

## Biodegradable Cup as A Substitute for Single Use Plastic

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**Abstract:** Be it on thin ice, plastic waste is not easily recycled or composed because it is not an organic material. Large amount of plastic waste has been improperly disposed due to the unregulated processing of plastic products, which has caused pollution around the world and has also shown that it is lethal to the ecosystem. The project investigates the feasibility of the biodegradable cutlery as an alternative to single-use plastics which would also serve as an important practical step in the direction of zero plastic use and waste along with the limitations. It would be made from organic material like corn and barley and is an ideal alternative to any plastic tableware and cutlery. Grinding, mixing, heating, compressing, cutting, and no chemical compounds are required for the process. By looking at the quality of product, they can replace the plastic cutlery as the quality of biodegradable cutlery from organic materials are near to the perfect characteristic of the plastic one. All the tests that are conducted would be determined the overall result that brings toward the idea of eliminating the single-use plastic that helps to have a healthier, safer and greener future.

**Keywords:** Biodegradable, Cutlery, Plastic, Corn, Barley

### 1. Introduction

Single-use plastic cutlery or packaging is a smart, functional innovation. Since it is non-organic, plastic waste is not effectively recycled or compounded. Unregulated manufacturing of plastic material has led to a large amount of poorly handled plastic waste resulting in a large amount of contamination across the globe and has also shown to be deadly to the environment [1]. Plastic waste is still a major problem in Malaysia, which ranks 8th out of the top 10 countries in the world with poorly handled plastic waste. The study estimated that Malaysia generated 0.94 million tons of untreated plastic waste, which could have been swept through the oceans by 0.14-0.37 million tonnes [2].

Plastics do not decompose easily into the environment and take decades and centuries to do so. They limit the use of natural resources for future generations. In fact, a substantial reduction in plastics will be one of the highest priorities, in particular equipment and utensils used specifically for food

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consumption [3]. This research will focus on edible and biodegradable cutlery as an alternative to single-use plastics. It will also serve as a significant practical move forward towards zero use of plastics and waste.

The purposes of the research are to scientifically determine the most effective raw ingredient in the manufacture of biodegradable cutlery products. The creation of biodegradable cutlery products in an effort to reduce the need to use single-use plastic products. Analyzing the features of biodegradable cutlery with the same quality as other forms of traditional cutlery. Biodegradable and edible cutlery or tableware itself is product made of organic material which can be created from a wide variety of ingredients. This is the ideal solution to that disposable tableware, such as plastic or polystyrene. Corn and barley at a proportion of 50:50 are the main ingredients or components of our product.

Due to their light weight and balloon-shaped form, plastic bags are effortlessly blown up in the sky and eventually end up in the environment decomposing, contaminating soil and water throughout decades or centuries, and posing severe ingestion, strangling and suffocating hazards to habitats on land and in the ocean [4].

## 2. Experimental Procedure

There are five keys processes are involved in this project. The underlying mechanisms include grinding, combining, compressing, baking and cutting. Each process is closely controlled in order to ensure better outcomes. The composition of the resulting model is not unduly complicated. It's very basic, yet it works very well. Selection of materials on the basis of previous studies and review of knowledge for better outcomes.

### 2.1 Materials

Corn and barley are the main ingredients of this product. The amount of water required has always been believed to be an important feature of the effectiveness of this product. The scarcity of moisture and fat in our products helps us to get a longer lifespan without the need for any additional preservatives' chemical. The combination within one substance to another corresponds to a specially defined ratio of 7:3 [5]. That is equalized to 7 parts of the grain and 3 parts of the water. It is very important to the success of a stronger and more sustainable product. **Figure 1** shows the instruments used during this project production processes such as (a) blender, (b) Cupcake tray, (c) Oven.



**Figure 1: Instruments used in the production process**

## 2.2 Methods

The processes to produce the biodegradable cutlery were involving grinding, mixing, compressing, baking and cutting as summarize below:

Natural resources, such as corn and barley, must have been ground or crushed even further into smaller bits for the manufacture of the product. In fact, with the used of grinding machine to crush corn as well as barley.

Accordingly, the materials were grounded and weighed at a predetermined ratio of 7:3. Just these 3 sections of the water itself may simply decide the durability of this product, as over-watering can be resulting the mixture to weaken and lead the product to break easily with much less durability. If the water is too less, these materials will become brittle thanks to the shortage of moisture required to hold them together throughout the heating process. The 7-part key ingredients are corn and barley partitioned by 50:50 for the development of a combination of ingredients that improves the strength of this product.

The full material composition shall be rolled out on a ready-made mold using an aluminum cupcake tray as the same tray underneath. This would therefore give the product a beautiful form. The mixture has been placed with a weight of 10 minutes.

Though if the dough is ready, bake around temperature of 360°C for 15 minutes. Let it cool it down for a further process at room temperature. About this heating method removes just about all the excess moisture from the mixture, rendering the final product extremely hard.

The trays and bowls, that has returned to room temperature after heating, undergo a cutting process where each product is cut over excess material and the surrounding edges are tested and checked for the same thickness. Once these things have been checked, the product is completed and finished.

## 3. Results and Discussion

Toward the end of the project study, the planned outcome would be the development of biodegradable cutlery with the ideal characteristic made by the relevant raw material from the entire investigation.

### 3.1 Determine the most suitable raw ingredient

Two main raw ingredients, corn and barley, are the ideal ingredients for real edible and biodegradable cutlery compared to other raw ingredients. This refers to all the research on the strength of the product to be made, the lifetime of the product, the cost of the product in the manufacturing process, how the market can easily embrace and shift its direction from the old single-use plastic product to the biodegradable one, and also the consistency of the biodegradable cutlery compared to the conventional plastic cutlery that could be used.

**Table 1: The period on different types of biodegradable cutlery last long [6].**

| Type of raw ingredients | Lifetime   |
|-------------------------|--|
| Corn +<br>Barley        | 1. Expected for about one month.   |
|                         | 2. Edible when still dried or already wet or soften. Cannot re-keep after one single-use.                      |
|                         | If this product has not been used yet but has been eaten a little, it can be stored again in the refrigerator. |

|                                     |   |
|-------------------------------------|---|
| Sorghum or Jowar                    | 1. Can no longer be used if it is wet or soggy. (only get soft and soggy after 10-15 minutes if wet food was put on it.<br>Short amount of time to degrade (5-6 days with no use), can't keep longer. |
| Biscuits dough                      | 1. Last for several months (same as a normal biscuit period)<br>Edible in dried (up to 45 days) and in wet (immediately and cannot be re-used)  |
| Wheat bran                          | 1. Similar to sorghum after use.<br>A little bit longer to degrade than sorghum, can keep longer to eat, but can't re-keep (it is single use)   |
| Fruit and vegetables (seaweed agar) | 1. Only few minutes if hot water/wet food put on it, the cutlery can be damaged.<br>Same as normal fruit and vegetables, but need to keep in refrigerator.  |

**Table 1** shows how long the raw ingredients can be long lasting. Once it goes to characteristics, the main aspect that needs to be looked at is the quality and performance of the biodegradable cutlery based on various types of raw ingredients. However, as all these items are often edible and need to hold whether soggy, wet or dry food, this proof there is a difference in performance. Still, not most ingredients could be incorporated with a natural range of flavors. One of several characteristics that need to be based on is how long these items will last, as biodegradable cutlery is also edible and people need to hold cutlery in large amounts for a long time in different type.

**Table 2. Temperature endurance among types of cutlery [6-8]**

| Biodegradable cutlery | Plastic cutlery (single use one) [6].                 | Glass cutlery   | Stainless steel cutlery   |
|-----------------------|---|---|---|
| -25 °C – 220 °C       | 100 °C – 126.9 °C<br>(Boiled water/soup can break it) | -40 °C – 300 °C<br>(glass is a good heat conductor, this will give hazard to anyone who touch the cutlery in high temperature.) | Up to 500 °C.<br>(dangerous to user since steel can transform heat easily.) |

In addition, even the raw materials are different, biodegradable cutlery is still available with better pros compared to traditional plastic cutlery and even compared to other forms of conventional cutlery. Two aspects that really are a major benefit of biodegradable cutlery, which are cost and temperature endurance. The comparison of temperature endurance among types of cutlery can be seen in **Table 2**.

The biodegradable and edible cutlery are the best option of single-use cutlery and can replace the use of plastic. Thus, the best performance and endurance among ingredients is important where corn and barley are the best option to produce the biodegradable and edible cutlery compared to others ingredients.

### 3.2 Production of the product

To ensure that the production process of this biodegradable cutlery is runs smoothly, all the stated method needs to be done very clear with least of flaws. These are included five step of process which are grinding, mixing, compressing, heating and cutting. The process of making the biodegradable cutlery is started by grinding process. As the ratio of ingredient to water is 7:3 respectively. 140 grams of barley and corn are blended by using a dry blender and mix with 60 grams of water. By going through all these processes, six biodegradable cutleries in small-cup shaped size managed to be produce with total of 70 grams barley and 70 grams corns with 60 grams of water. The process to produce the biodegradable cutlery can be seen from **Figure 2**: (a) grinding using dry blender, (b) mixing of raw ingredient with water, (c) compressing the mixture in a cup-shaped tray, and (d) heat treatment of the sample in the oven.



a



b



c



d

**Figure 2: Process of the production**

### 3.3 The characteristics of the biodegradable cutleries

Research has shown that biodegradable cutlery often has the same standard as conventional cutlery, perhaps with a better endurance and a little safer to use and handle. As the standard to plastic cutlery is the same, biodegradable corn and barley cutlery is expected to be the best choice to replace plastic use.

**Table 3: Overview of the comparison of the biodegradable cutlery product to the plastic [7][8][9][10].**

|                                   | Corn-Barley Based Biodegradable Product   | Single-Use Plastic Product                         |
|-----------------------------------|---|--|
| Temperature Endurance             | 200°C for 20 minutes<br>-7°C for two weeks or more since due date is coming up. | 126.9°C maximum.<br>-40°C maximum low temperature. |
| Long Lasting Monitoring Divisions | Recorded until 41 days because of our due date.                                 | 1000 years to decompose.                           |
| Degradable Period                 | 27 days to be fully degraded.   | 1000 years to decompose.                           |
| Quality Effectiveness Evaluations | Hold water for 22 minutes.<br>Bear less than 12kg limit before breaking.        | Waterproof.<br>4.85 kg / 10.7 lb maximum.          |
| Recognition of Price              | 0.25 cent per single product  | 0.10 cent per single product.                      |

Based on the **Table 3**, it shows an overview of the characteristics of the bio-product that have been made compare to the plastic as summarize below:

Temperature endurance, biodegradable cutlery was left inside the oven at a temperature of 200°C for high temperatures testing. After 20 minutes, variations in color can be seen on the product, where it becomes darker brownish as time goes on. Therefore, it is concluded that this is indeed the limit for the product. For low temperatures, the biodegradable cutlery was placing in the refrigerator at -7°C. After leaving it for two weeks and no differences has been seen, it can be concluded that the product is ideal for cold temperatures. It slightly better that the plastic because when extra heat is applied to the plastic, it would release toxic chemical which would harm everyone [7].

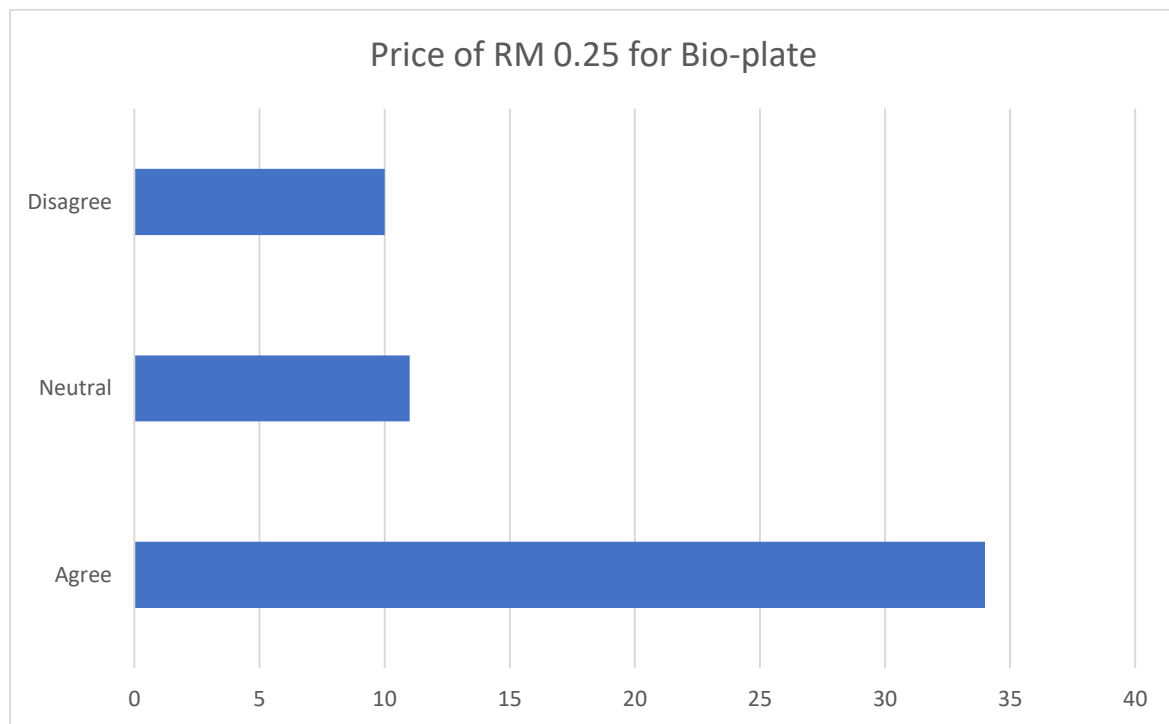
Long lasting monitoring durations, the biodegradable cutlery was placed inside of an airtight container and exposed to room temperature only. Testing began on 25 November 2020 and last reported until 5 January 2021 due to our deadline for the completion of the project. The product is still in good shape for the entire 41 days without any differences at all. Therefore, this shows that it is still can be store at room temperature with many days in counting even months better than most organic material cutlery. Although the biodegradable cutlery cannot compete to the plastic in this testing, it is still better than any other type of biodegradable cutlery.

Degradable period, the degradable duration is validated from how long it takes for a product to degrade in the natural environment. Product was buried half within the soil and exposed to the environment starting on 25 November 2020 and the product has been shown to have been fully degraded on 21 December 2020 taking a total of around 27 days. This make the statement that this organic materials' combination is one of the fastest degradations, moreover, it is 97.3% faster than minimum

degradation of plastic. Consequently, it can decrease the waste material all around the world if implementation of bio-cutlery is occurred.

Quality effectiveness evaluations, two tests are carried out to determine the quality effectiveness of the product, which is waterproof and the strength of the product. As a waterproof test, water was put inside the biodegradable product and waited for the product to absorb the water before it began to leak. We reported the time the product was able to retain the water for around 22 minutes. It is still can be improve if only the machine needed is accessible. The strength endurance test planned to position a balanced weight on top of the product to be seen is either capable of maintaining it or not. But since the balanced weight is inaccessible, it is decided to position the dumbbell since it does have a specific mass on it. After the test is carried out, the amount of weight the biodegradable product can bear is less than 12 kg as the product fully breaks the 12 kg limit. This conclude that the product is extremely strong compare to plastic due the elasticity properties that they have. Thus, plastic cannot hold weight more than 4.8 kg.

Recognition of Price, by calculating the price range, from the amount of raw ingredients being used, a single product of our biodegradable cutlery is weighed about 22.33 g and the final price for a single product is about RM 0.25. One survey had been done among the community to know either the price is reasonable to buy or not compare to plastic that cost Rm 0.10 and the result can be shown in **Figure 3**. Majority of people has voted on “Agree” and the second most voted is on “Neutral”. From the results, it can safely say that the result has been positive towards this biodegradable product.



**Figure 3. Results on the public opinion on the acceptance of the price given.**

#### 4. Conclusion

The main purpose of this research would have been to create an effective, environmentally friendly alternative to plastic cutlery, which would threaten our biodiversity. Action towards environmental issues is one of the most important initiatives to achieve the objectives and ensure sustainable livelihoods for future generations. Biodegradable and edible cutleries would be a whole new vision and alternative for the struggle towards plastic pollution. The study analyses the plastics manufacturing

sector as well as its cutlery sector, and how the ecological system is disintegrating, thereby looking deeper through the product like edible cutlery, as an environmentally friendly and comprehensive solution for counteracting plastic pollution.

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### Appendix A

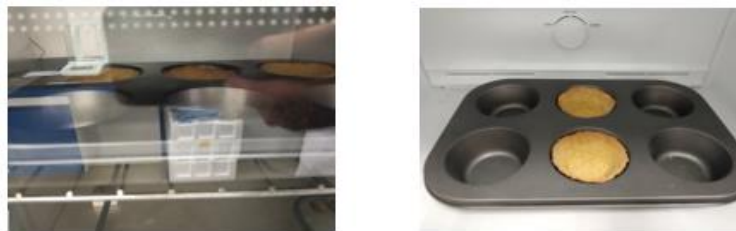


Figure 4: Testing of the temperature endurance.



Figure 5: Monitoring testing such as (a) long-lasting period, and (b) degradable period.

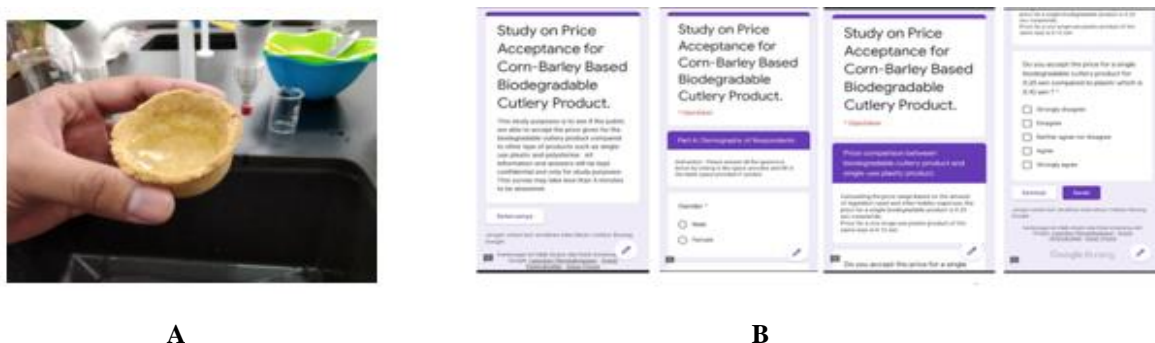
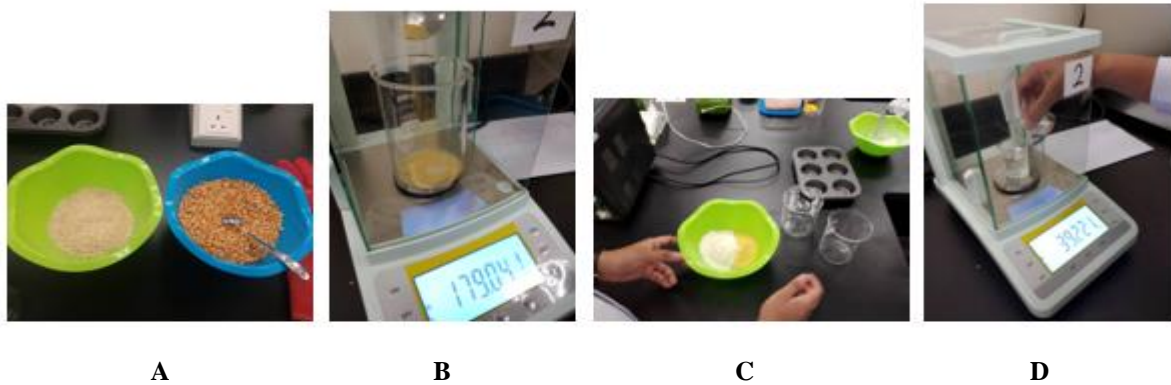


Figure 6: Other testing, such as (a) quality performance, and (b) price recognition survey.





**Figure 7: (a) raw ingredients, (b) and (d) measuring the ingredients, and (c) combining and mixing.**

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