

Three Experimental Phases of Cornstarch-Based Biodegradable Plastic

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Abstract— Three Experimental Phases of Cornstarch-Based Biodegradable Plastic is the focus of this current study whose purpose was to create a bio-plastic from eco-friendly materials as a platform for an alternative commercial plastic. This study used a pre-experimental research design where three bio-plastic experiments were monitored to identify which among them was likely to produce the most efficient bio-plastic. At the end of the study, it was concluded that in terms of elasticity, tear resistance, appearance, texture, and odor, Experimental Two with four tablespoons of cornstarch, one cup of water, two tablespoons of vinegar, and two tablespoons of glycerin, is the most reliable among the three experiments.

Hence, this study recommends to the biologists and scientists that may use this study to help them find ways to lessen biological problems caused by non-biodegradable plastics; to the producers that the study may help them to create and manufacture bio-plastics and to improve the study using other materials for the product to last longer indoors; to the consumers that the study may let them know the reliability and liability of the plastic they use in their everyday life; and to the future researchers who will want to conduct a further study about bio-plastics, this study may serve as a related study and think of an intervention to improve the results from the problem.

Keywords— Cornstarch, Biodegradable Plastic, vinegar, glycerin.

I. INTRODUCTION

Over the years, plastics played an important part in everyone's life. They are used for packaging like containers, bottles, cups, shopping bags, and zip-locked bags. Though they are useful, plastics can bring harm to the environment and to the human lives. The effects of marine plastic pollution in environmental and socio-economic are experienced in all maritime governance (Jambeck et al., 2015).

The long-term impacts of plastics became more alarming with each discovery of new sources (Boucher and Friot, 2017). The failure of current legal and policy frameworks to address the global marine debris problem has been partly attributed by the lack of progress of emitting plastic pollution (Borrelle et al., 2017; Simon and Schulte, 2017; UNEP, 2016; UNGA, 2012).

Increasing public perspective is leading to a need of prioritizing the effective litter reduction over the need for more scientific evidence of the impacts (Williams et al., 2005). This is illustrated by the groundswell in many States where the public urges governments to implement bans on plastic bags, micro beads and polystyrene take-away

containers, as well as campaigns to implement container deposit schemes. In addition to land-based sources of marine plastic debris, sea-based sources include vessel garbage, derelict fishing gear (FAO, 2016; Macfadyen et al., 2009) and micro-plastics (FAO, 2017), which also contribute to the global stock of marine plastic debris. The issue of marine plastic debris has steadily gained attention at the international level. However, implementation remains a national activity (Raubenheimer & McIlgorm 2018).

It may be argued that the feasibility and effectiveness of a global funding mechanism to prevent marine plastic debris would require an associated international legally binding instrument to harmonize and guide action across coastal and land-locked states. A new international agreement would need to consider a broad range of elements (Raubenheimer, K., & McIlgorm, A., 2018).

Without a new global agreement, there are limited options to regulate the full lifecycle of plastics within the current international legally binding framework (Raubenheimer & McIlgorm, 2018). Plastic wastes are usually disposed through burning or landfill treatments

causing environmental problem such as air, soil, and water pollution (Adhikari et al, 2016). Land breakdown is a widely recognized serious threat not only in the Philippines but also to the worldwide agricultural productivity (Briones, 2009).

On the other hand, plastics affect human health because of the toxic chemicals that are found in the human blood and tissues, which is also can cause cancers, birth defects, impaired immunity, and other ailments if too much exposure to plastics (Naguran, 2018).

In the Philippine operations in nourishing their countrymen through fishing and agriculture went slack because of plastic pollution that infiltrates the rivers and ocean where fishermen make their living (Jackson, 2018). Marine plastic pollution is one of the major problem Philippines faces today due to high-usage level, poor 'end life', and improper disposal of plastics (Garcia et al, 2019). When the plastic particles dispersed in the bodies of water, the water will be polluted which cause pervasive adverse impacts to the environment and to human health (Garcia et al, 2019).

Philippines used 48 millions of shopping bags everyday which is 17 billion per annum including 16.5 billion of the smaller, thinner, and mostly transparent plastic bags known as plastic "labo" (Phys.org, 2019). Philippines is the third largest contributor of plastic waste in the ocean. These plastics are found entangles in or ingested by 65/120 mammal species in the country (Espina, 2018).

Drowning and stomach rupture of marine plastic debris among the species in the Philippines caused marine species mortality. Plastics can also affect marine animals ecologically, introducing them to the food web simplification (Abreo et al, 2016). Marine plastic pollution sets more threats to the biodiversity of the Philippines despite of being one of the largest biodiversity hotspots in the world (Abreo et al, 2016).

Since plastic are produced by mass production, the amount of plastic entering marine and freshwater ecosystem has increased. Releasing plastic in the environment is a result of inappropriate waste management. Plastic pollution is one of the environmental problems that the world is facing (Barnes et al, 2009). Five million of solid marine debris are thrown overboard or lost from ship daily (UNEP, 2009).

Burning plastics can give off toxic chemicals (Woodford, 2019). Recycling of plastics is also a very hard process, from selecting and segregating plastics manually up to the actual recycling. These are some of the reasons why it is important to replace plastics with bio-plastics other than

the harm that plastics bring to the environment (Simionescu et al, 2009).

Bio-plastics are plastics that are made out from polymers of organic materials such as plants and animals and variety of biological resources (Momani, 2009). Bio-plastics break down more quickly and easily than the normal plastics. They do not produce a net increase in carbon dioxide when breaking down unlike traditional plastic (Woodford, 2019). Carbon dioxide is the most common greenhouse gas that traps heat in the atmosphere leading to climate change (Nunez, 2019).

Use of bio-plastics reduces the litter and composting of plastics. Single use of shopping bags is an obvious example of how plastics pollute the environment and disposable plastic bags have the largest fraction of litters in the ocean. Most bio-plastics can be decomposed through biodegradation where microorganisms break down bio-plastics to the environment and others are processed for energy recovery (Chen, 2014).

Plastics are vital assets for humanity but non-biodegradable plastic affect marine life wherein it causes the death of fish and seabirds. The production of fish meat also decreases and it exploits the biodiversity in the ocean. Non-biodegradable plastic take long time to decompose. It takes up space longer than biodegradable materials, harms the solid, and finds its way into the forest field and the sea. Non-bio plastic also causes pollution where harmful and poisonous gases are released when burned, and the bodies of water and land are contaminated (Kopp, 2016).

The world needs to find a solution to this. Bio-plastics are non-toxic because they are usually made up of biological materials and do not use scarce crude oil to produce them. Bacteria break down the bio-plastic particles and when manufactured, there is a low carbon foot print, the production of greenhouse gases, wherein the impact of global warming are lessen and the impacts of plastics production to human health are reduced. Hence, the main purpose of this study is to develop a platform for alternative commercial plastic using eco-friendly materials.

II. STATEMENT OF OBJECTIVE

The main objective of this study was to create a bio-plastic from eco-friendly materials as a platform for an alternative commercial plastic. Specifically, this study sought to determine the following:

- 1) Enumerate the procedure in producing 3 sets of Experimental phase;
- 2) Describe the similarities and differences of the 3 Experimental phases; and
- 3) Answer, which among the three experiments is the most efficient.

III. METHODOLOGY

Research Design

The pre-experimental research design was used in the study where three samples or experiments were monitored to identify which among the three is likely to produce the most efficient bio-plastic. The basic instruments used in collecting the data were observation checklists constructed before making the experiments considering the appearance, texture, and the odor of the experiments.

Materials

The basic materials used in creating bio-plastics are the following:

A. Cornstarch

It's also known as corn flour that is carbohydrate extracted from the corn endosperm, it is a powdery substance that is used in culinary household as a thickening agent in making corn syrup, sugar, and other dishes. It is also used for industrial purposes for manufacturing adhesives and sizes for paper and textile. Cornstarch played the most important role in making the bio-plastic because it was the main material used in making the product. It served as the foundation of the experiment.

B. Water

A substance, which is, composed of chemical hydrogen and oxygen that existing in gaseous liquid and solid states. It is transparent, tasteless, odorless, and also colorless. It is the main constituent of earth hydrosphere. The water plays an important role in the production of bio-plastic. First it acts as a solvent that dissolved the starch, secondly it helped the starch molecules to stay disrupted after heating.

C. Vinegar

Vinegar is an aqueous solution of acetic acid and trace that also include flavoring. It typically contains 5-20 percent acid by volume. Vinegar is an acetic liquid that was produced through fermentation. A small amount of vinegar was used in making the product because vinegar broke up some of the polymers chains that make the bio-plastic less brittle.

D. Glycerin

It's a type of moisturizing agent that is a humectant. This is used as moisturizer to prevent dry, rough, scaly, and itchy or skin irritations. This is mild antimicrobial and antiviral and is an FDA approved treatment for wounds. But for the study, the glycerin was used in making the bio-plastic that was acts as the plasticizer, which lubricates the bio-plastic.

Data Collection and Procedure

The data collection of the study proceeded through the observations. The data were documented without any uncertainty to avoid false information or errors in the data collection. Also, well-developed communication between the researchers helped in detecting errors immediately.

In conducting the study, the researchers first combined cornstarch and acetic acid or vinegar in a beaker before adding water and glycerin from the original solution. Each had certain amount determined by the researchers during the study.

The researchers created three solutions of cornstarch, water, vinegar, and glycerin with various measurements, respectively, to identify which solution will produce the strongest biodegradable plastic. The solutions in the beakers were then heated using the Bunsen burner under the tripod and were stirred continuously until they reached the desired thickness.

The solutions increased their viscosity or thickened when heated and continuously stirred because the heat from the Bunsen burner forced the particles and molecules of the cornstarch and other ingredients to contract. The glycerin helped the solution to hold the viscosity while the vinegar converted the cornstarch back into its component sugars. The water, on the other hand, controlled the thickness of the solution. When the solution slightly boiled and thickened, remove the solution from the heat and respectively spread the solution with equal and even thickness, as possible, on a flat and smooth surface. Let the solution dry up in 2-5 days. After drying, bio-plastics film with different strength and tear resistance was formed.

Data Analysis

The data gathered from the experiments were interpreted through narrative analysis where the data were presented in a narrative form. In line with this, the analysis of data was conducted through the following steps of narrative analysis. First was identifying the problem to provide the purpose of the study. Next was selecting one or more

experiments to study, for several experiments with various amounts of materials will give different results followed by collecting the data from the experiments through the use of checklist. Next was narrating the results of the experiments by examining the raw data, sequencing them, and making a definite narrative. Last was validating the study's accuracy for an accurate narrative is essential to research.

IV. RESULTS AND DISCUSION

I. Procedures in Creating Bio-Plastic

Ingredients

The researchers used the following substances in creating bio-plastics:

Cornstarch - the main variable in creating bio-plastics

Water- the solvent in the solution

Vinegar- as the acetic acid solution

Glycerin- for the solution to hold its viscosity

Measurement

In conducting this study the researchers created there experiments with different amount of solutions as follows:

Experiment 1: 2tbsp of Cornstarch

1 cup of waters and 2tbsp of vinegar

2tbsp of glycerin (constant)

Experiment 2: 4tbsp of cornstarch

1 Cup of water and 2tbsp of vinegar

2tbsp of glycerin

Experiment 3: 2tbsp of cornstarch

2 cups of water and 4tbsp of vinegar

2tbsp of glycerin (constant)

Procedure

Experimental 1

In creating the first experiment, the researchers combined 1 cup of water, 2 tbsp of vinegar, and 2 tbsp of glycerin in the casserole. The next step was adding and dissolving the 2 tbsp of cornstarch in the solution. Then, the solution was heated on the gas stove and continuously stirred using the rubber spatula for three minutes. When the solution thickened, the researchers removed it from the heat and immediately poured a half cup of the solution in a paper plate and flattened it using the rubber spatula. Lastly, the researchers let the solution dry outdoor for three days.

Experimental 2

In creating the second experiment, the researchers combined 1 cup of water, 2 tbsp of vinegar, and 2 tbsp of glycerin in the casserole. Next, 4 tbsp of cornstarch was

added and dissolved in the solution. Then, the solution was put to heat on the gas stove and continuously stirred using the rubber spatula for three minutes. When the solution thickened, the researchers removed the solution from the heat and immediately poured a half cup of the solution in a paper plate and flattened it using the rubber spatula. Lastly, the researchers let the solution dry outdoor for three days.

Experimental 3

In creating the third experiment, the researchers combined 2 cups of water, 4 tbsp of vinegar, and 2 tbsp of glycerin in the casserole. Next, 2 tbsp of cornstarch was added and dissolved in the solution. Then, the solution was put to heat on the gas stove and was continuously stirred using the rubber spatula for three minutes. When the solution thickened, the researchers removed it from the heat and immediately poured a half cup of the solution in a paper plate and flattened it using the rubber spatula. Lastly, the researchers let the solution dry outdoor for three days.

II. Similarities and Differences of the Three Experimental Phases

Table1. Day One of the Experimental Exposed in Soil

DAY 1	DESCRIPTION
Experiment 1	T: soft and slick
	A: clear and thin
	O: smelt like vinegar
	B: stretchable
Experiment 2	T: smooth and slick
	A: clear and thin
	O: smelt like vinegar
	B: flexible
Experiment 3	T: bumpy
	A: shadowy and thick
	O: smelt like vinegar
	B: runny

Legend:

T – Texture

A – Appearance

O – Odor

B – Brittleness

Table 1 shows the day one observation of the three experiments exposed in soil. The researchers observed that Experiment 1 had soft and slick textures, clear and thin appearances, smelt like vinegar, and was stretchable. Experiment 2 also had a slick and smooth texture, clear and thin appearance, smelt like vinegar, but was flexible. On the

other hand, Experiment 3 was bumpy, shadowy and thick, smelt like vinegar, and was runny for it didn't dry up immediately.

Table 2. Day One of the Experimental Exposed in Water

DAY 1	DESCRIPTION
Experiment 1	T: soft
	A: clear and thin
	O: smelt like vinegar
	B: slightly dissolved
Experiment 2	T: soft
	A: clear and thin
	O: smelt like vinegar
	B: settled at the bottom
Experiment 3	T: soft
	A: clear and thick
	O: smelt like vinegar
	B: slightly dissolved

Legend:

- T – Texture
- A – Appearance
- O – Odor
- B – Brittleness

Table 2 shows the day one observation of the three experiments exposed in water. The researchers observed that Experiment 1 had soft texture, clear and thin appearances, smelt like vinegar, and slightly dissolved. Experiment 2 also had a soft texture, clear and thin appearances, smell like vinegar, but it settled at the bottom of the container. On the other hand, Experiment 3 was also soft, clear but thick, smelt like vinegar, and some parts of it slightly dissolved.

Table 3. Day Two of the Experimental Exposed in Soil

DAY 2	DESCRIPTION
Experiment 1	T: soft and slick
	A: clear and thin
	O: smelt like vinegar
	B: stretchable
Experiment 2	T: smooth and slick
	A: clear and thin
	O: smelt like vinegar
	B: flexible
Experiment 3	T: rough and bumpy
	A: thick
	O: smelt like vinegar

B: runny

Legend:

- T – Texture
- A – Appearance
- O – Odor
- B – Brittleness

Table 3 shows the second observation day of the three experiments exposed in soil. The researchers observed that Experiment 1 remained soft and slick, had clear and thin appearances, smelt like vinegar, and was stretchable. Experiment 2 also had a slick but smooth texture, clear and thin appearances, smelt like vinegar, but was flexible. On the other hand, Experiment 3 was bumpy and the dried part of it was rough, thick, smell like vinegar, and was runny in the middle for it wasn't completely dried up.

Table 4. Day Two of the Experimental Exposed in Water

DAY 2	DESCRIPTION
Experiment 1	T: soft
	A: clear and thin
	O: smelt like vinegar
	B: slightly dissolved
Experiment 2	T: soft
	A: clear and thin
	O: Smelt like vinegar
	B: settled at the bottom
Experiment 3	T: soft
	A: clear and thick
	O: smelt like vinegar
	B: slightly dissolved

Legend:

- T – Texture
- A – Appearance
- O – Odor
- B – Brittleness

Table 4 shows the second observation day of the three experiments exposed in water. The researchers observed that Experiment 1 had soft texture, clear and thin appearances, smelt like vinegar, and slightly dissolved. Experiment 2 also had a soft texture, clear and thin appearances, smelt like vinegar, but it settled at the bottom of the container. On the other hand, Experiment 3 became soft, clear but thick, smelt like vinegar, and some parts of it slightly dissolved.

Experiment 3	A: clear and thick O: smelt like vinegar B: slightly dissolved
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Legend:

T – Texture

A – Appearance

O – Odor

B – Brittleness

Table 5. Day Three of the Experimental Exposed in Soil

DAY 3	DESCRIPTION
Experiment 1	T: soft and slick A: clear, thin, shrink O: Smelt like vinegar B: Stretchable
Experiment 2	T: smooth and slick A: clear and thin O: smelt like vinegar B: flexible
Experiment 3	T: rough and bumpy A: thick O: smelt like vinegar B: runny and stretchable

Legend:

T – Texture

A – Appearance

O – Odor

B – Brittleness

Table 5 shows the third observation day of the three experiments exposed in soil. The researchers observed that Experiment 1 remained soft and slick, had clear and thin appearances but shrank a little, smelt like vinegar, and was stretchable. Experiment 2 also had a slick but smooth texture, clear and thin appearances, smelt like vinegar, but was flexible. On the other hand, Experiment 3 became rough and bumpy, thick, smelt like vinegar, and was a bit runny and stretchable.

Table 6. Day Three of the Experimental Exposed in Water

DAY 3	DESCRIPTION
Experiment 1	T: soft A: clear and thin O: smelt like vinegar B: slightly dissolved
Experiment 2	T: soft A: clear and thin O: smelt like vinegar B: settled at the bottom
	T: soft and smooth

Table 6 shows the third day observation of the three experiments exposed in water. The researchers observed that Experiment 1 remained soft, clear and thin, smell like vinegar, and slightly dissolved. Experiment 2 also had a soft texture, clear and thin appearances, smell like vinegar, but it settled at the bottom of the container. Meanwhile, Experiment 3 also remained soft and smooth, clear but thick, smelt like vinegar, and some parts of it slightly dissolved.

Table 7. Day Four of the Experimental Exposed in Soil

DAY 4	DESCRIPTION
Experiment 1	T: smooth A: clear, thin, shrink O: Smelt like vinegar B: had cracks
Experiment 2	T: smooth and slick A: clear and thin O: smelt like vinegar B: flexible
Experiment 3	T: rough and bumpy A: thick O: smelt like vinegar B: stretchable

Legend:

T – Texture

A – Appearance

O – Odor

B – Brittleness

Table 7 shows the fourth observation day of the three experiments exposed in soil. The researchers observed that Experiment 1 became smooth, had clear and thin appearances but continued shrinking, didn't smell, and had cracks in it. Experiment 2 also had a slick but smooth texture, clear and thin appearances, didn't smell, but remained flexible. On the other hand, Experiment 3 stayed

bumpy and rough, thick, smelt like vinegar, now dried up and became stretchable.

Experiment 2
A: clear, thin, and shrink
O: didn't smell
B: had cracks

Experiment 3
T: rough and bumpy
A: thick
O: smelt like vinegar
B: had cracks

Legend:

T – Texture

A – Appearance

O – Odor

B – Brittleness

Table 8. Day Four of the Experimental Exposed in Water

DAY 4	DESCRIPTION
Experiment 1	T: soft A: clear and thin O: didn't smell B: dissolved in tiny pieces
Experiment 2	T: soft A: clear and thin O: smelt like vinegar B: settled at the bottom and dissolves
Experiment 3	T: soft A: clear and thick O: smelt like vinegar B: slightly dissolved

Legend:

T – Texture

A – Appearance

O – Odor

B – Brittleness

Table 8 shows the fourth observation day of the three experiments exposed in water. The researchers observed that Experiment 1 had soft texture, clear and thin appearances, the smell disappeared, and dissolved into tiny pieces. Experiment 2 also had a soft texture, clear and thin appearances, the smell also disappeared, but it settled at the bottom of the container and slightly dissolved. On the other hand, Experiment 3 was also soft, clear but thick, smelt like vinegar, and some parts of it slightly dissolved into pieces.

Table 9. Day Five of the Experimental Exposed in Soil

DAY 5	DESCRIPTION
Experiment 1	T: smooth A: clear, thin, and shrink O: didn't smell B: torn to pieces
	T: smooth and slick

Table 9 shows the fifth observation day of the three experiments exposed in soil. The researchers observed that Experiment 1 remained smooth, had clear and thin appearances and continued shrinking, smell disappeared, and was torn into pieces. Experiment 2 also had a smooth but slick texture, clear and thin appearances and started shrinking, didn't smell, but had cracks in it. Lastly, Experiment 3 stayed bumpy and rough, thick, smelt like vinegar, and had a few cracks in its side, too.

Table 10. Day Five of the Experimental Exposed in Water

DAY 5	DESCRIPTION
Experiment 1	T: soft A: thin O: didn't smell B: dissolved into tiny pieces
Experiment 2	T: soft A: clear and thick O: didn't smell B: settled at the bottom and dissolved
Experiment 3	T: soft A: shadowy and thick O: smelt like vinegar B: dissolved into tiny pieces

Legend:

T – Texture

A – Appearance

O – Odor

B – Brittleness

Table 10 shows the fifth observation day of the three experiments exposed in water. The researchers

observed that Experiment 1 remained soft, had thin appearance, the smell disappeared, and dissolved into tiny pieces. Experiment 2 also had a soft texture, clear but became thick due to the absorption of water. The smell also disappeared. The experiment remained at the bottom of the container and slightly dissolved. However, Experiment 3 stayed soft, shadowy but thick, smelt like vinegar, and it dissolved into tiny pieces.

V. CONCLUSION AND RECOMMENDATIONS

In the study, it was observed that Experimental One on both soil and water broke down and dissolved the fastest. It also had a soft and smooth texture but it could be torn easily. On the other hand, Experimental Two dried up fastest but dissolved days after the first experiment, which means that it could be stored and had the longest life span among the three experiments. It also had a smooth and slick texture, shrank when decomposed, and was flexible, which means that it goes back to its original form when stretched. Lastly, the third experiment dried up the longest yet broke easily. It had a bumpy and rough texture, and its middle part was runny and reeked off vinegar.

Therefore, the study concludes that in terms of elasticity, tear resistance, appearance, texture, and odor, Experiment Two with four tablespoons of cornstarch, one cup of water, two tablespoons of vinegar, and two tablespoons of glycerin was the most reliable among the three experiments.

Hence, this study recommends to the biologists and scientists that may use this study to help them find ways to lessen biological problems such as the ones caused by non-biodegradable plastics; to the producers that the study may help them to create and manufacture bio-plastics using eco-friendly materials and improve the study for it to last longer indoors and to decompose immediately in land and water; to the consumers that the study may let them know the reliability and liability of the plastic they use in their everyday life; and to the future researchers who will want to conduct a further study about bio-plastics, this study may serve as a related study and think of an intervention to improve the results from the problem.

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