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Effect of Additional Cellulose Bacterial from Nata De Soya and Chitosan in Bioplastic Manufacturing

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Abstract

Plastics are synthetic polymers from petroleum or petrochemicals that are difficult to biodegrade by bacteria and microbes. Non-biodegradable plastics cause the accumulation of large amounts of plastic waste Solutions that can reduce plastic waste by making plastics that are easily biodegradable. In this study, tofu liquid waste is used as a basic material for the manufacture of bioplastics. Tofu liquid waste is waste generated from tofu production. This study aims to determine the effect of adding bacterial cellulose and chitosan on the manufacture of bioplastics from liquid waste tofu (whey) in terms of tensile strength, elongation, water solubility, and functional groups (FTIR) in accordance with PET plastic standards (Polyethylene terephthalate). The research procedure on the effect of adding bacterial cellulose and chitosan on the bioplastic fabrication of Nata De Soya. First, from tofu liquid waste, Acetobacter Xylinum starter was added and then fermented for 10-12 days to become Nata De Soya. After that it was neutralized with aquadest, removed the water by pressing, and dried to become bacterial cellulose. The process of making bioplastic with the addition of chitosan (grams) 2,3; 3.1; 3.9; 4.7 and 5.5 and bacterial cellulose (grams) 0.5 ;1.5; 3.9; 7; and 11. In the manufacture of bioplastics with the addition of Bacterial Cellulose and chitosan, it is appropriate, namely the tensile strength obtained will increase and the solubility in water decreases. From the results of our research, the best results were obtained in the addition of S5K5 with a tensile strength value of 9.665 MPa, an elongation value of 31.3%, and a solubility value in water of 17.9%. It has a higher tensile strength, smaller elongation and lower water solubility. The effect of the addition of chitosan on the tensile strength value can increase the tensile strength (Tensile Strength Value), the addition of bacterial bacterial cellulose and chitosan can affect the elongation of bioplastics getting smaller and the effect of chitosan can reduce solubility in water. It is good but still far from the standard PET (Polyethylene Terefelat) which is 60-80 Mpa.

Keywords: cellulose bacteria; nata de soya; bioplastic.

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1. Introduction

Plastics are synthetic polymers from petroleum or petrochemicals which are difficult to biodegrade by bacteria and microbes. Plastic is one of the food packaging materials or the manufacture of objects that are widely used in household appliances. Commercially circulated conventional plastics have properties that are not easily degraded. It takes hundreds of years to degrade conventional plastics. Plastic that does not decompose causes a large amount of plastic waste to accumulate. The accumulation of plastic waste on a large scale can cause serious environmental pollution problems because plastic takes years to decompose. (Novela, et al, 2018) (Awwaly, Manab, & Wahyuni, 2010).

A solution that can reduce plastic waste by making plastic that is easily *biodegradable*.plastic *biodegradable* is more expensive because the technology has not yet developed. One of the efforts made in previous studies using cassava, tubers and other materials that are easily decomposed. (Intandiana, Dawam, Denny, Septiyanto, & Affifah, 2019).

In this study, tofu liquid waste was used as the basic material for the manufacture of bioplastics. Tofu liquid waste is waste produced from tofu production. In tofu liquid waste, there are still some important ingredients that can be used

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as raw materials for biodegradable plastics. Because if tofu liquid waste is disposed of without processing directly into the environment, it will have a bad impact (Novela, Amri, & HS, 2018).

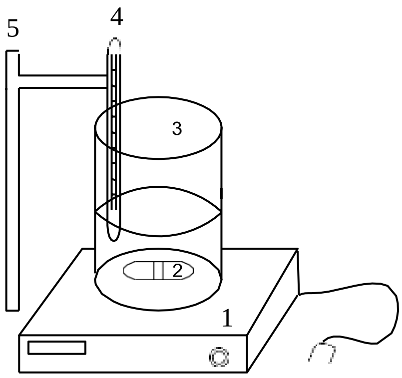
In addition, according to the database Saenab et al. (2018), the value of the ratio of tofu BOD/COD above 0.5 indicates that biodegradable waste can be processed by biological methods. (Rahardi, et al, 2020) conducted a study using tofu waste (whey) as a basic material for making bioplastics with reinforcement. Chitosan and *plasticizer*, the best results were obtained in the K2G2 sample where there were 2.3 grams of chitosan and 1.5 ml of glycerol . The value of tensile strength, elasticity, and water absorption from the best variation of bioplastic research results, namely K2G2 is greater than conventional plastic. (Selpiana, Patricia, & Anggraeni, 2016) conducted a study using bagasse and tofu waste as materials for making bioplastic with the effect of adding chitosan and glycerol. /cm^2. The weakness of the previous research is that in K2G2 the absorption capacity is less than conventional plastics, the addition of Bacterial Cellulose makes the bioplastic large in terms of water absorption. (Purwaningrum, 2016).

From previous research data, the researcher wants to compare the results of the research to be carried out with the results of previous studies. By using *Nata De Soya* as a Bioplastic with the effect of adding Bacterial Cellulose. (Rahadi, Wirosoedarmo, & Harera, 2018).

2. Research Methods

The materials used in this study were tofu liquid waste taken by A Hok (Jl Raya Karang Asem no.14, ploso, Tambaksari district, Surabaya city, East Java 60133). For chemicals such as NaOH, acetic anhydride, glacial acetic acid, H2SO4, NaHCO3, chitosan, glycerol, acetic acid, distilled water, granulated sugar and Acetobacter Xylinum and ZA Bacterial Seeds.

The tools used in this research are *Magnetic Stirrer*, Analytical Balance, Thermometer, Glass Beaker, Statives and Clamps, Measuring Cup, Erlenmeyer, Volumetric Flask, Glass Funnel, Spatula, Pipette, Filter Paper, Petridish, Hydraulic Pump Press and Oven. Series of magnetic tools.



Description:

1. Hot plate magnetic stirer
2. Magnetic Capsule
3. Beaker Glass
4. Thermometer
5. and Clamps

Procedure

Making Nata De Soya

1 liter of boiled water tofu (whey tofu) which has just been taken and is still fresh, filtered, and accommodated in an email pan (not an aluminum pan), then Add 86 grams of granulated sugar and 5 grams of ZA, stir until smooth then simmer for about 15 minutes. Remove and wait and add 10 ml of vinegar, stir until homogeneous. Put in a

plastic/glass container with a solution height of approx. about 3-4 cm, then closed and cooled. Added starter / liquid nata seeds 20 ml. The container is closed and stored in a safe and clean place for 10 days (during storage, the container should not be shaken). After 12 days or the thickness of the nata reaches a height of 1.5-2 cm, the layer of nata de soya can be harvested.

Bacterial

Cellulose Bacterial Cellulose (nata de soya) in sheet form is cut into four parts. It was mummified by immersing it in 1% NaOH solution for ± 12 hours at room temperature. Washed again with distilled water repeatedly until the pH is neutral. Pressed with a hydraulic pump to remove the water in the material. It is dried in an oven at a temperature between 30-35 °C. Drying at temperatures higher than 35°C will make Bacterial Cellulose less reactive.

Making Bioplastics

Dissolve NaOH using 1% vinegar as much as 100 mL until homogeneous. Mix the conditions under which chitosan 2,3; 3.1; 3.9; 4.7; and 5.5 grams with Bacterial Bacterial Cellulose as much as 0.5 g, 1.5 g, 3.9 g, 7 g, and 11 g and a predetermined concentration of 1.5 mL glycerol. After that, it was heated until the mixture was homogeneous. The bioplastic mixture is printed on a glass mold. Leave it at room temperature for 2-3 days to dry. Ready for Analysis with Tensile Strength, Elongation, Solubility in Water and Functional Group Tests (FTIR).

3. Results and Discussion

After obtaining bioplastics, the analysis of tensile strength, elongation, solubility in water, and functional groups (FTIR) was carried out. With the results and discussion in Table 1.

Table 1. Analysis Result of Tensile Strength, Elongation, and Solubility in Water

Cellulose : Chitosan (Gram : Gram)	Tensile Strength (Mpa)	Elongation (%)	Solubility in Water (%)
0.5 : 2.3	1.087	62.6	35.2
0.5 : 3.1	1.229	53.4	21.5
0.5 : 3.9	1.903	44.3	21.7
0.5 : 4.7	2.345	38	15.5
0.5 : 5.5	3.126	31.3	11.5
1.5 : 2.3	1.654	56.2	39.1
1.5 : 3.1	1.837	46.3	27.5
1.5 : 3.9	2.443	37.6	24.6
1.5 : 4.7	2.941	29.4	18,9
1.5 : 5.5	3.79	22.3	12.5
3.9 : 2.3	2.434	44.8	43.6
3.9 : 3.1	2.911	37.4	30.6
3.9 : 3.9	3.286	31.1	27.5
3.9 : 4.7	3.993	24.4	22.0
3.9 : 5.5	4.62	18.8	14.5
7 : 2.3	5.061	39.8	48.5
7 : 3.1	5.338	31.2	33.3
7 : 3.9	6.099	25.9	29.4
7 : 4.7	6.816	20.4	24.4
7 : 5.5	7.561	15.2	16.2
11 : 2,3	6.304	29.8	60.6
11 : 3.1	7.459	22.1	36.3
11 : 3.9	8.286	17.3	31.3
11 : 4.7	8.89	11.9	27.5
11 : 5.5	9.665	7.2	18.3

Cellulose *bacterial* can be seen in Figure 1.

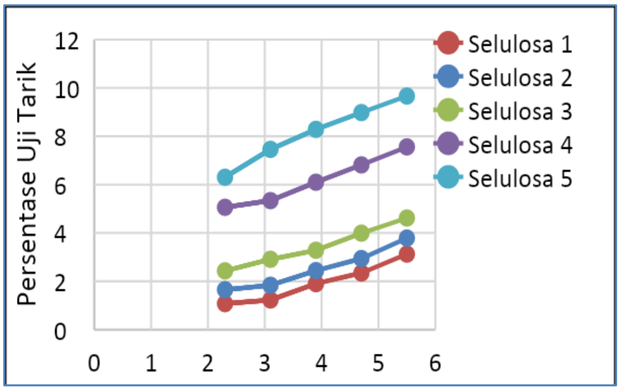


Figure 1. The relationship between the percentage of Tensile Strength with Chitosan and Bacterial Cellulose

Based on Figure 1 can see that there is an effect of adding Bacterial Cellulose with chitosan to the tensile strength value. The greater the addition of chitosan and cellulose, the greater the tensile strength value. The results of this study indicate that the highest tensile strength value is in the comparison of Bacterial Cellulose 5: chitosan 5 (11 gr: 5.5 gr), which is 9.665 Mpa and the lowest tensile strength is in the ratio of Bacterial Cellulose 1: Chitosan 1 (0 5 gr : 2,3 gr), which is 1.078 Mpa. The addition of chitosan and bacterial cellulose in this study aims to increase the tensile strength properties of the bioplastic film. According to (Apriyanti, Mahatmanti, & Sugiyo, 2013) The higher the composition of chitosan, the tensile strength also increases because this hydrogen bond causes the plastic film to be stronger and difficult to break. According to (Apriyanti et al., 2013) the addition of Bacterial Cellulose can increase the tensile strength of plastic films because Bacterial Cellulose has a straight and long polymer chain so that it can make the plastic stronger.

The relationship between the percentage of elongation with chitosan and bacterial cellulose can be seen in Figure 2.

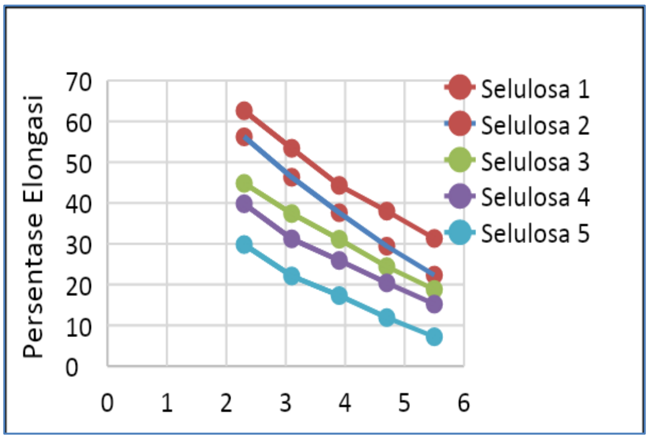


Figure 2. The relationship between the percentage of Elongation with Chitosan and Bacterial Cellulose

Based on Figure 2 it can be seen that there is an effect of adding bacterial cellulose with chitosan on the elongation value. The greater the addition of chitosan and cellulose, the smaller the elongation value. The results of this study indicate that the highest elongation value is in the ratio of Bacterial Cellulose 1: Chitosan 1 (0.5 gr: 2.3 gr), which is 62.6% and the lowest elongation value is in the ratio of Bacterial Cellulose 5: Chitosan 5 (11 gr: 5.5 gr), which is 7.2%. The addition of the concentration of Bacterial Cellulose and chitosan resulted in a *elongation* decreasedThis is because the function of the addition of glycerol is to reduce the stiffness of the bioplastic and increase the elasticity of the bioplastic so that if the amount of chitosan The less used, the more elastic the bioplastic produced (Francis et al., 2022) the more Bacterial Cellulose contained in it, the less elongation percentage this can mean that the tensile strength value is inversely proportional to the elongation value. elongation.

The relationship between the percentage of solubility in water with chitosan and bacterial cellulose can be seen in Figure 3.

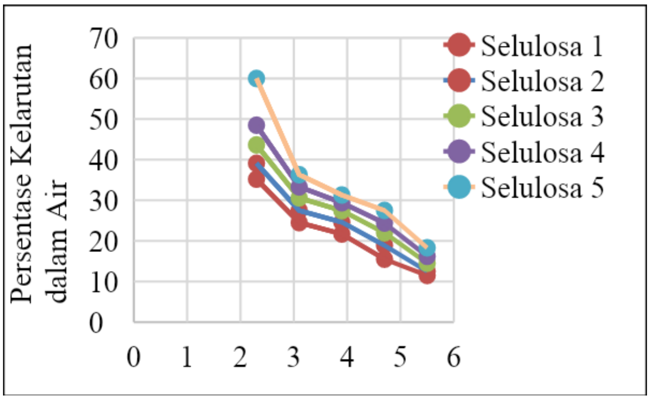


Figure 3. The relationship between the percentage of Solubility in water with Chitosan and Bacterial Cellulose

Based on Figure 3, it can be seen that there is an effect of adding bacterial Cellulose with chitosan to the value of solubility in water. The greater the addition of chitosan, the smaller the solubility value in water. The results of this study indicate that the highest water solubility value is in the Bacterial Cellulose 5: chitosan 1 ratio (11 gr: 2,3 gr), which is 60% and the lowest water solubility value is in the Bacterial Cellulose 1: chitosan 5 ratio (0.5 gr : 5.5 gr), which is 11.5%

The results of the relationship between variations in bacterial cellulose and chitosan in the water solubility test show that the higher the concentration of bacterial cellulose given, the higher the bioplastic film can absorb water. In the variation of Bacterial Cellulose with the addition of Bacterial Cellulose as much as 11 grams, it shows that the greater the concentration of Bacterial Cellulose, the greater the absorption of water produced. So, the addition of chitosan to the variety of Bacterial Cellulose can inhibit the water absorption of *film* bioplasticThis is in accordance with research (Ningsih, Ariyani, & Sunardi, 2019), the addition of chitosan as an additive makes bioplastic films have good water resistance properties. This is because chitosan is a hydrophobic biopolymer and easily interacts with organic substances such as proteins.

From the table and figure above, it can be seen that the bioplastic produced is still far from bottled plastic, namely PET (Polyethylene Terephthalate) maybe this is due to the lack of addition of chitosan in the running conditions and reducing the glycerol set according to (Selpiana, 2016) because chitosan and glycerol form cross-links therefore it can cause a lack of intermolecular forces of the polysaccharide chain so that the plastic sample can be smoother and more flexible. As glycerol increases, the tensile strength value for plastic samples tends to decrease. This is due to the addition of glycerol as a plasticizer. Then the addition of glycerol can reduce the intermolecular forces of polysaccharide chains which can cause decreased flexibility in plastic samples.

And also the addition of higher cellulose according to (Septiosari, Latifah, & Kusumastuti, 2014) the addition of cellulose tends to increase the value of tensile strength in bioplastics. This increase in tensile strength occurs because cellulose has polymer chains that are straight and long so that it can make bioplastics strong. Because the plastic bottle, namely PET (Polyethylene Terephthalate) has a high standard of tensile strength of 60-80 Mpa. However, the bioplastic produced from this research has the advantage that it can be extracted quickly because it uses Nata De soya as the main ingredient and compared with the ANOVA Test to find out which one is the best.

ANOVA Test

From Figure 4, it can be seen that what affects the Tensile Strength test is the addition of bacterial cellulose where the more additions, the greater the percentage of the tensile strength test as well as with chitosan. The best result was the addition of 11 grams of cellulose and 5.5 grams of chitosan, namely the S5K5 sample with a tensile strength test percentage of 9.665 MPa. This is in accordance with the discussion in the figure 5.

From Figure 5, it can be seen that what affects the Elongation test is the addition of bacterial cellulose where the more additions, the smaller the percentage of the elongation test as well as the more chitosan the addition the smaller the percentage of elongation . The best result was the addition of 11 grams of cellulose and 5.5 grams of chitosan, namely the S5K5 sample with an elongation test percentage of 31.3%. This is in accordance with the discussion in the figure 6.

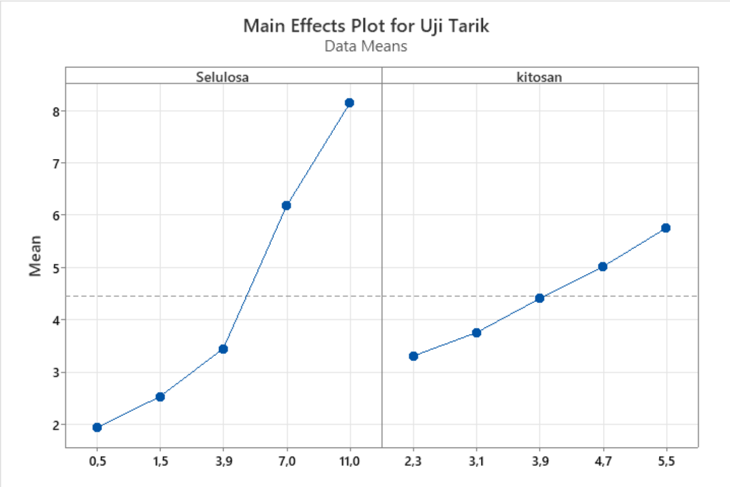


Figure 4. The relationship of Tensile Strength with Chitosan and Bacterial Cellulose in the ANOVA Test

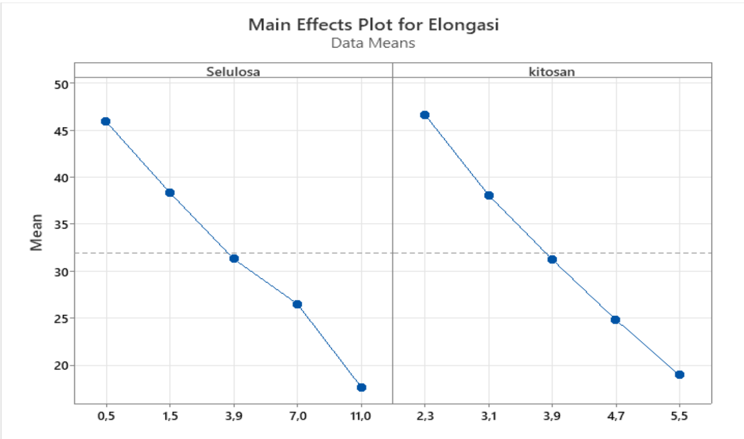


Figure 5. The relationship of Elongation with Chitosan and Bacterial Cellulose in the ANOVA Test

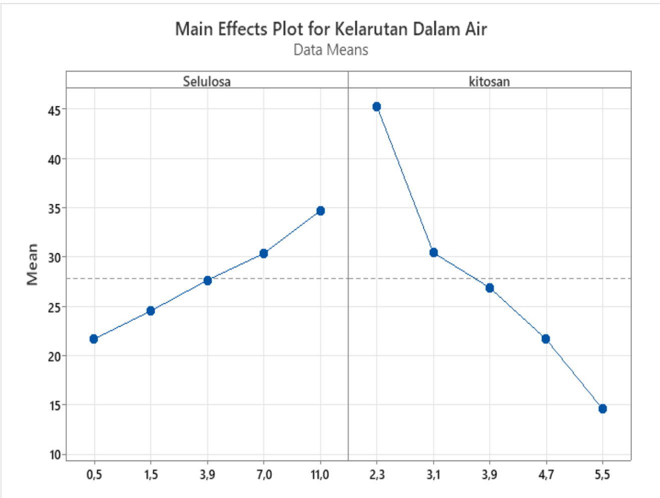


Figure 6. The relationship of Solubility in Water with Chitosan and Bacterial Cellulose in the ANOVA Test

From Figure 6, it can be seen that what affects the Water Solubility Test is the addition of bacterial cellulose where the more the addition, the greater the percentage of the solubility test in water is inversely proportional to chitosan The more the addition, the smaller the percentage of solubility in water. The best result was the addition of 11 grams of cellulose and 5.5 grams of chitosan, namely the S5K5 sample with an elongation test percentage of 17.9%. This is in accordance with the discussion in the figure.

FTIR Analysis

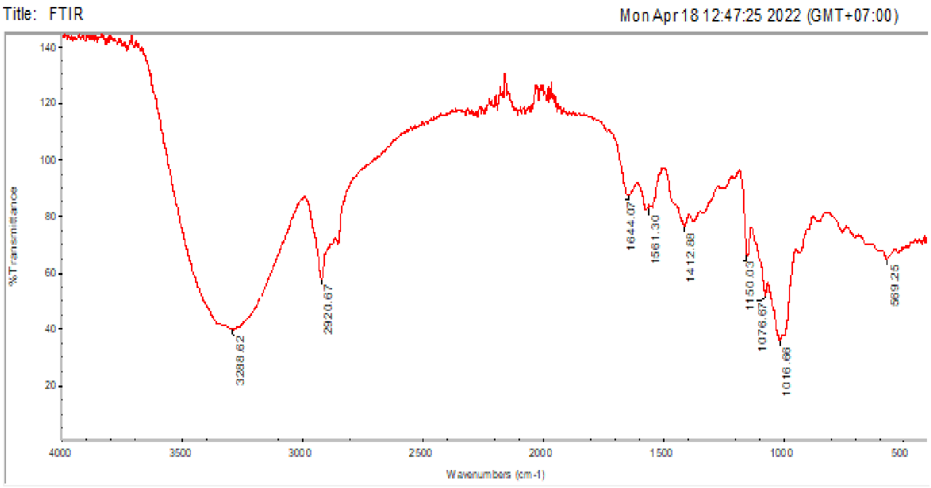


Figure 7. FTIR Analysis Image

The results of the FTIR test have functional groups that are not much different from the basic ingredients used, namely tofu dregs protein, glycerol, and chitosan solution. It is proven that the compounds contained in these materials reappear in the resulting bioplastic spectrum. One of them is the IR spectrum detects the presence of amide elements because the basic ingredients used are tofu dregs protein which has a content of 29.72% and OH compounds which are functional groups of glycerol, thus bioplastics from tofu dregs do not have new functional groups formed in the resulting bioplastics. So that the components of bioplastics from tofu dregs protein only interact physically (Sarifudin, 2013)

4. Conclusion

In the manufacture of bioplastics with the addition of Bacterial Cellulose and chitosan, it is appropriate, namely the tensile strength obtained will increase and the solubility in water is getting smaller. From the results of our research, the best results were obtained in the addition of S5K5 with a tensile strength value of 9.665 MPa, an elongation value of 31.3%, and a water solubility value of 17.9%. However, the tensile test value is still far from the PET standard, which is 60-80 MPa. The effect of the addition of chitosan on the tensile strength value can increase the tensile strength (Tensile Strength Value), the addition of bacterial bacterial cellulose and chitosan can affect the elongation of bioplastics getting smaller and the effect of chitosan can reduce solubility in water. It is recommended that further research is needed to improve the mechanical properties that meet the standard of PET plastic in general.

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