Formulating and Evaluating an Epazote-Infused Repellant Biodegradable Plastic Using Cassava Starch and Sargassum

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Abstract

Plastic contamination is becoming one of the world's major environmental issues, along side food loss and impurity due to multiple factors. Our goal with our experiments was to address both problems, reducing pollution, and protecting food from flour beetles. We wanted to reflect our culture in this project, which is why we used cassava and epazote as our main components for our bioplastic.

Our project uses cassava and epazote, both of which are a huge part of Mexican culture. These 2 however when combined, form a powerful combination if used correctly. Epazote has very good antimicrobial properties, when used in moderation, helps against flour beetle infestations. Additionally, cassava has starch that is biodegradable, which can be used as a bioplastic. Together, they form the cassava starch based bioplastic that's capable of repelling flour beetles. We tested 2 types of bioplastic: one with epazote infused into it and another one without it. They were both det into an artificial monitored environment. The plastic with the epazote infusion significantly outperformed the one without epazote, seeing very little flour lost one the one with epazote compared to the one without it.

The results represent how well epazote can work to repel flour beetles. This is supported by the calculated p-values or 0.0016, which means the results of the epazote infusion are significant and efficient. In overall, our experiments were successful, and demonstrated an impressive performance, which could contribute to better food conservation technologies.

Introduction

Biodegradable plastics, which are polymers derived from renewable biological sources such as plants or microorganisms, offer a promising alternative by reducing reliance on fossil fuels and minimizing environmental pollution. However, further investigation is needed to enhance their functional benefits beyond sustainability alone. This study aims to develop and assess an epazote-infused biodegradable plastic made from cassava starch and sargassum, specifically designed to repel flour beetles. By integrating natural repellant properties into the bioplastic, this material looks to address both problems, contributing to the reduction of fossil fuel dependency and addressing pest-related hazards in stored products, particularly in food packaging and storage applications.

Background Research

Plastic pollution has become one of the most persistent global environmental issues. Plastics can last hundreds to thousands of years, breaking down into microplastics and nanoplastics that can contaminate ecosystems ranging from the Arctic tundra to tropical coral reefs. Each year, an estimated 19 to 23 million tons of plastic enter aquatic ecosystems, damaging habitats, reducing climate stability, and threatening global food security and livelihoods. Low recycling and high continued consumption in wealthier nations, have made the problem worse. Beyond environmental damage, plastics also carry serious health risks throughout their entire lifecycle, from fossil fuel extraction to production and disposal, releasing toxic chemicals and particles that have been linked to cancer, neurological harm, and other health issues.

Bioplastics have appeared as one promising solution. Unlike conventional petroleum-based plastics, bioplastics are made from renewable resources such as corn, sugarcane, mushrooms, or food and agricultural waste. They can be designed to be recyclable, biodegradable, or compostable, which helps reduce plastic waste accumulation while also lowering dependence on fossil fuels. In addition to reducing environmental impact, bioplastics support more sustainable production practices and a circular economy by turning waste into useful materials. Recent innovations have further improved their performance, with antimicrobial bioplastics offering extra benefits. These materials limit microbial growth, extend product durability, and improve hygiene in applications such as food packaging and healthcare. By preventing contamination and biofilm buildup, antimicrobial plastics enhance safety and functionality while also reducing the need for synthetic preservatives. These advancements show how bioplastics, particularly those with antimicrobial properties, can reduce pollution while meeting modern demands for sustainability and safety.

A key focus of this project is applying repellant properties to bioplastics to enhance food protection, specifically against flour beetles, a common pest in stored grain and flour products. These beetles contaminate food with larvae, shed skins, and waste, and their feeding activity reduces both the quality and quantity of stored commodities. Studies have shown that infestations by red flour beetles and flour beetles can lead to weight losses of up to 30% in wheat flour and cause widespread spoilage in stockpiles all around the globe. In developing nations, flour beetles are estimated to contribute to approximately 20% of annual grain and flour losses. Because they thrive when packaging fails, antimicrobial bioplastic packaging offers a promising solution by creating protective barriers that resist infestation while also reducing microbial

growth. This dual function not only helps preserve food safety and freshness but also reduces food waste, linking the fight against plastic pollution with the need to secure global food supplies.

Statement of the Problem

General Problem:

This project aims to create a bioplastic that repels flour beetles, using epazote as a natural repellant, and cassava and sargassum as our key components of our bioplastic.

Specific Questions:

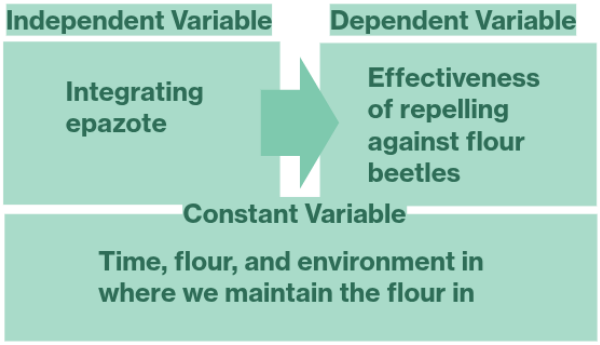
1- Is the epazote infused bioplastic effective in repelling the flour beetles?

2- Does the epazote-infused bioplastic affect germination rates?

Hypothesis

Since epazote has multiple properties, including antimicrobial and repelling properties could help protect food from pests like flour beetles. With this in mind, by infusing epazote into the bioplastic, we can create a bioplastic that works as a natural repellant, which is effective and sustainable.

Variables



Methods

Extracting Cassava Starch:

The preparation of cassava starch involved several steps. The cassava was peeled and cut into small pieces. The pieces were dehydrated until completely dry and ground into a fine powder. We added water to the powder and allowed it to settle, permitting the starch to separate and sink to the bottom. Once settled, the mixture was carefully filtered to isolate the starch. The collected starch was dehydrated again and stored for later use.

Figure #1: Cassava starch collection after filtering multiple times. (Image taken by the student researchers, 2025)

Collecting Sargassum's Alginate:

To collect the alginate, we blended it with water to achieve a smooth consistency. The resulting mixture was boiled at a high temperature with the addition of sodium hydroxide. Following this, sodium bicarbonate was added while the mixture was at a controlled temperature. Finally, the alginate was strained and filtered to clean it and properly collected the alginate for later use.

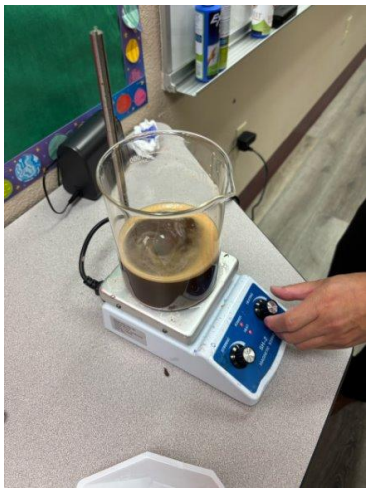


Figure #2: Boiling sargassum in the process to collect the alginate. (Image taken by the student researchers, 2025)

Creating the Plastic:

Once the needed materials were ready, we proceeded to create the plastic by mixing all the materials in a glass beaker. First, we measured 100 mL of distilled water, 1 g of agar-agar powder, 10 g of cassava starch, 10 mL of sodium alginate, 2 mL of vinegar, and 2 mL of glycerin. The mixture was heated in a magnetic stirrer until fully combined. Once the solution was well mixed, we added 10 mL of epazote extract. Finally, the bioplastic solution was poured into a silicone mold and placed in an incubator at 60 degrees Celsius until fully dried.

Figure #3: The 2 plastics being heated inside the incubator. (Image taken by the student researchers, 2025)

Testing the Plastic:

We performed two tests: one tested how effective the plastic was at repelling beetles, and the other looked at the germination rate of seeds surrounded by the plastic. In the first experiment, we immediately noticed that the beetles were attracted to the plastic without epazote, which showed that the epazote was effectively repelling them. After that, we moved on to the second experiment and discovered that the epazote did not interfere with seed germination. It also helped prevent mold. We noticed this because, over time, the seeds inside the plastic without epazote began to mold, while the ones with epazote did not.

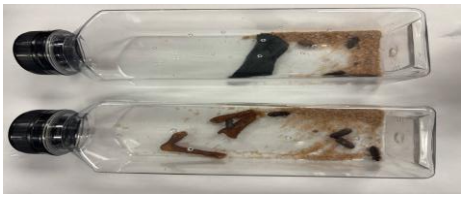
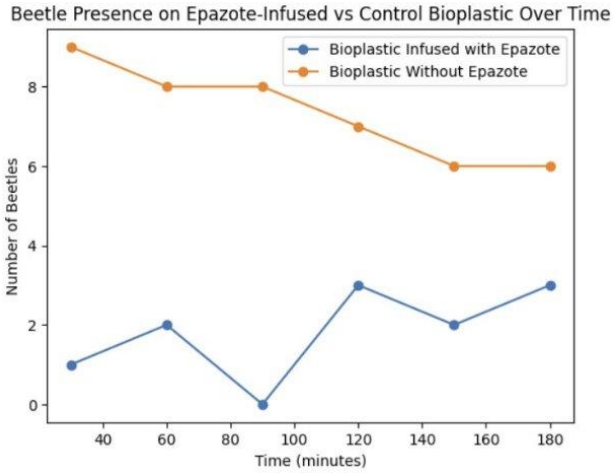
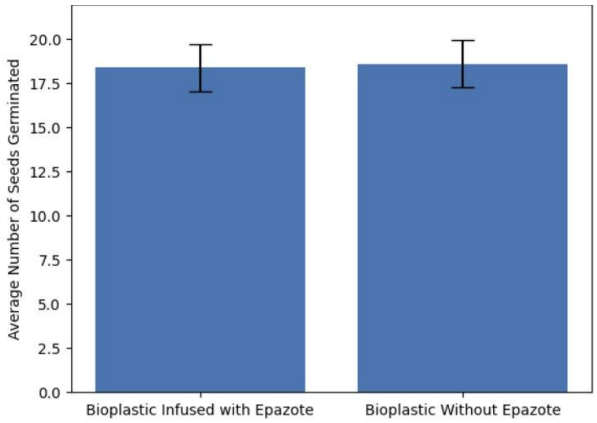
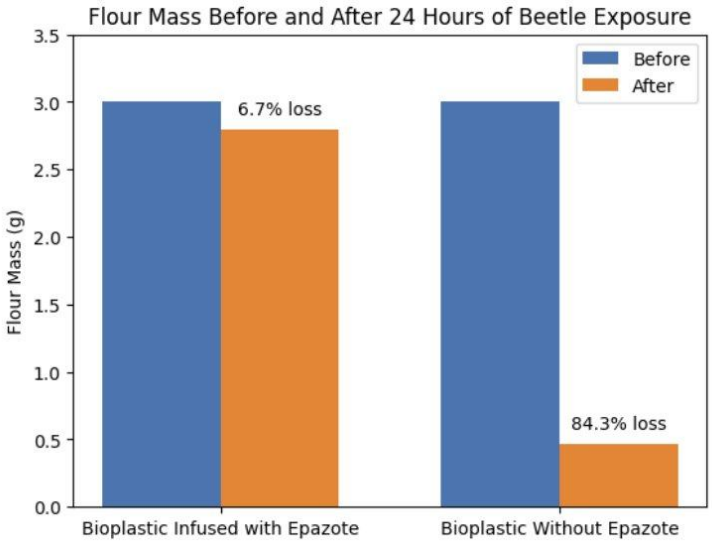


Figure #4: The beetles were not as attracted to the epazote-infused bioplastic as they were to the plastic without epazote. (Image taken by the student researchers, 2025)

Results


Beetle Presence on Epazote-Infused vs Control Bioplastic Over Time
Bioplastic Infused with Epazote
Bioplastic Without Epazote
Number of Beetles
Time (minutes)


Average Number of Seeds Germinated
Bioplastic Infused with Epazote
Bioplastic Without Epazote


Flour Mass Before and After 24 Hours of Beetle Exposure
Before
After
6.7% loss
84.3% loss
Flour Mass (g)
Bioplastic Infused with Epazote
Bioplastic Without Epazote

Statistical Test	Comparison	Test Statistic	p-value	Effect Size
Paired t-test	Epazote vs Control	t = −6.21	0.0016	Cohen's d = 2.54

The data suggests that the epazote-infused bioplastic provides an effective protection against beetle damage, while having no negative impact on seed germination. The results are statistically significant, making the epazote-infused bioplastic a promising solution for reducing damage caused by beetles.

Discussion

The epazote-infused bioplastic reduced beetle presence by a lot when compared to the control group, indicating a highly effective repellency likely caused by the presence of volatile bioactive compounds within the epazote. Statistical analysis further confirmed a significant difference in beetle behavior between treatments, promoting a very large effect size that demonstrates the repellent effect was both statistically and biologically meaningful. In addition, flour wrapped in the epazote-infused bioplastic experienced substantially lower mass loss after 24 hours, proving that the material actively protects food sources from beetle damage. Furthermore, seed germination results showed no difference between the epazote-infused and control of bioplastics, suggesting that the material is compatible with plant growth and remains environmentally safe. Taken together, these findings strongly support the potential of epazote-infused cassava–sargassum bioplastics as an effective, sustainable, and eco-friendly active packaging material for long-term pest control.

Conclusion

Our hypothesis was supported, as the epazote-infused cassava–sargassum bioplastic exhibited significantly lower beetle presence and feeding damage compared to the control, demonstrating that epazote's bioactive compounds effectively repel flour beetles. Statistical analysis confirmed a strong, meaningful repellent effect with no negative impact on seed germination. With this information, we can affirm the material's environmental and agricultural safety. Ultimately, these results highlight the potential of epazote-infused bioplastics as a sustainable alternative to conventional plastic packaging for integrated pest management.

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