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Edible-Base Drinking Straw Coated of Carnauba Wax at Low Rate of Absorption in Banning Plastic Straw

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Abstract: Plastics today poses a major threat to marine life, animals and human health. After every single use, more than 50% of the manufactured plastics including straws, are disposed of. Fresh alternatives to disposable plastic straws are considered due to consumer demands for sustainability and recent changes in government policies and regulations, such as bans on single-use plastic products. The aim of this invention project was to develop an edible drinking straw as an alternative to plastic straws by using raw food-grade ingredients. The selected ingredients are food stabilizer, food humectant and food gelling agent. The paste preparation was the process where the specific amount of stabilizer, humectant and gelling agent were mixed using dough kneader. The paste being shaped through a straw shaping mold process before placing them into the drying oven. The straw formed was rigid since it comes at only 12% moisture content after the drying process with desired length of 15cm and small diameter of 0.6 cm. Thereafter, the water-repellent coating comprises of carnauba wax which typically used in the candy industry was applied. Zebra Danio fish being fed with the straw and the pH meter of fish tank's water showed the reading at 6.9 which is relevant to verify our straw toxicity. The study revealed that microbial growth is not active at low moisture content of dry food, however straw shelf life can only be predicted if the water activity of the straw being measured.

Keywords: Carnauba Wax, Edible-Base, Food-Grade, Toxicity, Zebra Danio Fish

1. Introduction

In 2018, the total of world plastics production is around 360 million metric tons [1] and Malaysia ranks in the top 10 for worst countries worldwide in plastic waste. It is also believed that some of 18 billion pounds of plastic waste flow into the oceans every year [2] and 7.5 millions of it consists of plastic straws. Therefore, a few solutions have been made to produce efficient straws that can be both degradable and affordable. For an 'eco-straw', it is important to be biodegradable and have strong durability. Eco-straw is a short form of ecological straw and it is a brand name of straw that friendly-use and can be eaten. It also does not damage the environment since it is made of natural materials.

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Thus, researchers declared to decide that the edible straw was the best option to replace the other kinds of straw.

As plastic waste is one of the prime reasons for land and marine pollution, limiting plastic usage should be at high priority to save the fragile ecosystem. The exploitation of trees for the manufacture of paper straws is a major problem and gives a disadvantage to all the inhabitants of the earth. Meanwhile, metal straw is more durable than paper straws, but it also can bring the threat and drawbacks. By producing metal straw, the factors will release a lot of carbon dioxide into the air and may pollute the environment. Hence, the objectives of edible straw project are to fabricate an edible-based material of the straw through paste preparation using food-grade ingredients, to characterize the physical properties of straw in the shaping mould process and to analyse the straw to be edible, rigid and waterproof through validity tests.

2.0 Materials and Methods

This project was conducted using percentage that obtained from the journal to produce the edible straw. With that being said to facilitate the production of edible straw, the certain amount of these materials was taken to meet minimum requirements in order to be performed in the laboratory. The amount of 50 straws is made as the minimum value to determine the weight used to produce this product based on a predetermined percentage.

2.1 Material

The type materials used and weight based on 50 straws are:

- Distilled water : 75ml
- Gelatin : 10g
- Icing sugar : 397.5g
- Carboxymethylcellulose : 10g
- Glycerine : 7.5ml
- Carnauba wax : 100g

2.2 Methods

Figure 1 shows the flow chart of sample preparation of the edible straw making process. There are several processes to be performed such as paste preparation, straw shaped process, dry process, and validity test.

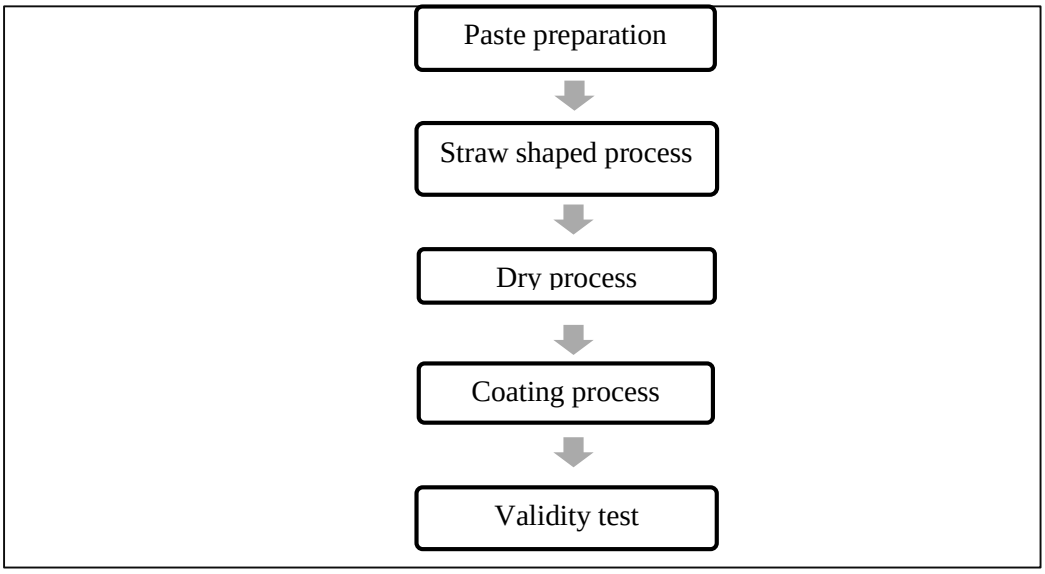

Figure 1: Flow chart of sample preparation of making edible straw [3]

2.2.1Paste preparation

Paste preparation was a process that has be done in more detail in mixture the ingredients. The weight of the straw is 10 g for each where 50 straws are set as the amount for the paste that has been mixed. The ingredients that has been used in this process such as gelatin as gelling agent, icing sugar as sweetening agent, carboxymethyl cellulose as stabilizer, glycerine as plasticizer, and carnauba wax as coating. The steps of this process shown in **Figure 2**.

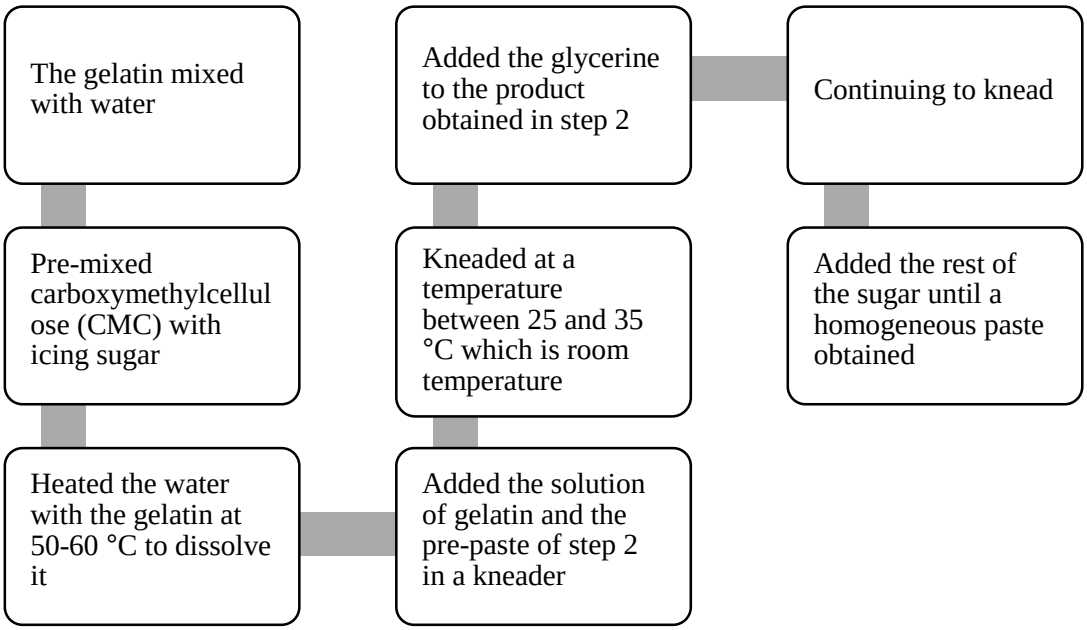

Figure 2: Flow chart of preparing the paste [3]

2.2.2Straw shaped process

The process was carried out based on the concept of bakery method where the product is placed in a mold to get the shape, texture, and thickness. It has been modified and improved for use in this project which is **Figure 3** shows step to run straw shaped process.

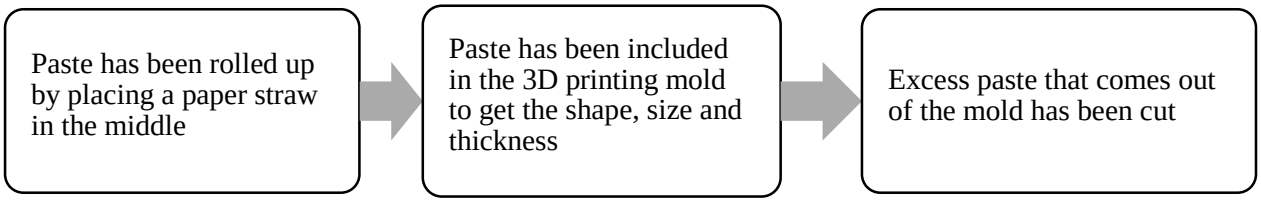

Figure 3: Flow chart of straw shaped process [4]

2.2.3Dry process

This dry process was carried out when the product has formed into a straw after the shaped process was made to make sure the suggestion of moisture content is followed. **Figure 4** show steps of this process.

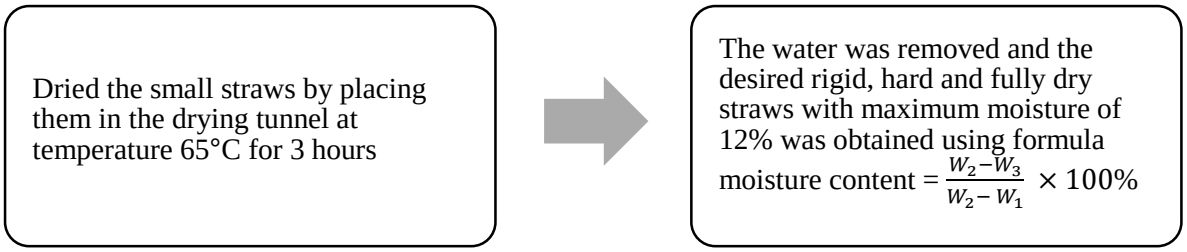

Figure 4: Flow chart of dry process [4]

2.2.4Coating process

The purpose of coating process is generally to extend the shelf life and improve the quality of product by creating a modified atmosphere inside the fruit due to their barrier properties to gases and moisture. In **Figure 5**, shows step to run the coating process which using the liquid paraffin wax method.

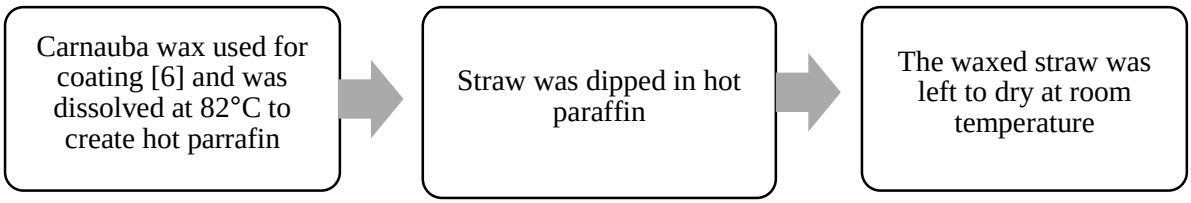

Figure 5: Flow chart coating process [5]

2.2.5 Validity test

This validity test was conducted to see the durability, capability and sustainability of this edible straw. There are three tests to run for this product which is water resistant test, toxicity test, and drinking test. **Figure 6** shows the step of water resistance test which aimed for developing a simple, quantitative index for measuring the water resistance of the product.

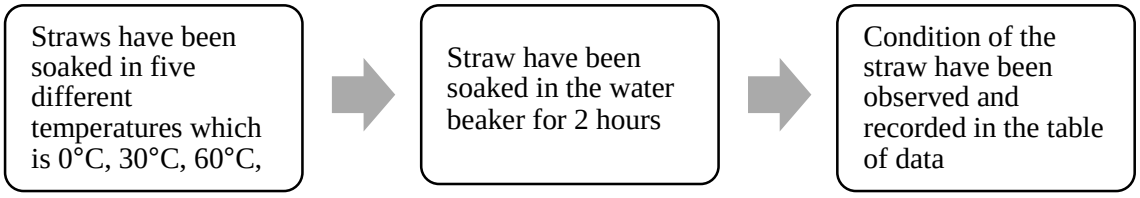

Figure 6: Flow chart of water resistance test [6]

Calculation of water resistance test as stated in Eq. 1.

$$WU(\%) = \frac{Final\ weight\ (g) - Initial\ weight\ (g)}{Initial\ weight\ (g)} \times 100\% \quad \textbf{Eq. 1}$$

This experiment has been conducted for three days. On day three, the water in the container was evaluated using a pH meter to determine whether the water is too acidic or too alkaline. The water pH should be in optimal value of pH to prove that there is no toxicity in the water. The flow chart of toxicity test shown in **Figure 7**.

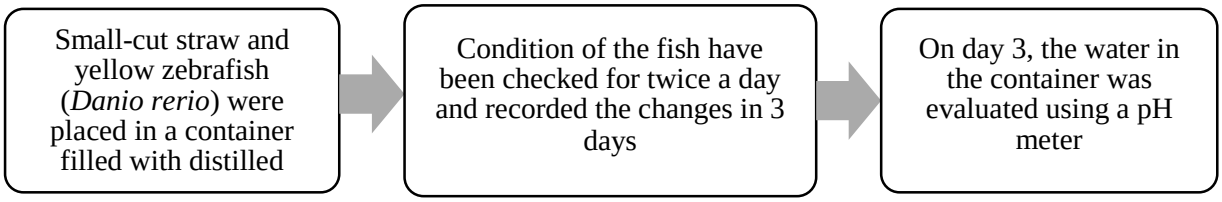

Figure 7: Flow chart of toxicity test [7]

Figure 8 shows the flow chart of drinking test, that has been performed after the toxicity test was carried out. If the toxicity test is unsuccessful, an automated life-safety suction test is cancelled since the test substance to be used is human. If the toxicity test is successful, the suction test was continued by placing the straw in a water-containing cup. The aim of test is to create the pressure by the plate that has been pressed is used to calculate the possible amount of water that can be sucked through the edible straw.

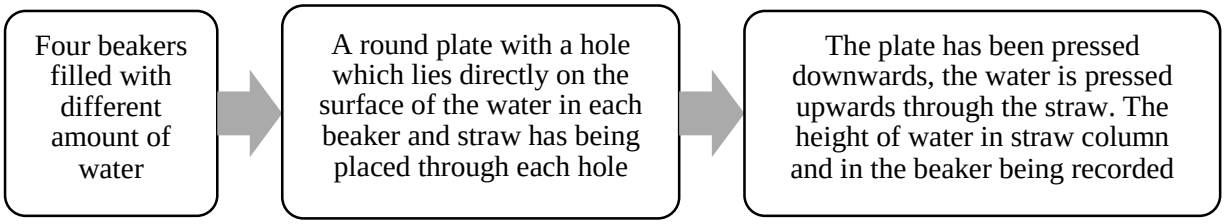

Figure 8: Flow chart of drinking test [8]

2.3 Moisture content determination

Moisture content determines the amount of water in the food and ingredients, but water behavior describes how the water in the food interacts with microorganisms. The rate of microbial growth is poor with a lower moisture content [9]. The moisture content of straw was calculated by a formula as shown in Eq. 2.

$$\text{Moisture content (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100\% \qquad \textbf{Eq. 2}$$

Where,

$W_1 =$ weight of straw
$W_2 =$ weight of straw with a tray before drying
$W_3 =$ weight of straw with a tray after drying

3.0 Results and Discussion

The results and discussion sections present data and analysis of the study. This study only focused on the making of straw's paste from the food ingredients such as stabilizer, humectant, and gelling agent. Based on the processes that have been conducted in the laboratory, all the products formed were able to be molded into drinking straw shape as shown in **Figure 9** (a) and (b) for the product placed horizontally and vertically, respectively.

Based on Figure 9 (a) and (b), the characteristics of the products were cylindrical. The length of straw was 15 cm and had a diameter of 0.6 cm. After the resultant product has been fully dried in the drying oven, the product was left in a room temperature region and the straw has a hard and firm texture

for the outer body. After completing the previous process, the validity test was made as this was the main purpose of this project, to know whether the straw is edible or not. The results were stated in Table 1 until Table 3 and also has been calculated in a certain formula. Based on the previous objectives stated, it is clear here that all the stated objectives were managed to be achieved.

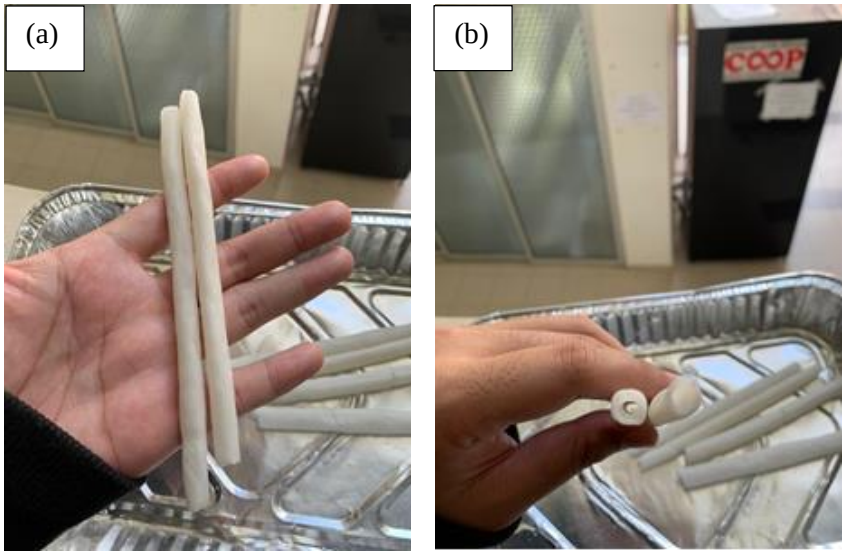

Figure 9: The products placed (a) horizontally and (b) vertically

For the validity testing, the water resistance calculation when the straws started to melt is 80% and moisture content is 12% by using Eq. 1 and 2, respectively. The water resistance test is able to perform that the straw did not absorb water at all in 0 ºC, 30ºC, 60ºC, and 70ºC. However, in the water with a temperature of 80ºC, the straw started to absorb the water in the beaker and melted. **Table 1** shows the observation related to the shape of the straw with the different of the temperature.

Table 1: Observation of straw's shape [8]

Temperature (ºC)	Observation	Explanations
0	The straw remains in shape	The ingredient in the edible straw is carboxymethyl cellulose (CMC), which tends to form a film that provides rigidity to the small tube. Carnauba wax also helps the outer body of straw.
30	The straw remains in shape	
60	The straw remains in shape	
70	The straw remains in shape	
80	The straws started to melt	Because the starting point of melting point for carnauba wax is 82ºC.

Figure 10 shows the results of the water resistance test that has been conducted where the graph is in a horizontal state except at a temperature of 80°C. This is due to the condition of the straw that is waterproof and able to withstand from 0°C to 70°C. It is found that at 80°C of water temperature, straw begins to absorb water because it has reached the melting point for carnauba wax.

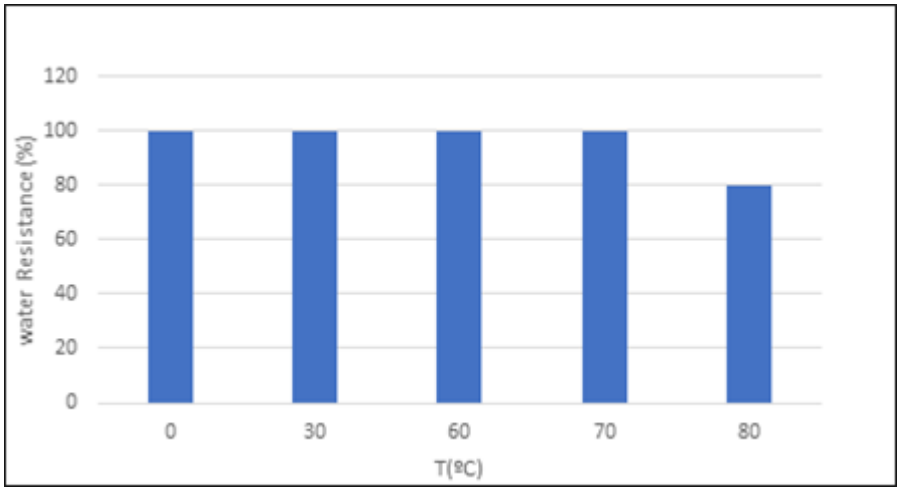

Figure 10: Graph of water resistance test

Table 2: Result of validity test

Validity test	Results	Explanations
Toxicity	The fish (*Danio rerio*) is still alive after 3 days because the water in the container is tested with a pH meter and the pH meter reading 6.9.	This is proven that the straw developed in this project are non-toxic and safe to eat for everyone because the water is not too acidic and alkaline.

Table 3: Result of drinking test

Amount of water in a beaker (ml)	Initial amount (ml)	Final amount (ml)	Amount of water can be suck (ml)
100	100	2.3	97.7
200	200	4.2	195.8
300	300	6.5	293.5
400	400	8.0	392.0

Table 2 and **3** show the result of validity and drinking test, respectively. The straw was shaped in an ideal size and there was no hole or irregular shape in the straw body. The pressure produced by the straw is lower than outside the straw. High pressure on the surface of the straw is also causing the water to fall out of the straw in the cup.

4.0 Conclusion

The edible straw was made mainly of food-based ingredients and had been tested for their toxicity, water resistancy and function effiency. The pH water reading is 6.9 which is in between the optimum value for good water quality and stable pH. Their surfaces have formed to be smooth and waterproof with coating of carnauba wax. The water resistance test proved this straw can last in cold water and

warm water up to 60°C since the carnauba wax's melting point is 82°C. For suction test, it showed the law of atmospheric pressure that makes it possible for the water in the drinking straw to be pushed upwards. However, since the paste was manually rolled and the straw shaped by baking mold, the first suggestion is to upgrade this straw shaping procedure by using plastic extrusion machine which can control the fixed temperature during the process to create a desired and maintain the fixed shape of straw. Moreover, the measuring tape can be replaced by vernier caliper to get more precise measurement for the length and diameter of straw. In closing, a wax coating machine should be used instead of dipping the straw into the hot pot of carnauba wax to be more efficient and methodical.

5.0 Acknowledgement

We hereby declare that the final year project work entitled "Edible-Base Compostable Drinking Straw at Low Rate of Absorption in Banning Plastic Straw" submitted to the Jabatan Sains dan Matematik (JSM), Centre for Diploma Studies (CeDS), Universiti Tun Hussien Onn Malaysia (UTHM), is record of an original work done by us under surveillance and guidance of Madam Jamilah Binti Mohd Ghazali. The results embodied in this project have not been submitted to any other University or Institute.

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