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**DAVID ANGELLO L. WISPER, RALENE MAE S. ARTUZ, MARISA A. ABOGADA, KYLE ANGELOU M. SARDUAL, CYPRIL JAY L. NAMOCO, KYEANNABABE A. RALLOS, "INVESTIGATING THE PHYSICOMECHANICAL PROPERTIES OF THE BIOPLASTIC MATERIAL WITH TARO STARCH AS THE ESSENTIAL COMPONENT", FRANCISCO RAMOS NATIONAL HIGH SCHOOL ZAMBOANGA SIBUGAY**

## ABSTRACT

Plastic plays an important role in our daily lives. It is used as containers, packaging, consumer products, construction, and industrial machinery. But it has a disadvantage because it is not biodegradable nor eco-friendly, and thus unsafe for the environment.

*Colocasia Esculenta* (Taro), a tropical tuber crop, is one of the plant-based starch that is used in making bioplastic. Bioplastic or biodegradable plastic is a plastic material that could be degraded in the environment and is made of renewable materials such as starch, cellulose, lignin, lipid, and protein (Guilbert S., Gontard., Cuq B. 1995).

The starch-based bioplastics produced in this study is made primarily from Taro starch as the main component, together with paraffin wax, water, vinegar, and glycerin. Its physical properties in terms of flexibility, rate of decomposition, and water absorption were determined to test its effectiveness as a bioplastic. Three treatments with varying amounts of starch were conducted.

Bioplastics prepared from Taro starch plasticized using glycerin were prepared in three treatments with variation of 15 grams 30 grams and 45 grams of Taro starch. The highest level of flexibility during the destructive pull test, rate of decomposition, and water absorption was obtained from the bioplastic with 15 grams of Taro starch while the bioplastic with 45 grams of Taro starch has the highest level of flexibility during the fatigue

test. However, the latter has the lowest level of flexibility during the destructive pull test, rate of decomposition, and water absorption.

In the ANOVA (analysis of variance), it showed that the data in testing the bioplastic's flexibility in both fatigue and destructive pull test shows no significant difference among the three treatments. However, the data in testing the rate of decomposition and water absorption showed that the alternative hypothesis is accepted. This implies that there is a significant difference, and treatment 1 with the larger weight difference decomposed faster than the other.

# CHAPTER I

# INTRODUCTION

This chapter shows the background of the study, the statement of the problem, hypothesis, the conceptual framework, the significance of the study, the scope and delimitation, and definition of terms.

## Background of the Study

Nowadays, people tend to use plastic for their daily needs. But this plastic can affect our communities, the environment, and our health in terms of its handling and the chemicals that create it. According to the article by Gracija Nikolovska (2023), plastic is mainly made from fossil fuels, crude oil, and natural gas, which are chemicals from fuel production that heat the planet. Our dependence on plastic perpetuates the need for these dirty fuels. Burning plastic in our backyards and in incinerators also releases climate-destroying gases and toxic air pollution. Some of the toxins found in plastic have been directly linked to health problems such as cancer, birth defects, child development problems and problems related to the immune system (Gianna Andrews 2012).

Bioplastics are renewable, biodegradable, durable and environmentally friendly plastics that increase our ability to protect the environment. Plants containing large amounts of starch can be suitable for bioplastic production.

The Philippines has the largest taro growing area in Asia, after China.
In 1996, about 34,000 hectares of land were devoted to taro cultivation, with an output of about 117,000 tons (FAO 1997). Taro is a starchy, spherical root of aroid plants, containing

73 to 76% starch (DSB), as shown by Jane et al. (1992). The amylose content of starch is an important property for bioplastic production because it is responsible for the gelatinization and degradation processes necessary for film formation. Short and medium-chain taro amylopectin facilitates the formation of firm, highly elastic gels when heated (Pramodrao & Riar 2014).

Bioplastics can be the best alternative to commonly used plastics. One of them could be the use of Colocasia Esculenta (Taro) starch as one of the main ingredients. So, instead of using conventional plastic, cultivated Colocasia Esculenta (Taro) starch can be converted into bioplastic to live in harmony with nature and bring about lasting improvement on Earth for the future generations.

The results of the study are called Colocasia Esculenta (Taro) Bioplastic crops will benefit society because this will be an alternative type of bioplastic. Non-biodegradable plastic waste is a common problem today. This research will help find ways to reduce the use of non-biodegradable plastics and may reduce cases related to plastic waste.

**Statement of the Problem**

This study attempted to determine the properties of Taro Root (Colocasia Esculenta) starch and its effectiveness as bioplastic. It aimed to answer the following questions:

1. Can the Taro starch be used as a component in bioplastics?
2. What is the effect of Taro starch bioplastic in terms of flexibility, rate of decomposition, water absorption, durability, and tensile strength?

3. Is there a significant difference between the varying amounts of Taro starch in bioplastic in terms of flexibility, rate of decomposition, water absorption, durability, and tensile strength?

**Objectives:**

1. To determine the effectiveness of Taro starch as the main component in bioplastic.
2. To determine the effectiveness of Taro starch as bioplastic in terms of flexibility, rate of decomposition, water absorption, durability, and tensile strength.
3. To determine the difference between the varying amounts of Taro starch in bioplastic in terms of flexibility, rate of decomposition, water absorption, durability, and tensile strength.

**Hypothesis:**

**Alternative Hypothesis:**

There is a significant difference between the characteristics and the varying amounts of Taro starch in bioplastic in terms of flexibility, rate of decomposition, water absorption, durability, and tensile strength.

**Null Hypothesis:**

There is no significant difference between the characteristics and varying amounts of Taro starch in bioplastic in terms of flexibility, rate of decomposition, water absorption, durability, and tensile strength.

**Conceptual Framework**

The concept of this research was to produce bioplastic with the use of Taro starch. Below shows the conceptual framework of the research.

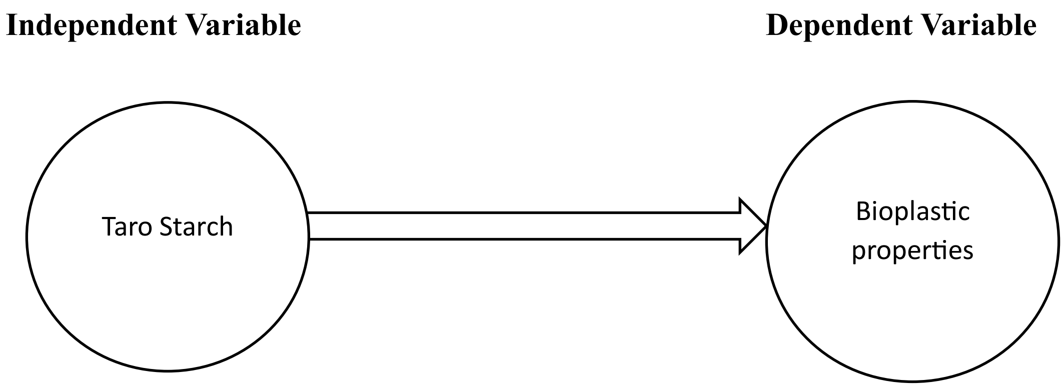


**Figure 1: The conceptual framework of the research.**

**Significance of the Study**

This research study aims to help the sectors of society with the use of Taro starch as bioplastic to reduce carbon gas emission and to introduce the bioplastic product as an eco-friendly plastic. To find solutions to plastic waste, the researchers produced a homemade biodegradable plastic out of Taro starch as an alternative to the non-biodegradable plastic uses.

This study is significant to the following:

**Environment:**

This could help lessen the burden in our existing waste disposal systems and reduce plastic landfill waste. The use of this plastic can be eco-friendly to the environment.

**Community:**

The product is much easier to dispose of by the people in the community due to its biodegradability.

**Students:**

The use of bioplastic by students will be less hazardous to their health compared to their use of ordinary plastic.

**Economy:**

Using biobased plastic helps increase resource efficiency and contribute to a more circular and more eco-friendly economy.

**Locale, Scope, and Delimitation**

The study was about *Taro Starch as Bioplastic*. This study was conducted in August 2023. The researchers did an experiment to find the answer to the hypothesis made.

This study focused on the investigation of Taro starch as an alternative material for making bioplastics. The idea is to make bioplastic out of Taro starch to reduce the non-biodegradable plastic uses in the community. The tests that were made in this study were limited to its three characteristics which are: flexibility, rate of decomposition, durability, tensile strength, melting point, and water absorption.

**Definition of Terms**

***Amylopectin* –** is a water-insoluble polysaccharide and highly branched polymer of a glucose units found in plants.

***Amylose* –** a type of polymer found in starch.

***Biodegradable* –** capable of being decomposed by bacteria or other living

***Bioplastic* –** Plastics that are produced from renewable biomass.

***Colocasia Esculenta* –** A tropical plant primarily for its edible corms.

***Decomposition* -** the process by which the taro-based bioplastic was buried under the soil to test its decomposition.

***Durability* -** the ability to withstand wear, pressure, or damage of the taro-based bioplastic.

***Eco-Friendly* –** not harmful to the environment.

***Elongation* -** the amount that the taro-based bioplastic was permanently lengthens when experiencing a tensile force (strain).

***Fatigue* –** weaken (a material, especially metal) by repeated variations of stress.

***Flexibility* –** the ability of the taro-based bioplastic to bend when load or force is applied.

***Glycerol* –** a sweet colorless syrupy alcohol usually obtained from fats and oil.

***Physicomechanical* –**the study or analysis of the physical and mechanical properties of the bioplastic.

***Starch* –** A polymeric carbohydrate consisting of numerous glucose units joined by glycosidic.

***Taro* –** A root vegetable found in Colocasia Esculenta tropical plant.

***Water Absorption* -** the amount of water absorbed of the taro-based bioplastic.

***Wax-*** are a diverse clads of organic compounds that are hydrophobic, malleable solids near ambient temperatures.

# CHAPTER II

# REVIEW OF RELATED LITERATURE

This chapter shows all the relevant knowledge and information of our study.

## Plastics

Plastic persists in the ecosystem for a very long time, endangering species and dispersing pollutants. A large portion of plastic is not biodegradable and cannot be recycled. Additionally, plastic products frequently degrade into tiny pieces known microplastic, which can injure species pollute ecosystem. Referring to the article of (Ahmed et al.,2018; Awdiya, Kumar, and Verma ,2016) that although plastics have many uses, they are harmful to the environment since they are not biodegradable. In addition, excessive use, poor disposal, and recycling of plastics result in their accumulation in landfills and in the ocean which in turn affects marine life and the sequestration of carbon, respectively. The problem of plastic waste is strangling the earth and polluting the ecosystem can be reduced by using bioplastic, which are biodegradable materials derived from renewable sources. Furthermore, biobased polymers improved a product's carbon footprint while reducing reliance on fossil fuels. Bioplastic are used in wide variety of other disposable products, including containers, packaging, straws, bags, bottles etc.

## Bioplastic

Polylactic acid, also known as PLA, is the most widely used bioplastic and is primarily produced from fermented plants starches, as opposed to fossil fuels. According to (Mbeya et al. 2013) plant starch is common raw material used to create bioplastic that has the potential to produced new materials that are biodegradable due to its low cost, availability, and renewable nature. Starch-based polymers that degrade are more environmentally friendly and deteriorate more quickly than a typical plastic would.

**Taro**

Tropical tuber crops called Colocasia Esculenta (Taro) are one source of plant-based starch utilized in bioplastic production. According to Hong and Nip's (1990) research, taro is a crop that is grown worldwide, including in the Philippines. Taro is also used to make baby food, taro chips, taro bread, and taro sorbet. Additionally, 3.44 tons of taro may be harvested from a single hectare (FAO, 1997), proving that the crop is renewable in terms of output. Taro is a starch-rich, globular, fleshy taproot belonging to the aroid family of plants. From Jane et al.family plants, it has 73%-76% starch (dsb) stated by Jane et al (1992), which can be used in making an effective bioplastic due to its large amount of starch. In addition, taro have more calories than potatoes, where each 100g provides 112 calories.

**Taro Starch Properties**

Their complex carbohydrates, amylose, and amylopectin, which are biopolymers, are what provide them much of their caloric worth. The use of these biopolymers as barriers in packaging materials is appealing to raw materials. According to a report by Pramodrao & Riar (2014), the amylopectin in taro is short and has a long average chain length, which helps in the formation of a firm gel with high elasticity when heated. Additionally, the amylose content in starch is a crucial characteristic for bioplastic products. Amylose is poly (a-1,4-glucopyranosyl), a linear thermoplastic Additionally, the granules are smaller. in contrast to Solanum tuberosum. On the basis of Mrithula Shanmathy's (2012) report, the physicochemical characteristics of the starch and, consequently, the bioplastic film produced, are affected by the size and shape of the granules.

**Water**

Water is a crucial component in the creation of bioplastic because it serves as a solvent and a medium for the chemical interactions that occur between the other components. Starch, gelatin, or agar can be made to dissolve more easily and combine uniformly with glycerol and vinegar with the use of water. Adding more water will make the bioplastic thinner and more flexible, while diminishing water will make it thicker and stiffer. Water also aids in controlling the viscosity and elasticity of the bioplastic (matthieu Schon, Pit Schwartz ).

**Preservatives**

Studies have shown that the inclusion of fillers and additives can improve the characteristics of bioplastics. The incorporation of antibacterial additives into bioplastics enables the creation of active food packaging, extending the shelf life of food by inhibiting spoilage-causing bacteria and microorganisms, based on recent studies by Sariah Abang, Farrah Wong, Rosalam Sarbatly, Jamilah Sariau, Rubival Baini, and Normah Awang Besar (2023).

**Wax**

Bioplastics might include wax to enhance their mechanical and thermal characteristics. As stated in C's article. A. C. Esmeraldo Bispo, F. Oliveira Silva, and R. According to J. A. Leite (2019), wax boosted the hydrophobic features of the films, lowering their water solubility, moisture, water vapor permeability, and thermal stability while also enhancing their light barrier capabilities. Wax can act as plasticizer and lower the glass transition temperature of the bioplastic, which refers to the temperature at which the material transitions from a hard glassy state to a softer rubbery state. This can make the bioplastic easier to process and more flexible at lower temperatures. Wax may function as a plasticizer and decrease the bioplastic's glass transition temperature, which is the point at which the material changes from a hard, glassy state to a softer, rubbery one. This may facilitate the processing of the bioplastic and increase its flexibility at low temperatures.

**Glycerol**

Bioplastics can easily degrade and flexible, it is necessary to add glycerol plasticizers. Based on the article of S N Fauziah et al (2021), Glycerol is a material that can reduce the internal hydrogen bonds in the intermolecular bonds and is amorphous. This ability which causes glycerol is classified as a plasticizer, which can increase bioplastic flexibility so that it can influence mechanical properties which include strength, flexibility, and water resistance of bioplastic. Glycerol plasticizers must be added to bioplastics since they are flexible and readily breakdown. According to S N Fauziah et al.'s article from 2021, glycerol is an amorphous substance that might weaken intermolecular hydrogen bonding. This property of glycerol, which is classified as a plasticizer, can increase bioplastic flexibility in order to alter mechanical qualities of bioplastic, such as strength, flexibility, and water resistance.

**Vinegar**

A bit amount of vinegar is reinforced, which breaks up part of the polymer chains and reduces the plastic's brittleness (Robert Horton, 2007). The tensile strength and barrier properties of the films can also be considerably influenced by glycerol; the lower the glycerol content, the better the tensile strength and barrier qualities will be (Souza et al., 2012). In general, bioplastics have the potential to lessen issues with plastic waste and overuse of non-biodegradable plastics. In terms of biodegradability, toughness, and flexibility, all of taro starch's attributes and traits in the relevant research are extremely successful. Furthermore, the gelatinization and retrogradation of the taro root are caused by the starch and calorie-rich taro starch's amylose and amylopectin content.

**Flexibility**

Flexibility of a plastic is a one major factor since it makes the plastic more versatile and can be used in product packaging (Team Xometry, 2023). Bending strength is defined as the ability of a material to resist deformation under a load. For specific applications, fatigue and destructive pull tests are an important feature to test the bioplastic's flexibility (Renaud Anjoran, 2015).

**Rate of Decomposition**

Plastic can take anywhere from 20 to 500 years to decompose, depending on the materials structure and environmental factors such as sunlight exposure (Mariah Hughes, 2022). According to BBC Science Focus, biodegradable plastics take only three to six months to fully decompose, far quicker than traditional plastic that can take hundreds of years.

**Water Resistance**

Plastic has always been water-resistant because of its long chains of molecules, which are tightly packed together, creating a barrier that prevents water from passing through (Marjee Chmiel, 2023). Bioplastics, in their natural form, typically do not possess inherent waterproof properties. They tend to have similar characteristics to conventional plastics, which are hydrophilic and susceptible to water absorption (AirXCarbon, 2023). However, certain modifications can be made to enhance the waterproof nature of bioplastics. One of a possible way to test its water resistance is through Water absorption testing (Hemsri et al, 2015).

**Durability**

The durability of plastic comes from the long molecule chains that create it. They ensure that the polymer is strong and capable of withstanding wear and tear while remaining flexible enough to handle a hit (Miller Plastics, 2023). Biodegradable plastics can be just as durable as other types of plastic, as they only break down in specific conditions. Determining the bioplastic's durability can be tested through load-deflection test where a weight is applied to a bioplastic sample, causing it to deflect or bend (Ladan Rashidi, 2022). The relationship between the applied load and resulting deflection provides valuable information about the material's stiffness and resilience.

**Tensile Strength**

Tensile strength is one of the most important and widely measured properties of materials used in structural applications. High tensile strength plastics can take the place of metal in many applications, reducing weight and cost without sacrificing performance (Team Xometry, 2023). Bioplastics that undergo a tensile strength test to determine their durability and sustainability for various applications (Animo labs, 2023). The results provide insights into the material's ability to withstand tension forces.

# CHAPTER III

# RESEARCH METHODOLOGY

This chapter deals with the procedures and methods that were used in the study. This briefly discusses the research environment, materials and equipment that are used, procedure in making the bioplastic out of Taro starch, the data gathering, and the research design.

## Research Environment

The study was conducted in Francisco Ramos National High School, Barangay Concepcion, Kabasalan, Zamboanga Sibugay.

## Materials and Equipment

The materials and equipment needed to prepare in making the product are the following: glycerin, vinegar, taro starch, water, plastic cover, sodium benzoate, paraffin wax, metal pot, tablespoon, grater, containers, and Taro (Colocasia Esculenta).

## Procedure in Making the Product

These are the steps that were followed in order to make the product which is the biodegradable plastic out of Taro starch. First, all the equipment and necessary materials needed were prepared. Next, the Taro was grated into small shreds using the grater. Starch of the shredded Taro was later then extracted through filtering process where, 100 mL. of water was dispersed in the container and the shredded Taro was deposited in the same container. After the solution was set aside within 30 minutes to separate the starch and the liquid layer, the liquid solution was filtered out leaving the starch layer at the bottom of the container. This process was repeated three times to fully extract the Taro starch. After the extraction of starch, 1g. of paraffin wax, 0.075g. of sodium benzoate, 7.5ml. vinegar, 7.5ml. of pure glycerin, the extracted Taro starch, 60ml. of water, and plastic cover were prepared. 7.5ml. of vinegar, 7.5ml. of pure glycerin, 0.075g. of sodium benzoate, 1g. of paraffin wax, 60 ml of water and a desired amount of Taro starch were mixed in a pot to make a bioplastic solution. Then, the pot with the bioplastic solution was heated on the stove in a medium heat. The bioplastic solution was stirred while heating until the desired viscosity was reached. The solution was placed on a plastic cover and left aside to air dry. The bioplastic was later then removed from the plastic cover after the drying process.

**Data Gathering Procedure**

Experimentation was used to gather data needed for the study. The experiment was divided into three treatments to test the bioplastic's flexibility, rate of decomposition and water absorption, durability, and tensile strength.

**Flexibility Test**

The flexibility test for each treatment of bioplastic was tested in to two branches namely:

- Fatigue test:

The bioplastic is flexed back and forth until it breaks. The higher the number of cycles, the better the plastic's property.

- Destructive pull test:

The bioplastic's original length was measured, then the bioplastic was stretched up to its breaking point. The final length was measured after stretching to its breaking point. The percentage of elongation of the bioplastic was calculated using this formula:

Percentage of elongation = (change in length / original length) * 100

**Rate of Decomposition Test**

The rate of decomposition was tested through a soil burial test for the three treatments, each treatment of bioplastic was buried in soil, then incubated at room temperature for 3 days. The buried samples were then cleaned from the soil and weighed. The weight loss of the bioplastics was calculated using this equation:

$$\% \text{ Weight Loss} = [(Wo - Wf)/Wo] \times 100\%$$

Where *Wo* and *Wf* are weight of a treatment before soil burial and after soil burial, respectively.

**Water Resistance Test**

The water absorption of the bioplastic was tested through water submersion for the three treatments, each treatment of bioplastic was horizontally submerged in water at a room temperature. At certain times of 5, 15, 25, 35, 50, and 60 mins, the treatments were taken out from water. The excess surface water was removed with a tissue and weight of the treatment was immediately measured as a function of time. The weight loss of the bioplastics was calculated using this equation:

$$\% \text{ Weight Loss} = [(Wo - Wf)/Wo] \times 100\%$$

Where *Wo* and *Wf* are weight of a treatment before water submersion and after water submersion, respectively.

**Durability Test**

The amount of load that a bioplastic can withstand was tested by continuously putting weight to the bioplastic every minute, whose dimensions of every treatment are equal. The weight on the bioplastic was recorded after the bioplastic meets its breaking point. This was repeatedly conducted 3 time in every treatment.

**Tensile Strength Test**

The bioplastic's tensile strength was tested using the newton's spring scale to calculate the force applied to the bioplastic. Every treatment of bioplastics has a dimension 1 x 2 inches, where the bioplastic was hung at the end of a spring of the apparatus, the bioplastic was pulled until it breaks. The force was later then recorded by calculating the distance the spring extends. This was conducted 3 times in every treatment.

**Research Design**

This research used Quantitative Research. This research used table and ANOVA to determine the effectiveness of Taro (Colocasia Esculenta) as bioplastic in terms of its flexibility, rate of the decomposition, and water absorption. Then, the data were analyzed and interpreted with the most appropriate statistical procedures using ANOVA (analysis of variance). Tables below are used in the presentation of results.

**Table 1: Fatigue Test**

| Treatments | Repetition of Folds | | | Mean |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | |
| **15g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | | | | |
| **30g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | | | | |
| **45g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | | | | |

**Table 2: Elongation Test**

| Treatments | Elongation Percentage (%) | | | Mean |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | |
| **15g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | | | | |
| **30g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | | | | |
| **45g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | | | | |

**Table 3: Rate of Decomposition Test**

| Treatments | Weight Loss Percentage (%) | | | Mean |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | |
| **15g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | | | | |
| **30g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | | | | |
| **45g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | | | | |

**Table 4: Water Absorption Test**

| Treatments | Weight Loss Percentage (%) | | | Mean |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | |
| **15g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | | | | |
| **30g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | | | | |
| **45g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | | | | |

**Table 5: Durability Test**

| Treatments | Weight after Breaking Point (Kg.) | | | Mean |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | |
| **15g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | | | | |
| **30g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | | | | |
| **45g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | | | | |

**Table 6: Tensile Strength Test**

| Treatments | Force after Breaking Point (N) | | | Mean |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | |
| **15g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | | | | |
| **30g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | | | | |
| **45g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | | | | |

# CHAPTER IV

## RESULT AND DISCUSSION

This chapter presents the results and discussion gathered from the tests and statistical analysis.

**Table 8.** Results for Fatigue Test in repetition of folds

| Treatments | Repetition of Folds | | | Mean |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | |
| **15g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | 31 | 40 | 42 | 38 |
| **30g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | 60 | 164 | 210 | 145 |
| **45g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | 127 | 109 | 395 | 210 |

From the table above, the researchers made three treatments of their Taro starch bioplastic to test its flexibility through a fatigue test. In this test, the higher the number of folds made would mean the better the plastic's property is. Treatment 1 has an average of (38), treatment 2 has an average of (154) and treatment 3 has an average of (210). In the table above, treatment 3 shows the highest average of folds among the three treatments while treatment 1 has the lowest average of folds. Therefore, treatment 3 can withstand the greatest repetition of folds while treatment 1 can withstand the least repetition of folds among the three treatments.

**Table 9:** One-way analysis of variance (ANOVA) of fatigue test.

ANOVA

| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
|---|---|---|---|---|---|---|
| Between Groups | 45574.89 | 2 | 22787.44444 | 2.16357 | 0.196116 | 5.143253 |
| Within Groups | 63194 | 6 | 10532.33333 | | | |
| | | | | | | |
| Total | 108768.9 | 8 | | | | |

The results show that the P-value (0.196116) is greater than the alpha level 0.05, therefore, the null hypothesis is accepted. This implies that there is no significant difference between the characteristics of the varying amounts of taro starch in bioplastic in terms of its flexibility when the fatigue test was conducted.

**Table 10.** Results for destructive pull test

| **Treatments** | **Elongation Percentage (%)** | | | **Mean** |
|---|---|---|---|---|
| | **Trial 1** | **Trial 2** | **Trial 3** | |
| **15g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | 10 | 11.63 | 10 | 10.54 |
| **30g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | 8.88 | 6.25 | 11.11 | 8.75 |
| **45g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | 6.67 | 8.33 | 9.3 | 8.1 |

From the table above, the researchers made three treatments of our bioplastic out of Taro starch to test its flexibility through destructive pull test, where the higher the elongation percentage, the better the plastic's quality. Treatment 1 has an average of 10.54%, treatment 2 has an average of 8.75% and treatment 3 has an average of 8.1%. In the table above, treatment 1 shows the highest average of elongation percentage among the three treatments, while treatment 3 has the lowest average elongation percentage. Therefore, treatment 1 is the most ductile while treatment 3 is the most brittle among the three treatments.

**Table 11:** One-way analysis of variance (ANOVA) of destructive pull test.

ANOVA

| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
|---|---|---|---|---|---|---|
| Between Groups | 0.000962 | 2 | 0.000480803 | 1.682549 | 0.262976 | 5.143253 |
| Within Groups | 0.001715 | 6 | 0.000285759 | | | |
| | | | | | | |
| Total | 0.002676 | 8 | | | | |

The results show that the P-value (0.262976) is greater than the alpha level 0.05, therefore, the null hypothesis is accepted. This implies that there is no significant difference between the characteristics of the varying amounts of Taro starch in bioplastic in terms of its flexibility as per the destructive pull test.

**Table 12. Results for Rate of Decomposition Test**

| Treatments | Weight Loss Percentage (%) | | | Mean |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | |
| **15g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | 41.82 | 45.24 | 33.33 | 40.13 |
| **30g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | 14.52 | 30.77 | 7.14 | 17.48 |
| **45g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | 2.25 | 9.09 | 18.18 | 9.84 |

From the table above, the researchers made three treatments of our bioplastic out Taro starch to test its rate of decomposition through soil burial test, where the higher the weight loss percentage, the higher the plastic's rate of decomposition. Treatment 1 has an average of 40.13%, treatment 2 has an average of 17.18%, and treatment 3 has an average of 9.84%. In the table above, treatment 1 shows the highest average weight loss percentage among the three treatments while treatment 3 has the lowest average weight loss percentage. Therefore, treatment 1 decays faster while treatment 3 decays slower among the three treatments.

**Table 13: One-way analysis of variance (ANOVA) of decomposition rate test.**

ANOVA

| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
|---|---|---|---|---|---|---|
| Between Groups | 0.148898 | 2 | 0.074449 | 9.019804 | 0.015548 | 5.143253 |
| Within Groups | 0.049524 | 6 | 0.008254 | | | |
| Total | 0.198421 | 8 | | | | |

The results show that the P-value (0.015548) is less than the alpha level 0.05, therefore, the null hypothesis is rejected. This implies that there is a significant difference between the characteristics of the different amount of Taro starch in bioplastic in terms of its rate of decomposition when the soil burial test was conducted.

**Table 14. Results for Water Absorption Test**

| Treatments | Weight Loss Percentage (%) | | | Mean |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | |
| **15g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | 57.22 | 66.6 | 62.18 | 62.03 |
| **30g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | 14.65 | 29.65 | 37.22 | 27.17 |
| **45g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | 2.63 | 21.08 | 8.6 | 10.77 |

From the table above, the researchers made three treatments of our bioplastic out Taro starch to test its water absorption through water absorption test, where the higher the weight loss percentage, the higher the plastic's water absorption. Treatment 1 has an average of (62.03%), treatment 2 has an average of (27.17%) and treatment 3 has an average of (10.77%). In the table above, treatment 1 shows the highest average weight loss percentage among the three treatments while treatment 3 has the lowest average weight loss percentage. Therefore, treatment 1 absorbs the most water while treatment 3 absorbs the least water among the three treatments.

**Table 15: One-way analysis of variance (ANOVA) of water absorption test**

ANOVA

| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
|---|---|---|---|---|---|---|
| Between Groups | 0.41105 | 2 | 0.205525 | 25.38096 | 0.001181 | 5.143253 |
| Within Groups | 0.048586 | 6 | 0.008098 | | | |
| | | | | | | |
| Total | 0.459635 | 8 | | | | |

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The results show that the P-value (0.001181) is less than the alpha level 0.05, therefore, the null hypothesis is rejected. This implies that there is a significant difference between the characteristics of the different amount of Taro starch in bioplastic in terms of its water absorption when the water absorption test was conducted.

**Table 16: Results for Durability Test**

| **Treatments** | **Weight after Breaking Point (Kg.)** | | | **Mean** |
|---|---|---|---|---|
| | **Trial 1** | **Trial 2** | **Trial 3** | |
| **15g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | 0.12 | 0.18 | 0.16 | 0.153 |
| **30g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | 0.4 | 0.58 | 0.68 | 0.553 |
| **45g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | 1.8 | 2.5 | 2.7 | 2.333 |

From the table above, the researchers made three treatments of their Taro starch bioplastic to test the weight it can withstand through load-deflection test, where the heavier the weight, the more resilient the plastic will be. Treatment 1 has an average of (0.153), treatment 2 has an average of (0.533) and treatment 3 has an average of (2.333). In the table above, treatment 3 shows the highest average weight while treatment 1 has the lowest average weight among the three treatments. Therefore, treatment 3 is the most durable while treatment 1 is the least durable among the three treatments.

**Table 17: One-way analysis of variance (ANOVA) of durability test.**

ANOVA

| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
|---|---|---|---|---|---|---|
| Between Groups | 8.0808 | 2 | 4.0404 | 49.59574 | 0.000186 | 5.143253 |
| Within Groups | 0.4888 | 6 | 0.081467 | | | |
| | | | | | | |
| Total | 8.5696 | 8 | | | | |

The results show that the P-value (0.000186) is less than the alpha level 0.05, therefore, the null hypothesis is rejected. This implies that there is a significant difference between the characteristics of the different amount of Taro starch in bioplastic in terms of its durability when the load-deflection test was conducted.

**Table 18: Results for Tensile Strength Test**

| Treatments | Force after Breaking Point (N) | | | Mean |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | |
| **15g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | 1.2 | 1.8 | 1.6 | 1.53 |
| **30g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | 4 | 5.8 | 6.8 | 5.53 |
| **45g. of taro starch**<br>7.5mL. Vinegar<br>7.5mL. Glycerin<br>60mL. Water<br>1g. Paraffin Wax<br>0.075g. Sodium Benzoate | 15.6 | 22.2 | 24.5 | 20.76 |

From the table above, the researchers made three treatments of their Taro starch bioplastic to test if it can withstand tension forces through melting point test, where the higher the force, the higher the plastic's tensile strength. Treatment 1 has an average of (1.53), treatment 2 has an average of (5.33) and treatment 3 has an average of (20.76). In the table above, treatment 3 shows the highest average force applied treatments while 1 has the lowest average force applied among the three treatments. Therefore, treatment 3 is the most resilient while treatment 1 is the least resilient among the three treatments.

**Table 19: One-way analysis of variance (ANOVA) of tensile strength test.**

ANOVA

| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
|---|---|---|---|---|---|---|
| Between Groups | 617.9756 | 2 | 308.9878 | 39.52935 | 0.000351 | 5.143253 |
| Within Groups | 46.9 | 6 | 7.816667 | | | |
| Total | 664.8756 | 8 | | | | |

The results show that the P-value (0.000351) is less than the alpha level 0.05, therefore, the null hypothesis is rejected. This implies that there is a significant difference between the characteristics of the different amount of Taro starch in bioplastic in terms of its tensile strength when the tensile strength test was conducted.

# CHAPTER 5

This chapter shows the conclusion and recommendations of this study.

## Conclusion

After the preparation and tests, the researchers are convinced that Colocasia Esculenta starch or mainly known as “Taro starch” has a potential to be a component in making an alternative bioplastic. The level of flexibility during the fatigue test, durability and tensile strength is directly proportional to the amount of starch itself that is used in formulation, where the higher the taro starch content in the bioplastic, the higher the bioplastic’s properties and vice versa. On the other hand, the level of flexibility during the destructive pull test, rate of decomposition, and water absorption are inversely proportional to the amount of starch itself that is used in formulation, where the higher the taro starch content in the bioplastic, the lower the bioplastic’s properties and vice versa. The null hypothesis is accepted in terms of its flexibility where there is no significant difference among the three treatments during the fatigue and destructive pull test in different trials. On the other hand, the alternative hypothesis is accepted in terms of its water absorption, rate of decomposition, durability, and tensile strength test where there is a significant difference among the three treatments in different trials.

**Recommendation**

This study revealed the effectiveness of Colocasia Esculenta starch as a main component in making bioplastics. It is recommended to conduct more tests; thermal test, anaerobic degradation, compression test, and melt index test to name a few, to further support the effectiveness of the bioplastic. Appearance wise, additionally it is recommended to improve the color or transparency and texture of the product. It is also recommended to enhance the process of molding the plastic to have a firm and smooth surface. It is further recommended to conduct research on the uses of the product like food wrappers, containers, or medicine films or capsules.

# Appendix

**Photos:**

**Taro (Colocasia Esculenta)**

**Rinse the Taro (Colocasia Esculenta)**

**Peel the Taro (Colocasia Esculenta)**

**Grate the peeled Taro (Colocasia Esculenta)**

**Filter the Taro Extract**

**The Taro Starch**


**Prepare the necessary ingrideints**

**Mix the Ingredients**

**Heat the bioplastic solution until its desired viscosity.**

**Dry the bioplastic solution**

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