# COMPARATIVE ANALYSIS ON THE QUALITY OF RICE-BASED AND CORNSTARCH-BASED BIOPLASTIC


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## PREFACE

To start with, the researcher would like to praise and thank God, who has accompanied and led her journey to accomplish her research paper entitled: "COMPARATIVE ANALYSIS ON THE QUALITY OF RICE-BASED AND CORNSTARCH-BASED BIOPLASTIC".

This research is submitted to Chandra Kumala School as part of the mandatory curriculum learning process for year 12 students. The researcher would like to express gratitude to all of those who have given contributions so that this research can be finished. This researcher would like to thank:

1. Ms. Tisha Tabhita Siregar, S.Pd as the mentor for this research paper who guides and assists the researcher from beginning to end
2. All of the researcher's friends and family who motivates her and gives her their unwavering support during this research

The researcher acknowledges that this research paper is far from perfect, therefore, the researcher expects criticism and constructive suggestions. The researcher hopes that this research paper is able to give a positive contribution to education.

Deliserdang, 27 April 2025

Alfreda Ellis Onggono

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# CHAPTER I

# PRELIMINARY

## 1.1 Background of Research

Plastics possess the quality of strong, durable, and inexpensive synthetic or semi-synthetic organic polymers. Their characteristics justify the crucial use of plastic in life. Approximately 99% of plastics are made starting from non-renewable resources such as charcoal, petroleum, and natural gas, about 20% of the overall petroleum consumption could be related to the plastics industry as well (Kasavan 2021). In Society, plastics are mainly exploited in the packaging (~40%), construction field (~20%), textile industry (~15%), automotive (~10%), and goods (~10%). Considering all these applications, the use of plastics could grow in the near future (World Economic Forum 2016; Gu 2017).

This could call for danger because plastics break down into microplastics, which attract toxins in the ocean. Marine life ingests these, and the toxins move up the food chain, with humans consuming about a credit card's worth of plastic each week. Microplastics can also enter our bodies through breathing and skin contact, potentially harming our health. In low and middle-income countries, poor waste management leads to plastic blocking waterways, worsening flooding and disease. Burning plastic pollutes the air, harming local communities, especially children. Every 30 seconds, someone dies from diseases caused by mismanaged waste. (Schröder *et al*, 2022)

Researchers all over the world have recognized this problem, hence there are a lot of pre-existing alternatives for biodegradable-plastics. For instance, the development of neem based bioplastic for food packaging application (Shellikeri *et al*, 2018), and bioplastic based on starch and cellulose nanocrystals from rice straw (Agustin *et al*, 2014). As mentioned above, the majority of these research are present with a common ingredient among them which is rice or starch.

Rice based biopolymer is used to make biodegradable polymers that can be helpful to replace the use of synthetic polymers as it jeopardizes the environment (International Journal of Applied Science and Engineering, 202024). This media proves worthy of use due to their biodegradability, non-toxicity, varying solubility, controlled release characteristics, and responsiveness to microbial degradation in the environmental atmosphere (Zohuriaan-Mehr *et al*, 2009; Petre *et al*, 1999 ; Ali *et al*, 2018).

On the other hand, Starch, which is a biodegradable natural polymer and produced in abundance at low cost is proven to be one of the most promising candidates for fabrication of bioplastics (Huangu *et al*, 2004). The amylose content in starch is an important characteristic for bioplastics production as it is responsible for gelatinization and retrogradation. Thus, it is strong and durable like synthetic plastic (Shimazu *et al*, 2007).

The production and use of bioplastics instead of synthetic plastics reduce emissions of polluting gasses and provide materials from renewable and/or biodegradable sources, availability of raw materials, and a promising alternative for the destination of solid biomass residues (Lackner, 2015; Paula *et al*, 2018; Naik *et al*, 2009; Pachauri *et al*, 2014; Neuling and Kaltschmitt, 2017). On account of the reasons mentioned above, the necessity to conduct this research should be done in order to provide knowledge and understanding on the **"COMPARATIVE ANALYSIS ON THE QUALITY OF RICE-BASED AND CORNSTARCH-BASED BIOPLASTIC"** that can benefit the environment and humanity.

### 1.2 Problem Identification

According to the background stated before, these problems can be recognized:

a) Synthetic plastic takes centuries to decompose because of its non-biodegradable chemical structure which makes it resistant to decomposition by microorganisms.

b) The negative effect synthetic plastic does to the environment: polluting gasses, toxicity, plastic landfills, over-consumption of petroleum.
c) The overflowing amount of research circling around starch-based and rice-based bioplastic

### 1.3 Research Question

According to the background and problem identification stated before, the research questions are:

a) How to create rice-based bioplastic and cornstarch-based bioplastic for day-to-day use?
b) How to compare the quality of rice-based bioplastic and cornstarch-based bioplastic?

### 1.4 Purpose of Research

According to the statements stated before, the purpose of this research are:

a) To create rice-based bioplastic and cornstarch-based bioplastic for day-to-day use.
b) To compare the qualities of rice-based bioplastic and cornstarch-based bioplastic.

### 1.5 Benefits of Research

a) For student:

   The result of this research will bring awareness and enhance student's knowledge about the comparative qualities of rice-based and cornstarch-based bioplastic.

b) For teacher:

   The result of this research will bring awareness and enhance teachers' knowledge about the comparative qualities of rice-based and cornstarch-based bioplastic.

c) For researcher:

   The result of this research can be applied for future study as assistance and reference for relevant research.

## 1.6 Scope and Limitation of Research

This research is only focused on comparing the qualities of rice-based bioplastic and cornstarch-based bioplastic in the direction of day-to-day use. This research will compare the qualities of bioplastic by: swelling test, solubility test, and degradation by soil burial method.

## CHAPTER II

## LITERATURE REVIEW

### 2.1 Bioplastic

Bioplastics are made fully or partially from renewable biomass sources. Some bioplastics are biodegradable or even compostable in the right condition. Bioplastics made from biodegradable materials that can be naturally recycled by biological processes, thus reducing the harm and use of fossil fuels in the environment. Therefore, bioplastics are sustainable, largely biodegradable, and biocompatible. In this era, bioplastics are widely used for many industrial applications such as food packaging, agriculture and horticulture, composting bags, and hygiene. It has also found their use in biomedical, structural, electrical, and other consumer products. (Daverey *et al*, 2023)

### 2.2 Types of Bioplastic

a) Starch-based plastics

Figure 2.1 starch bioplastic (Logeshwaran *et al*, 2020)

Pure starch is able to absorb humidity, and is thus a suitable material for the production of drug capsules by the pharmaceutical sector. However, pure starch-based bioplastic is brittle. Plasticizer such as glycerol, glycol, and sorbitol can also be added so that the starch can also be processed thermo-plastically. The properties of starch bioplastic is largely influenced by amylose/amylopectin ratio. Generally, high-amylose starch results in superior mechanical properties (Li *et al*, 2011). However, high-amylose starch has less processability because of its higher gelatinization temperature (Liu *et al*, 2006) and higher melt viscosity (Xie *et al*, 2009).

b) Cellulose-based plastics

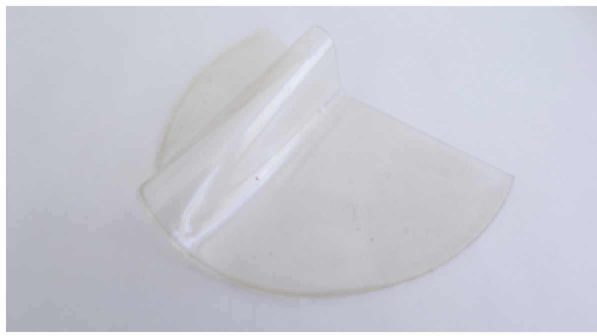

Figure 2.2 agar bioplastic (Houthuijs, 2023).

Cellulose bioplastics are mainly the cellulose esters (including cellulose acetate and nitrocellulose) and their derivatives, including celluloid.

Cellulose can become thermoplastic when extensively modified. An example of this is cellulose acetate, which is expensive and therefore rarely used for packaging. However, cellulosic fibers added to starches can improve mechanical properties, permeability to gas, and water resistance due to being less hydrophilic than starch (Avérous *et al*, 2014).

c) Protein-based plastics

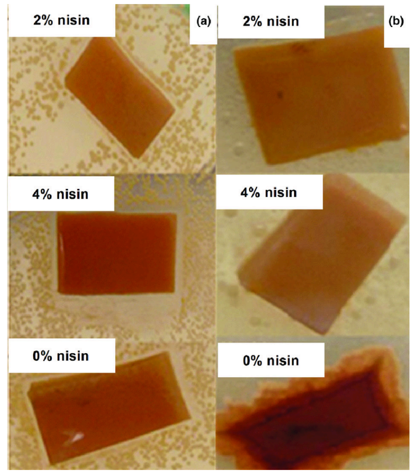


Figure 2.3 pea-based protein bioplastic (Romero *et al*, 2016)

Bioplastics can be made from proteins from different sources. For example, wheat gluten and casein show promising properties as a raw material for different biodegradable polymers (Song *et al*, 2009)

Additionally, soy protein is being considered as another source of bioplastic. Soy proteins have been used in plastic production for over one hundred years. For example, body panels of an original Ford automobile were made of soy-based plastic (Ralston *et al*, 2008)

There are difficulties with using soy protein-based plastics due to their water sensitivity and relatively high cost. Therefore, producing blends of soy protein with some already-available biodegradable polyesters improves the water sensitivity and cost. (Zhang *et al*, 2006)

### 2.3 Bioplastic as Sustainable Product

Plastic is made of artificially created chemicals "that don't belong in our world and don't mix well with nature." After we use plastic–sometimes only for a few seconds–we throw it away. These plastics are a big source of pollution, getting into our food and water, creating toxic health hazards for neighboring communities as part of their production and disposal and killing marine wildlife. While public pressure has made companies appear to be more environmentally friendly, most haven't cleaned up their act. They've only created more confusing terms, greenwashing their products to make us feel like we're acting responsibly (Ecology Center, 2017).

A 2015 Nielson survey found that nearly 75% of millennials globally are willing to pay extra for sustainable products. And new research has shown that the next generation, Gen Z, thinks similarly in regards to the environment and sustainable products. A study conducted by First Insight in December 2019 found that 62 percent of Gen Z prefer to buy from sustainable brands. And 10 percent are willing to pay a premium price for sustainable items. Opting for sustainable business practices and materials isn't just a nice to have - it's a requirement. Younger customers today care about where companies are sourcing ingredients and components, and how products are packaged and shipped. As we've also seen, the younger generations have pushed companies to eliminate wasteful packaging and single-use plastic. (Langlois, 2020)

Bioplastics can replace nearly every type of conventional plastic and are diversifying into various markets. But while the growth of bioplastics is promising, their sustainable integration requires addressing resource use, improving supply chain traceability, increasing recycling, and reducing overall consumption.

As the bioplastics industry matures, it must address the complexities of sustainability and consumer education to ensure that the potential environmental benefits of bioplastics can be fully realized. Thus, the future of bioplastics is not just about creating alternatives to conventional plastics but about fostering a culture of circularity and responsibility that transcends industries and reshapes our environmental (Malooly & Daphne, 2023)

### 2.4 Qualifications of Bioplastic

The same properties that make plastics an essential commodity in modern day life are also what cause an environmental problem. Since large scale plastic production was established, plastics have become ubiquitous with society becoming dependent on their use. Unfortunately, the ubiquity and durability of plastics have led to problems if waste plastic is inappropriately dealt with, invading natural habitats and causing harm to local ecosystems. Some areas have such high levels of plastic pollution that a new epoch has been coined relating to the levels of plastic in soil samples (Geyer *et al*, 2017l & Harrison *et al*, 2018l)

Bioplastics are plastics that can be decomposed by the microorganisms' activity quickly (Kelibay, 2020). It is made entirely or at least 20 percent composed of renewable biomass sources, such as starch, cellulose or sugar (Goodall, 2011). Because of its biological origin, it is inherently biodegradable, which means that it can easily be broken down into CO2, water, energy and cell mass with the aid of microbes, rendering it largely carbon neutral (Lorcks, 2006). Bioplastics can decompose without leaving toxic residues after being used up because of their nature that can return to nature. (Kelibay, 2020)

Plastics are primarily degraded by bacteria. The long chains created in the polymerization are difficult for many bacteria to degrade. They can only attack the molecule at the ends. When starch is combined with the PLA, it can be degraded more easily by the bacteria. Plasticisers such as agar, glycerol, sorbitol and triethyl citrate are also added to starch-PLA compounds to prevent brittleness. “PLA is fully biodegradable when composted in a large-scale operation with temperatures of 60 ºC and above. The first stage of degradation of PLA (two weeks) is via hydrolysis to water-soluble compounds and lactic acid” (Shah *et al*, 2008). Microorganisms then break down the lactic acid into $CO^2$, biomass and water.

# CHAPTER III

# RESEARCH METHODOLOGY

## 3.1 Method of Study

The research method that is used in this study is experimental-qualitative, it is a hybrid approach that combines elements of both experimental and qualitative methodologies to explore and understand phenomena. This approach allows researchers to manipulate one or more variables while also collecting and analyzing qualitative data to gain deeper insights into the underlying reasons, opinions, and motivations behind observed outcomes.

Sirisilla believes that experimental research design relies on statistical analysis to prove or disprove a researcher's hypothesis. It is one of the most accurate forms of research because it provides specific scientific evidence (Sirisilla, 2023)

## 3.2 Place and Time of Research

This research is held in Chandra Kumala School's Biology Lab starting from May 2024 - April 2025.

## 3.3 Data Collection Technique

In this research, data collection will be done by conducting an experiment. This researcher will create bioplastic with rice as base and another with starch as base. The researcher will then test, compare, and analyze the results of swelling test, solubility test, and degradation by soil burial method.

## 3.4 Research Instrument

Instrument of the research is a tool to collect the data by the researcher

(Arikunto, 2009). In this research, the bioplastic will be tested by these following tests:

a) Swelling test

To evaluate the sustainability and retention of the bioplastic, the swelling test was conducted. Pre-weighed samples were immersed in solvents such as water, chloroform and methanol for 3 hours. The weight difference was calculated.

b) Solubility test

The bioplastic developed is subjected to different solvents to examine their solubility. Samples of the size 5 cm by 5 cm were taken. Solvents such as alcohol, hydrochloric acid, and distilled water were utilized. Alcohol was diluted to 70% and 20%, and hydrochloric acid to 1 M and 0,5 M for the comparative study. The bioplastics were immersed in these solvents for about 3 hours and results were tabulated.

c) Degradation by soil burial method

Samples of bioplastic were cut into 5 cm by 5 cm and buried in soil. Bioplastic degradation was then observed over 14 days. (Shellikeri et al, 2018)

### 3.5 Research Procedure

The research procedure in this study are:

a) Rice-based bioplastic

1. In a glass bowl, mix water, glycerin, rice-flour, and vinegar in the ratio of 24:3:6:1.
2. Stir and heat on medium until the mixture changes to a gel and starts to become clear
3. Wait for the mixture to cool then pour the corn plastic in a mold or chosen surface. Let the mixture dry.

b) Starch-based bioplastic

1. In a glass bowl, mix water, glycerin, cornstarch, and vinegar in the ratio of 24:3:6:1.
2. Stir and heat on medium until the mixture changes to a gel and starts to become clear
3. Wait for the mixture to cool then pour the corn plastic in a mold or chosen surface. Let the mixture dry. (KS Corn, 2024)

# CHAPTER IV

# RESULTS AND DISCUSSION

## 4.1 Research Findings

a) Swelling test results

The swelling test was conducted by immersing both rice-based and starch-based bioplastic samples in distilled water, alcohol, and hydrochloric acid for 3 hours, then calculating the increase in weight.

| No. | Medium | Bioplastic Type | Initial Weight (g) | Final Weight (g) | Swelling (%) |
|---|---|---|---|---|---|
| 1. | Alcohol (20%) | Rice-Based | 0,701 | 1,082 | 54.50% |
| | | Corn Starch-Based | 0,465 | 0,691 | 48.60% |
| 2. | Alcohol (70%) | Rice-Based | 0,560 | 0,551 | -1.61% |
| | | Corn Starch-Based | 0,355 | 0,467 | 31.55% |
| 3. | Hydrochloric Acid 1M | Rice-Based | 0,458 | 0,887 | 93.66% |
| | | Corn Starch-Based | 0,471 | 0,725 | 53.93% |
| 4. | Hydrochloric Acid 0,5M | Rice-Based | 1,085 | 1,861 | 71.52% |
| | | Corn Starch-Based | 0,245 | 0,518 | 111.43% |
| 5. | Water | Rice-Based | 0,724 | 1,443 | 99.31% |
| | | Corn Starch-Based | 0,564 | 1,175 | 108.33% |

Table 4.1 Swelling test results

- Swelling percentage formula

$$Swelling\,\% \;=\; \frac{Final\,Weight - Initial Weight}{Initial\,Weight} \times 100$$

These results indicate that rice-based bioplastic has better resistance to water absorption compared to cornstarch-based bioplastic, making it more suitable for applications exposed to moisture.

b) Solubility test results

The solubility test was conducted by immersing both rice-based and starch-based bioplastic samples in distilled water, alcohol, and hydrochloric acid for 3 hours, then evaluating the characteristics of the bioplastic after stirring.

- Rice-based bioplastic

| No. | Medium | Characteristics after 3 hours |
|---|---|---|
| 1. | Alcohol (20%) | Soften |
| 2. | Alcohol (70%) | Hardened |
| 3. | Hydrochloric Acid 0,5M | Soften |
| 4. | Hydrochloric Acid 1M | Broke down |
| 5. | Water | Swell |

Table 4.2 Solubility test results

- Cornstarch-based bioplastic

| No. | Medium | Characteristics after 3 hours |
|---|---|---|
| 1. | Alcohol (20%) | Soften |
| 2. | Alcohol (70%) | Harden |
| 3. | Hydrochloric Acid 0,5M | Soften |
| 4. | Hydrochloric Acid 1M | Soften |
| 5. | Water | Swell |

Table 4.3 Solubility test results

These results indicate that cornstarch-based bioplastics are less soluble in strong acidic environments and water, implying better structural integrity in humid environments.

c) Degradation by soil burial method test results

The degradation by soil burial method test was conducted by burying them in soil and observing deterioration over 14 days.

| No | Bioplastic Type | After 14 days |
|---|---|---|
| 1. | Rice-based Bioplastic | Decomposed |
| 2. | Cornstarch-based Bioplastic | Decomposed |

Table 4.4 Degradation by soil burial method test results

These results indicate that rice-based bioplastic and cornstarch-based bioplastic are both equally biodegradable under soil conditions, making them more environmentally friendly in terms of degradation rate.

## 4.2 Comparative Analysis of Bioplastic Quality

a) Visual and texture comparison

Both types of bioplastics were successfully molded into thin films. Rice-based samples appeared more transparent and flexible. while starch-based samples appeared more cloudy and brittle. The difference in appearance may be due to differences in gelatinization during the drying process.

The following tests were conducted to measure the qualities of each type of bioplastic in various environments:

- Swelling test: This test evaluated how much water or liquid each bioplastic absorbed when submerged. The rice-based bioplastic exhibited lower swelling levels in most tested liquids, indicating a more compact molecular structure that resists water absorption. In comparison, the corn starch-based bioplastic absorbed more water, causing it to expand and soften. This suggests that rice-based bioplastics are more suitable for use in humid or wet conditions where dimensional stability is important.

- Solubility test: In the solubility test, samples were exposed to strong chemicals, such as hydrochloric acid, to assess their resistance. The corn starch-based bioplastic showed higher resistance to chemical breakdown, maintaining its shape and strength throughout the test. Meanwhile, the rice-based bioplastic showed partial softening, suggesting it is less chemically durable. This indicates that corn starch-based bioplastics may be better suited for applications involving chemical exposure.
- Degradation by soil burial method test: To evaluate biodegradability, both bioplastic samples were buried in soil under the same conditions and observed over a set period. The results showed that both rice-based and corn starch-based bioplastics began degrading at approximately the same rate. This indicates that regardless of the starch source, both materials are equally biodegradable and capable of decomposing naturally in the environment. Their similar degradation performance reinforces their potential as sustainable alternatives to conventional plastics.

b) Interpretation of Findings

The rice-based bioplastic performed better in terms of water absorption resistance, having a lower swelling percentage. On the other hand, cornstarch-based bioplastics performed better in the solubility test, proving its durability in moist conditions. In the soil burial test however, both types of bioplastic showed biodegradability which makes them equally beneficial for reducing long-term environmental impact.

c) Correlation with Theory

These findings align with studies by (Yuliani, 2020), which states that starch-based bioplastics are less resistant to water compared to rice-based bioplastics.

d) Factors Affecting the Results

The following may have affected the results:

- Glycerol concentration as a plasticizer.
- Drying conditions such as temperature and humidity.
- Fineness of rice flour vs cassava starch
- Environmental conditions during soil burial test such as the moisture and weather.

# CHAPTER V

# CONCLUSION AND SUGGESTIONS

## 5.1 Conclusion

This research aimed to compare the properties of bioplastics made from rice starch and cornstarch using glycerin as a plasticizer for day-to-day use. Both types were then tested by swelling test, solubility test, and degradation through soil burial method test.

To create rice-based bioplastic and cornstarch-based bioplastic for day-to-day use, first prepare 24 grams of water, 3 grams of glycerin, 6 grams of either rice flour or cornstarch, and 1 gram of vinegar. Stir the ingredients together in a glass bowl and heat the mixture on medium until it thickens into a gel and becomes clear. Once the mixture cools down, pour it into a mold or onto a chosen surface, and allow it to dry completely. This simple process can be used to produce bioplastics that are more environmentally friendly for everyday applications.

The conclusion that can be drawn from the results of the swelling, solubility, and soil burial degradation tests are:

a) Rice-based bioplastic has less swelling in all types of liquids, meaning it absorbs less water. This makes it more suitable for wet or humid environments.
b) Corn starch-based bioplastic did not dissolve easily in strong chemicals like hydrochloric acid. This shows it is stronger in harsh chemical conditions.
c) Both types of bioplastic broke down in soil, which means they are biodegradable.

## 5.2 Suggestions

a) Mixing in other materials might help improve their resistance to water or chemicals.

b) Test these bioplastics in real-life situations like food packaging or farming to see how well they work.
c) Observe the degradation in soil for a longer time to get more complete results.

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