado Bio-Based Plastic	Maintained the same structure throughout the 50-minute duration
Milk Bio-Based Plastic	Maintained the same structure throughout the 50-minute duration
Potato Starch Bio-Based Plastic	Maintained the same structure throughout the 50-minute duration
Bread Bio-Based Plastic	Maintained the same structure throughout the 50-minute duration

Statistical Analysis

Type of Material	T-Value	P-Value	Null Hypothesis: Accept or Reject
Bread Bio-Based Plastic vs. Commercially Available Bioplastic	-5.313	0.000024	Rejected
Avocado Bio-Based Plastic vs. Commercially Available Bioplastic	-4.982	0.000048	Rejected
Milk Bio-Based Plastic vs. Commercially Available Bioplastic	-5.609	0.000013	Rejected
Potato-Starch Bio-Based Plastic vs. Commercially Available Bioplastic	-5.438	0.000018	Rejected

Conclusion

Following all the tests it was found that the bread plastic has the most promise because they showed better results in all three tests.

Heat Test: the bread plastic kept its form throughout the duration of the test, while the commercial bioplastic changed form within the 3 minutes.

Water absorption test: the bread plastic was statistically similar to the bread plastic.

Growth Test:, the bread plastic grew on average 0.4 cm while the commercial bioplastic decreased height by approximately 0.1 cm. The plants with the commercial bioplastics were seen to wilt quicker than the the other plants with bio-based plastics.

Cost: The Bread Bio-Based plastic and the Milk Bio-Based plastic are 13.13% and 10.89% cheaper than the commercially available plastic respectively.

Future Applications

Packaging

Plastic products and packaging take up nearly 322 million tons in landfills around the world. Due to the rise in online shopping, plastic packaging is one of the most commonly found items in landfills today. To alleviate this issue, the bioplastics developed can be modified to replace currently available plastic packaging such as packing peanuts and bubble wrap as a more sustainable solution.

Medical equipment

Single use plastics including disposable gloves and masks, dialysis bags, and disposable syringes account for 20% to 25% of medical waste in landfills. Bio-based plastics have the potential to replace single-use plastic medical equipment due to their durability and cost-effectiveness.

Disposable Food Products

The fast food industry produces approximately 15% of the waste entering landfills. Majority of the waste in from the food industry is due to disposable forks, spoons, packaging containers, and plastic plates. By incorporating bio-based plastics into cutlery and food packaging, we can hope to see a 33% decline in food sector waste in landfills,

Future Research

Edible Bio-based Plastic
Approximately 33 million cubic miles of municipal solid waste occupy the ocean and cause harm to marine life. To assess if bio-based plastics can prevent further harm to marine life, the interaction between daphnia magna (a commonly found water organism) and bio-based plastic can be assessed. The biological functioning of daphnia magna (i.e heartbeat) when exposed to bio-based plastics can provide a better look into their environmental viability.

Elasticity
The bio-based plastics can be use packaging materials and single-use disposable gloves that use latex or PET, future research should be done to add a material to make the bio-based plastic more elastic. Currently, in plastics today, polyethylene coatings allow for plastics to be flexible and more elastic. To replicate this stretchiness, materials comparative to the chemical structure of polyethylene should be researched and added to the given plastics to make them more elastic.

Leachate
As other plastics when decomposing in landfills create a substances with leachate, these bio-based plastics should be tested in an environment highly similar to a landfill (same temperature changes, rainfall, ect) and test whether amount of leachate production remains the same or reduces. Leachate reduction can help reduce contamination and harm to the lives of humans and animals.