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Manufacture of Biodegradable Plastics from Cassava Starch (*Manihot Escullenta*) with Variable Glycerol Plasticizers and Chitosan Reinforcement

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A B S T R A C T

Biodegradable plastic is an alternative environmentally friendly packaging material because it is made from renewable materials and is scientifically easily degraded by microorganisms and by weather. Renewable material that is abundant in Indonesia is cassava which has high potential as a raw material for making biodegradable plastics. Purpose This study was conducted to determine the process of making biodegradable plastic from cassava starch, knowing the effect of adding glycerol and chitosan to the mechanical properties of biodegradable plastics, and know the characteristics of biodegradable plastics from the best conditions. The process of making biodegradable plastic from cassava starch begins with mixing cassava starch with water and processing until starch dough is formed. Next, glycerol is added to the starch dough and mixed until homogeneous. The final stage is chitosan added to the mixture and stirred until well mixed. The mixture is then heated and molded according to the desired shape. Biodegradable plastics produced from a mixture of cassava starch, glycerol, and chitosan have good mechanical properties and can decompose naturally in the environment for the study variables with concentrations of glycerol 2%,4%,6%,8%,10% and chitosan 1%,3%,5%,7%,9% in a mixture of 100 ml. Mechanical tests such as tensile strength, percent elongation and biodegradation of biodegradable plastics are carried out on product characteristics. The result of this study was to obtain the highest tensile strength in sample 1 of 3.41 Mpa and had an elongation of 68%. While the highest elongation in sample 3 was 130% and tensile strength was 0.26 MPa. The highest biodegradation result in sample 1 was 31.70% and the lowest in sample 5 was 6.55%.

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Introduction

Environmentally friendly plastic is plastic that can be decomposed by the activity of decomposing microorganisms. Eco-friendly plastics have the same uses as synthetic plastics or conventional plastics. Environmentally friendly plastics are usually referred to as bioplastics, which are plastics whose entire or almost all components come from renewable raw materials. Environmentally friendly plastic is a plastic material that is friendly to the environment because of its nature that can return to nature [1].

In the process of making biodegradable plastic, it is necessary to add plasticizers so that the resulting plastic is more elastic, flexible and resistant to water [2]. One plasticizer that is widely used in the manufacture of biodegradable plastics is glycerol. This addition aims to improve physical properties, mechanical properties and protect plastic from microorganisms that can damage plastic [3]. The way plasticizers work in the process of making biodegradable plastics occurs through the process of mixing and measuring raw materials [4]. Important parameters that determine the performance of plasticizers are plasticizer content (glycerol concentration), mechanical strength (tensile strength, flexural strength and plastic impact strength) and biodegradability which has the main purpose of using glycerol as a plasticizer in

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biodegradable plastics is to increase the ability of plastics to be degraded naturally by microorganisms [5]. In the manufacture of biodegradable plastics, what is often used is glycerol. Glycerol is widely used as a plasticizer because of its stability and non-toxicity. The addition of plasticizers can increase flexibility and permeability to water vapor and gases [6].

The manufacture of biodegradable plastic adds chitosan, this is because chitosan is non-toxic, polyelectrolytic and easily biodegradable [7]. Chitosan is an environmentally friendly material and serves to increase the mechanical properties of bioplastics and better water resistance. Chitosan is easily degraded, easily combined with other materials, and is antimicrobial as an antimicrobial and reinforcing agent. The use of chitosan as an additive in the manufacture of bioplastics will reduce the speed of water absorption, improve mechanical properties, and reduce the moisture properties of the film [8]. Chitosan is a biopolymer as an anti-microbial material. Chitosan is a natural biopolymer that is safe for consumption, able to absorb fat and biodegradable. And can also function as a reinforcement, so as to increase (strain) tensile strength and (elongation) elongation at break. While the physical properties of thickness indicate the resistance of the film to the transfer rate of water vapor, gas, and other volatile compounds [9]. The use of chitosan as an additive in the manufacture of bioplastics will reduce the speed of water absorption, improve mechanical properties, and reduce the moisture properties of the film [10].

Biodegradable plastic is an alternative environmentally friendly packaging material because it is made from renewable materials and is scientifically easily degraded by microorganisms and by weather [11]. Renewable material that is abundant in Indonesia is cassava which has high potential as a raw material for making biodegradable plastics[12]. The nutritional content of cassava tubers in 100 grams of material is as follows: calorie 146 kcal; protein 1.6 gr; fat 0.3 gr; carbohydrates 34.7 gr; lime substance 33 gr; phosphorus 40 mg; iron 0.7 mg; and thiamin 0.02 mg. The chemical composition of cassava starch is as follows: moisture content 13%; ash content 0.2%, fat content 0.8%, protein content 1%, fiber content 3.4%, and starch content 81.6% [13].

To determine the results obtained from the effect of the addition of glycerol and chitosan on the characteristics of biodegradable plastics with the best operating conditions. By showing the novelty of the glycerol variable concentration of 2%,4%,6%,8%,10% and the variable of chitosan concentration of 1%,3%,5%,7%,9% on the characteristics of mechanical tests and biodegradability tests.

Methods

Cassava is extracted to obtain cassava deposits which will become cassava starch. Furthermore, making biodegradable plastic from cassava starch with the addition of glycerol plasticizers and chitosan reinforcements with concentration variations of 2%,4%,6%,8%,10% and 1%,3%,5%,7%,9%, using a temperature of 65°C for 30 minutes. The analysis includes tensile strength, elongation and biodegradation of plastics.

In this biodegradable plastic manufacturing research in analyzing data using the regression method, where this method is an approach to model the relationship between the dependent variable Y and one or more independent variables called X.

$$Y = a_0 + a_1 . x_1 + a_2 . x_1{}^2 \; \ldots . \; (1)$$

Results and Discussions

This discussion includes the results of analysis conducted in research on making Plastic Biodegradable

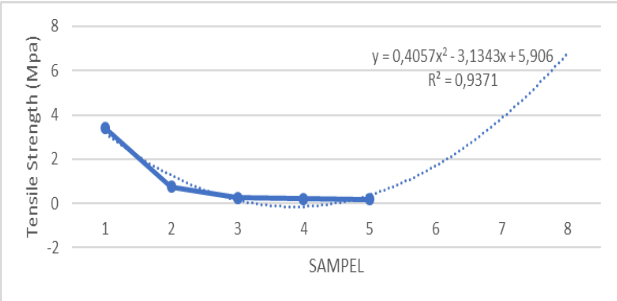

Figure 1. Effect of Glycerol and Chitosan Addition on Tensile Strength

Figure 1 Illustrates the relationship between glycerol and chitosan to tensile strength. It can be seen and concluded that the best tensile strength value is 3.41 Mpa in the variable glycerol of 2 ml and chitosan of 1 gram. From the graph of the research test results found that the of chitosan 3%,5%,7%,9% and the ratio of glycerol 4%,6%,8%,10% decreased tensile strength. The more chitosan and glycerol, the value of tensile strength decreases. The results of adding chitosan to bioplastics show that there is an interaction in mixed films (starch-chitosan bioplastics). The addition of

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chitosan can add tensile strength value to bioplastics. The more chitosan added, the tensile strength value of bioplastics will decrease. In other words, the bioplastics produced will have fragile properties [14]. The addition of plasticizer compounds also has a significant influence on the tensile strength value of bioplastics. The value of tensile strength decreases, with more plasticizers being added. This is related to the high amount of plasticizer content will increase flexibility so as to reduce the tensile strength value of bioplastics [15].

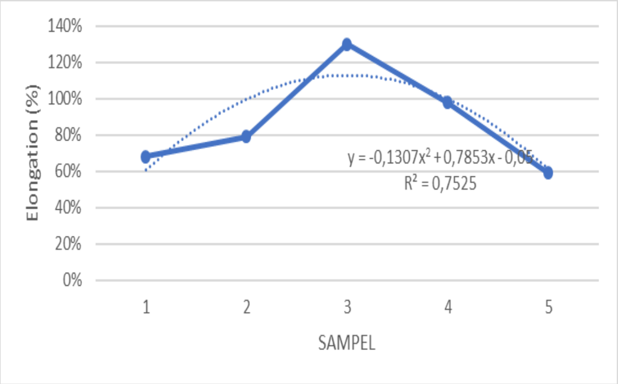

Figure 2. Effect of Glycerol and Chitosan Addition on Elongation

From **Figure 2** Above which illustrates the relationship between glycerol and chitosan on Elongation or Extension of Break, it can be seen that the highest percent elongation value in the 3rd sample which is 5 grams of chitosan and 6 ml of glycerol with an elongation result of 130%. From the graph above, it illustrates that samples 1, 2 and 3 experienced an increase in percent elongation and decreased elongation in samples 4 and 5. It can be stated that the effect of different concentrations of chitosan and glycerol on the percent elongation of biodegradable plastics shows that the higher the concentration of glycerol added, the higher the percent elongation value of biodegradable plastics [16]. The more chitosan addition, the elongation will decrease, This decrease in elasticity is caused by the decreasing bond distance between molecules, because the saturation point has been exceeded so that excess plastic molecules are in their own phase outside the polymer phase and will decrease the intermolecular force between chains, causing freer chain movement so that flexibility increases [17].

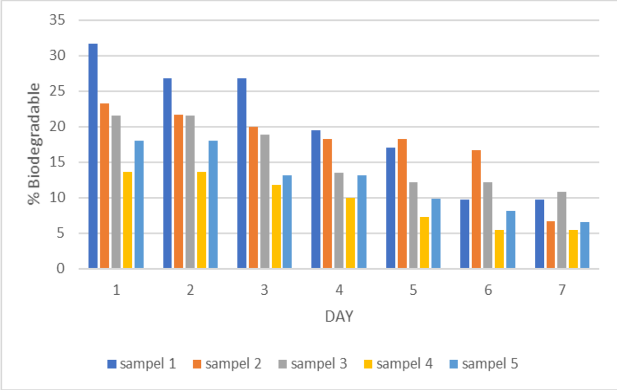

Figure 3. Percent (%) Sample Weight Loss

Figure 3, It can be seen that the biodegradation test in this study was carried out using the soil burial test method. This method utilizes soil media for observation of mass reduction (biodegradable) in samples, the parameters measured are in the form of mass reduction from samples that have been stockpiled in soil medium for a certain time. Planting biodegradable plastic samples on soil media for 1 week, with daily observation. The stage of the biodegradation test carried out is to weigh the mass of the sample before and after the biodegradation process within a certain period of time. And obtained sample results decreased sample weight after being stockpiled with soil, with the highest results found in sample 1 as much as 31.7%. If there is a greater decrease in mass, it indicates that the sample will degrade faster [18]. And the lowest percent as much as 6.55% in the 5th sample. The greater the addition of chitosan, the percent degradation value will decrease [19]. The addition of chitosan composition that increases will decrease the rate of biodegradation, and the more the use of starch and glycerol composition used, the more the rate of biodegradation, this is because starch and glycerol are hydrophilic [20].

Conclusions

Based on the research results it can be concluded:
The best and highest Tensile Strength Test results were obtained in sample 1 as much as 3.41 MPa. and the lowest tensile strength test result in sample 5 was 0.18. This is because the more glycerol added to biodegradable plastic, the tensile strength of biodegradable plastic will decrease which will affect the quality of plastic which becomes more fragile. The best and highest Elongation/Extend break test result was 130% in sample 3. And the lowest Elongation was 59% in sample 5. Elongation decreases with increasing chitosan. And in samples 1, 2 and 3 which initially had a percent increase of 68%, 79% and 130% with the increase in glycerol.

And in the results of the Biodegradation test conducted by observation for 7 days, the highest biodegradation value was obtained in sample 1 as much as 31.70% on the first day and the lowest in sample 5 as much as 6.55% on day 7. The greater the addition of chitosan and glycerol, the percent biodegradation value will decrease.

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Author Contributions
The authors' contributions to the paper are as follows: study conception, design, analysis, and interpretation of results: RAN, TYH; data collection: NZ; draft manuscript preparation: NZ. All authors have reviewed the results and approved the final version of the manuscript.

Conflicts of Interest
All authors declare that they have no conflicts of interest.

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