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Biopolymer/Edible Plastic used for Seasoning Packet in Instant Noodles

Natascha Adeline Ziliwu[1], Yalda Kinanti Suryasaputra[2]

[1,2]Student, School

ABSTRACT

Using plastics in Indonesia has gotten out of control in the coming years because of food or drink packaging. The build-up of plastic in rivers, abandoned land, forests, open waterways, and lakes have not only affected Indonesia but the rest of the world as well. Making edible plastic seasoning packets for instant noodles edible will help reduce the amount of trash due to plastics and help create a greener and cleaner environment for us. It could also reduce flooding when the rainy season comes. We want to create plastic seasoning packets of instant noodles that are edible and which people can boil/cook with the noodles themselves.

For our investigation, we wanted to know which biopolymer is the best material in making edible plastic seasoning packets for instant noodles. We used 6 different biopolymers (gelatin, potato starch, arrowroot starch, rice flour, cornstarch, and tapioca starch). Based on our findings, we found out that potato starch is the most suitable material for making edible plastic packaging. We have chosen this specific biopolymer because of its similarity to real plastic in terms of solubility, bacteria growth because it is made by organic ingredients and shelf life. We also find that the cost of production will be lower and will therefore be a good product to market worldwide should this be further developed.

INTRODUCTION

Background Research

Instant noodles are one of the most popular junk foods produced and consumed in Indonesia yearly. In 2023 alone, a total of 14,540 million servings of instant noodles were consumed in Indonesia (World Instant Noodles Association). The large number of servings also affects the amount of plastic produced. Since the average mass of plastic seasoning packets in instant noodles packaging is 5 grams, we get a total of 72,700,000 grams (72.7 tonnes) of plastic seasoning packets produced in 2023. But people just throw away the plastic packaging - both the outer packaging and the seasoning packets - once they have consumed the instant noodles. This leads to the buildup of plastic waste, which has gotten worse through the years, affecting Indonesia and the entire world. Indonesia's plastic waste has increased greatly in just 5 years, from 4,4 million tonnes in 2019 to 8,3 million tonnes in 2023 (SIPSN). Plastic waste will continue to increase in the upcoming years if we don't take action.

A great alternative to plastic packaging that has been around for the past few years is edible packaging. Edible packaging refers to packaging materials that are both edible and biodegradable, making them safe for human consumption and the environment. Plastics are made out of synthetic polymers, which are produced through chemical reactions. Synthetic polymers can take decades to hundreds of years to decompose. To overcome this problem, an alternative of using biopolymers is used to create edible and biodegradable plastic since they are natural polymers produced by living organisms. There has been quite a lot of research regarding edible plastic or packaging, each using different biopolymer materials such as starch, cellulose, and proteins.[1]

Biopolymer materials that have been tested for producing biodegradable or edible plastic include cassava flour, potato starch, corn starch,[2] gelatin, and seaweed. As mentioned before, polysaccharides are the most common biopolymer materials used. Polysaccharides are naturally abundant and have excellent mechanical strength and durability.

Several materials can be used for making edible plastic such as agar/gelatin, tapioca/cassava flour aloe vera powder, maize flour/ corn starch, almond powder, potato starch, rice starch, brown seaweed powder, lotus root powder, ginger starch powder, maca root extract powder, fermented milk dregs, and arrowroot flour.

Purpose

By using the chosen materials: Cassava (Manihot), Potato (Solanum tuberosum), Corn (Zea mays), Gelatin (Hydrolyzed collagen), Arrowroot (Maranta arundinacea) and Rice (Oryza sativa) for edible plastic in our experiment, we hope to answer our research question: *Which biopolymer is the best for making edible plastic?*

The basic criteria of plastic packaging specialized for food are being food grade, chemically safe, resistant to food substances, and free from contamination such as heavy metals & BPA. For more complex criteria, the plastic needs to have barrier properties, it must be durable, easy to use, and hygienic.

To test that, we use the following tests:

- Durability: Its ability to withstand force during transport or storage.
- Shelf Life: Could it survive different environments without mold growing and result in still the same unchanged product for a period of time?
- Microbiology: Aside from mold, what other microorganisms could potentially grow in our product?

Hypothesis

The question is, *which biopolymer is best for making edible plastic?* We hypothesize that cassava is the best because it contains a large amount of starch, which is suitable for the thick viscosity we require for the experiment.

For our research, we have made a few hypotheses on the different types of biopolymers that we will be using, such as gelatin would be the fastest and the most durable against tear but break apart the easiest and leave no taste on the food inside the packaging. By using tapioca/cassava, the result will be stickier than gelatin. We expect that the cassava starch can be used to make edible plastic, and the taste will be a little bit sour because of the vinegar that's added to the tapioca/cassava starch. The edible plastic with potato starch as the main ingredient will take some time to set, but it can be durable enough to be used as seasoning packaging. In addition to the taste, if added with the seasoning, there might be a little taste of sweetness added due to the vegetable glycerin. We predict the plastic made out of rice will be elastic and chewy and we also believe that the vinegar will disrupt how it will turn out. For cornstarch, we think that the end product will have a decent elasticity and is suitable enough to make a seasoning packet. It also won't affect the taste of the instant noodles later on.

[1] Edible Packaging: An Overview 1; 1.5 Comparison Between Edible Packaging Films and Synthetic Polymers

[2] Biodegradable plastic production from corn starch

METHODOLOGY

Materials

Spatula	Vegetable Glycerin 7.5 ml (for each biopolymer)
Stove	Water 75 ml (for each biopolymer)
Pan	Cassava Starch 10 g
Flat surfaced trays	Gelatin 10 g
Beakers (50 ml, 100 ml, 1L)	Potato Starch 10 g
Weighing scale	Vinegar 2.5 ml (for each required biopolymer)
Parchment paper	Arrowroot Flour 10 g
Plastic sealer	Cornstarch 10 g
Measuring cylinders (10 ml, 50 ml)	Rice Flour 10 g
20 Petri dishes	

Batch Procedure

1. Put the required materials for each experiment into a pan.
   a. 15 g of Gelatin + 15 ml of vegetable glycerin + 200 ml of water
   b. 15 g of Cassava Starch + 5 ml of vinegar + 15 ml of vegetable glycerin + 200 ml of water
   c. 15 g of Potato starch + 5 ml of vinegar + 15 ml of vegetable glycerin + 200 ml of water
   d. 15 g of Rice flour + 5 ml of vinegar + 15 ml of vegetable glycerin + 200 ml of water
   e. 15 g of Cornstarch + 5 ml of vinegar + 15 ml of vegetable glycerin + 200 ml of water
   f. 15 g of Arrowroot starch + 5 ml of vinegar + 15 ml of vegetable glycerin + 200 ml of water
2. Stir the mixtures using a spatula while it is being heated on a stove until each of them has thickened.
3. Once each of the mixtures has thickened, spread them evenly into a flat-surfaced tray.
4. Dry it for 2-3 days at room temperature (23°C / 73.4 °F).
5. After it's dried, carefully peel them off.
6. The result would then be tested in boiling water to see if it would dissolve or not.

Making of the Seasoning Packet

1. Prepare the finished edible plastics and cut them into 2 separate rectangles (3 cm x 6 cm).
2. Put the instant noodle seasonings in separate containers.
3. Iron the edible plastics between parchment/baking paper and leave an opening to put the seasonings.
4. Make sure the plastics are intact, then put the seasonings on and iron the opening.

Tests & Method

1. Shelf Life: Determining its shelf life by putting it through different scenarios in its environment.
   Method:
   1. First, the scenario where we kept it in a cupboard.
   2. Second, the scenario where we kept it out in the open and exposed it to the outside environment.
   3. Third, the scenario where it is kept in a more humid/cold environment.
4. Microbiology Tests: Testing for E.coli and checking its Total Plate Count (TPC).
   Method: We submitted our sample to a lab under the name MBRIO Food Laboratory. It was done through the dilution method instead of the swab method.

5. Solubility Test : Finding precipitate and how long it requires to dissolve. This is done to prove the solubility of the plastic to be used for the seasoning packet in instant noodles.
   - Temperature: 100°C/Boiling point
   - Mass: Solute = 2 grams/sample of plastic, Solvent = 100 cm^3

Method:

Solute

Digital balance

Glass stirring rod Thermometer

Distilled water Beaker (250mL)

Measuring cylinder (100mL) Stopwatch or timer

Step 1: Measure the water, use the measuring cylinder to measure 100 cm^3 of distilled water. Pour it into a clean beaker.

Step 2: Record the temperature, use a thermometer to check the temperature and record it.

Step 3: Weigh 2 grams of solute and add it to the water. Stir with the glass rod until it dissolves completely.

Step 4: When the solute is added, start the stopwatch and record.

Step 5: When the solute has dissolved fully, stop the stopwatch and measure the end temperature.

RESULTS

Table 1

Result: This table shows the result of our trials in making the biopolymers.

Biopolymer	**Trial #1**	**Trial #2**	**Trial #3**	**Trial #4**
Gelatin	It is a flexible but also breakable, glass-like material. **1.4 g** 	The result did not survive because it molded.	Very fragile and breakable. **0.4 g** 	It is thin but not elastic. **1.4 g** 
Potato	Dried to be a thick but easily peelable material that has a rubbery feel. **1.5 g** 	Thick consistency with a latex-like texture. Molded after a few months.	Fragile and glass-like. **1.9 g** 	Very plastic-like and not elastic. **0.2 g** 

Cassava	The tapioca is dried to be a thick but easily breakable material, It also has a rubbery texture. **3.0 g** 	Thick rubbery texture. **1.7 g** 	Easily breakable. **2.0 g** 	Thin but easily tear with the slightest force. **1.6 g** 
Corn	The finished results did not dry to be a whole film, but instead, it cracked. It is rubbery, almost like silicon.	Clear plastic with elastic, lightweight, and flexible. But it is not very durable because of its thin layer.		
Rice	The result had lots of tiny holes caused by the air bubbles in the cooking process. We couldn't peel it because it stocked to the surface of the pan.	Rice was once again unpeeled because of it sticking to the surface of the pan and it was too soft to even form a film.		
Arrowroot	The arrowroot flour fully dried, but it had a sticky feel.	The arrowroot plastic is a lightweight, smooth, and slightly flexible material.		

Table 2

Test: This table presents the test results we have done for our biopolymer.

Material	Solubility	Shelf Life	Microbiology
Gelatin (03156)	**Time:** 1.05 min **Precipitate:** oil-like yellowish precipitate **Temperature:** 77	No mold seen.	**E.Coli:** $< 1.0 \times 10^1$   **Total Plate Count:** 5.7×10^2  
Potato (01354)	**Time:** 2.21 **Precipitate:** white precipitate **Temperature:** 74	Molds if the formulas are not correct.	**E.Coli:** $< 1.0 \times 10^1$  **Total Plate Count:** 7.0×10^1 
Cassava (01355)	**Time:** 2.39 **Precipitate:** milky white **Temperature:** 74	Molds if the formulas are not correct.	**E.Coli:** $< 1.0 \times 10^1$  **Total Plate Count:** 5.0×10^3 
Arrowroot (01357)	**Time:** 2.45 **Precipitate:** cloudy white	No mold seen.	**E.Coli:** $< 1.0 \times 10^1$

	Temperature: 73		 **Total Plate Count:** 2.2×10^{3} 
Corn	**Time:** 1.24 **Precipitate:** cloudy white **Temperature:** 76	No mold seen.	**E.Coli:** $< 1.0 \times 10^{1}$  **Total Plate Count:** 1.3×10^{1} 
Rice	**UNAVAILABLE**	**UNAVAILABLE**	**UNAVAILABLE**

DISCUSSION

Gelatin is very similar to plastic. It has flexibility, elasticity, and durability like plastic. It is very suitable for packaging because it has zero = no leaks. Very flexible and thin. It has a reliable smooth surface. It is available everywhere and cheap for massive production. Cassava is thin and see-through, which gives it a clear look. Potatoes are flexible, elastic, and durable. It is very similar to plastic and has zero = no leaks. Cassava is thin and see-through which gives it an amazing clear look aesthetically. Potatoes are flexible, elastic, and durable, exactly like plastic. It is very similar to plastic and has zero to no leaks. Arrowroot has a smooth surface and a stretchy texture which make it suitable to be a plastic. Rice has a soft texture that helps it dissolve better in the water. Corn's silicon-like texture gives it an advantage where there will be minimum leakage.

But Gelatin turns yellow after a while and can be sharp if the consistency is not distributed evenly throughout the batch. It is also an animal product that gives off an unappealing smell. Tapioca/Cassava shrivels too easily after a while, so it is not suitable for long-term storage. Potatoes could potentially mold if made not specific to the preference of the methodology, this is not suitable for long-term storage. Tapioca/Cassava shrivels too easily after a while, so it is not suitable for long-term storage. Potatoes could potentially mold if the mixture made does not follow the methodology correctly; this is not advisable for long-term storage. In the drying stage rice obtains small circles and holes because of the bubbles that develop when we apply heat to the formula. The disadvantage of corn is when the batch cracks like dried clay, this is us a disservice at the time we need to make the final product. Arrowroot cannot achieve the viscosity we'd like if the temperature is too high.

ERRORS & IMPROVEMENTS

Mold started growing because of the high humidity and hot air in the drying area. The mold also became more likely to grow because of the parchment paper we used. As we pour the hot mixture, water condenses under the parchment paper and causes mold to form. The consistency is too thick, which results in a rubbery and uneven texture to the plastic. This is not suitable to cook with because it could cause the soup to have a thick consistency. The consistency is too thin, which results in a breakable and thin plastic. This is not suitable for packing the seasoning, because it could be damaged in transport.

Note to be taken, on our first three trials, we used corn syrup instead of vegetable glycerin since we didn't have it at first. The measurements of all of the materials stated before are taken from the most recent trial (trial #4) due to the edible plastics having similar properties to actual plastic.

After our first trial, we decided to improve our methods of making edible plastic. These improvements include replacing the tray with parchment paper for easier peeling off, pouring the liquid evenly so it is not too thick or thin, spreading the liquid more evenly, adding more water to balance out the ingredients used, mixing it enough so it is not too thick and chunky but not too loose, and avoiding using food coloring.

For our second improvement, keep stirring because if you don't, the mixture will lump and cause an unpleasant look on the plastic. Don't use parchment paper, as it causes mold to start growing due to the high humidity and hot air in the drying area. As we pour the hot mixture, water condenses under the parchment paper, causing mold to form. So, we used a flat-surfaced tray again.

As our third improvement, we use vegetable glycerin instead of corn syrup. We also increased the amount of the ingredients to 15 ml of vegetable glycerin and 5 ml of vinegar.

CONCLUSION

Our purpose of this research was to find the best biopolymer material for making edible plastic for instant noodles seasoning. As we conducted our research, we found three potential biopolymer materials that can be suitable for making edible plastic. These potential materials include potato starch, arrowroot flour, and cassava starch. From our analysis, these three biopolymer materials have similar properties to real plastic, such as lightweight, adaptability, and low thermal conductivity. Based on our findings, we believe that potatoes are the best material to make the best biopolymer material. We have chosen this specific biopolymer because of its similarity to real plastic, its durability, the ability to withstand any condition, and the potential to reduce plastic waste while pushing costs.

FURTHER RESEARCH

We will use deformed, imperfect, spoiled, misshapen, and unwanted potatoes that are usually thrown away by supermarkets, manufacturers, producers, and especially farmers to reduce the cost. This lowers the production cost while maintaining our product's sustainability. It may be a concern about the usage of spoiled potatoes but there will be methods to remove the rotten parts, and we use it to the fullest to minimize food waste. By using these unwanted products we can suppress the cost to make it as low as possible. With this, we could sell our product cheaply which allows it to be available everywhere in any part of Indonesia. This encourages branded instant noodles to work together with us to reduce plastic waste and save our planet.

Arrowroot is very suitable because it contains nutrients such as carbohydrates, and protein and has a high water content. Arrowroot could be a gluten-free option for those who prefer that. According to antaranews.com, this root could aid in food poisoning, assist with diabetic and autistic people, be able to heal wounds and help with constipation. It is also popularly known to be a natural cure for GERD. It also contains a low concentration of fat, which is suitable for people on a diet.

We could conduct more trials with different materials, such as seaweed powder, aloe vera, lotus root powder, ginger powder, and maca root extract powder, or try strange household materials like tea, coffee, fermented milk dregs, and juice extract powder. We could also explore alternatives that use more natural ingredients. For example, we could replace vegetable glycerin with honey or other natural plasticizers.

We also would do other test such as :

- Tensile Strength: Measures the force required to break a plastic specimen under tension, indicating its ability to withstand pulling forces. This test requires the plastic being pulled by the same force simultaneously on two different sides.
- Bending Test: Assesses the plastic's resistance to bending stress, relevant for applications where the plastic is subject to flexing. This test requires the plastic to be laid down in two metal pillars and applied force by a weighted metal on top.
- Pressure Test : where we test the weight limit that each packaging could withstand. We will be collecting the data on how many weights it requires to start breaking.

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