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# THE EFFECT OF VARIATION PERCENTAGE ALKALIZATION (NAOH) ON THE MECHANICAL PROPERTIES ANALYSIS AND WATER ABSORPTION BEHAVIOUR IN BIOCOMPOSITE WITH CASSAVA RUBBER STARCH

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***Abstract***

*Maluku as one of the provinces in Indonesia has a lot of potential sago plants, which is the basis for conducting research using sago fiber and rubber cassava starch as a base material for making composites that have good mechanical value and are environmentally friendly. Composites are made using natural ingredients namely sago fiber and cassava rubber starch as the matrix. The making of composites is expected to get good bending strength, impact strength, and water absorption rate. Composites are made using the hand lay-up method with a variation of the matrix. The variation of the volume fraction of sago pith fibers is 1:1 and 7:3 using NaOH liquid and distilled water in the alkali process with a percentage ratio of 0%, 5%, 10%, 15%, and 20% soaking time in NaOH liquid for 120 minutes.*
*The results of this study were found to be the best impact value on composites with 1:1 fiber volume variation with 15% alkaline NaOH liquid process. The highest value of the energy absorbed by the composite was 7.5479 J with an impact strength of 0.0755 J·mm$^{-2}$. At a variation of 7:3 the highest absorption energy is 5.7430 J, while the impact strength is 0.0574 J·mm$^{-2}$ at 15% of NaOH liquid percentage. The highest bending strength is 226.035 MPa at 1:1 volume fraction variation with 15% NaOH liquid percentage. In 7:3 fiber volume fraction variation, the highest value reaches 206.199 MPa at 15% NaOH liquid percentage. The best water absorption rate is at 8.82% that occurs in 1:1 fiber volume fraction variation, with 15% percentage of the NaOH alkaline process. In the other side, water absorption rate is 9.16% in the 7:3 fiber volume fraction variation with 15% NaOH liquid in the alkalization process.*

***Keynote :*** *sago pith fiber, cassava rubber starch, NaOH, hand lay up method, bending strength, impact strength and water absorption rate*

## 1. INTRODUCTION

The need for materials causes the development of knowledge in the field of metallurgy to get new materials developing rapidly, one of which is a composite which is a substitution of metal. The advantages of composite materials are that they have good strength and rigidity, are lightweight, have low production costs, are resistant to corrosives and can be made according to needs. Various advantages possessed by composite materials from other materials make composite materials an alternative choice for humans as one of the materials used to respond to increasing human needs. The rapid development of composite material technology development so that the mechanical strength value of the composite can be adjusted by modifying the composites.

Sago pith is the middle part of the sago tree trunk which is still stored along with starch. The sago pith is then soaked in water and then squeezed so that the juice mixes with the starch. The waste from the sago pith juice is in the form of fiber which is used in research. Sago pith waste has the largest content in the form of cellulose, hemicellulose and lignin. (Polnaya. F. J et al. 2022)

Rubber cassava starch (Manihot Glaziovii) is the result of extraction of old rubber cassava, the largest component contained in rubber cassava is starch. Rubber cassava starch is composed of carbohydrates which are glucose polymers consisting of emylose and amylopectin in a ratio of 1: 3 (the ratio of amylose and amylopectin varies depending on the type of starch). Amylose gives hardness while amylopectin causes stickiness. These two carbohydrates have different solubility in water (Yazid, et.al., 2006).

Matthew, et al., defines composite as a material that is formed from a combination of two or more forming materials through an inhomogeneous mixture, where the mechanical properties of each forming material are different.

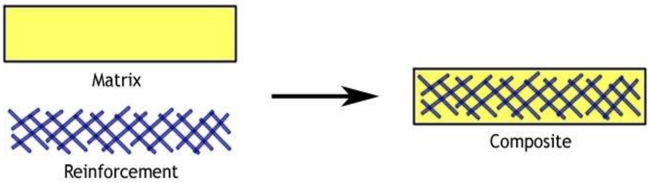


**Figure 1.** The composite material.

Jacob also explained that the placement of fibers and the direction of different fibers made the fiber reinforced composites differentiated into several sections, including: continuous or unidirectional, woven fiber composite, discontinuous fiber composite (J. A. Jacob et al, 1994). Gibson also say that the matrix in the composite structure can come from polymeric materials, metals, or ceramics (R. F. Gibson, 1994). To increase the adhesion of the fiber, the rougher the surface of the fiber as research by Nevada, et al.(2018), the adhesive bonding will also increase and the mechanism of interlocking bonding can occur on two surfaces between the fiber and the matrix. In this bond the rough surface is able to cause more interlocking and the resulting more perfect mechanical bonding. The interface bond is perfect if the load or force applied to the amplifier is parallel to the interface. (Hosne Ara et al. 2021)


**Figure 2.** Mechanical bonding.

In modifying the alkaline process proposed by Mohanty it will damage the hydrogen bonds and in this way will make the surface of the fiber more rough. The process of alkali in the fiber will remove a number of lignin, wax and oil on the surface of the fiber wall, resulting in depolymerization of cellulose. (A. K. Mohanty et al. 2005)

From this research it is expected to know the effect of changes in the variation of the volume fraction of sago pith fibers and rubber cassava starch matrix and the percentage of alkalization (soaking process with NaOH liquid) on the mechanical properties and behavior of water absorption from the biocomposite sago pith fibers with rubber cassava starch.

## 2. METHODS

### 2.1. Materials

Data collected in this study are data taken during experiments. The data taken is biocomposite with comparison of sago pith fiber and rubber cassava matrix are 1:1 and 3:7. The liquid used to soak the fiber consists of the percentage of distilled water compared to 0%, 5%, 10%, 15%, and 20% NaOH liquid (alkalization).

**Table 1**. Properties of Sago Pith

| Fiber | Cellulose (%) | Hemicellulose (%) | Lignin (%) | Water Content (%) |
|---|---|---|---|---|
| Sago Pith | 33 | 14 | 8.7 | 44.3 |

### 2.2. Fabrication of Composites

Weighing of sago pith fibers and cassava rubber starch matrices in accordance with the desired volume fraction, Preparation of molds; The mold shape of the test specimen is in accordance with ASTM standards. then pour the matrix into a mold that has been placed and arranged in the sago pith fiber in accordance with the specified volume fraction is compacted, and this is made to form layers. Drying the composite in the oven with a temperature of 100°C for 120 minutes, make observations on the composite whether there is no voids that occur by looking at the composite sheet. Its diameter is not more than 1 mm. Voids must not lump in one place (the radius of distance between voids allowed is 1 cm).

### 2.3. Characterization

**Bending Strength Testing**

Bending testing is one of the mechanical properties testing of materials carried out on specimens of the material. Bending is the process of loading a material at a point in the middle of the material held on two supports. With this loading the material will deform with two opposing forces working at the same time. As the behavior of the material to the loading, all materials will experience a deformation (deformation) gradually from elastic to plastic until finally experiencing damage (broken). (ASTM Standard D 790 - 03)

**Impact Strength Testing**

In the impact test the measurement of energy absorbed to break the test object. The greater the energy absorbed, the lower the swing back from the pendulum. The fracture energy absorbed is expressed in Joules (J). The principle of this impact test is that if the test object is given a shock load, then the object will experience an energy absorption process resulting in plastic deformation that results in fracture. Impact test specimens were made according to ASTM D 256 standard. To determine the object's resistance to fracture, Charphy's impact testing method was used. A material is said to be tough if it has the ability to absorb large shock loads without cracking or deformation easily.

**Water Absorption Testing**

The testing process conforms to the ASTM E 96 standard, where the container is filled with distilled water. The specimen before being put into the container was weighed to find out the initial weight, after that it was put into the container with the specimen distance from the surface of the aquades of 0.25 inches. The container is closed, after that the container is left at room temperature for 24 hours. After 24 hours the container is opened, the specimen is removed then weighed to determine the final weight of the specimen, then calculate the percentage of water absorption rate in the specimen by comparing the weight before and after the process.

## 4. RESULT AND DISCUSSION

### 4.1. Bending Strength Testing

From the calculation data of bending strength and bending strain can be shown the relationship between the percentage of NaOH vs. bending strength in Fig. 3 showed an increase in bending strength due to the increasing percentage of NaOH, this can be seen in the two variations of the fiber volume fraction, in the variation of the 1:1 fiber volume fraction, the highest value was at the 15% NaOH percentage of 226.035 MPa, while in the 7:3 fiber volume fraction variation at 15% NaOH percentage of 206.119 MPa. The increase in the value of bending strength at 15% NaOH is caused by the increased levels of NaOH in the alkalization process resulting in better chemical reactions in removing lignin, wax, oil, hemicellulose compounds and impurities on the surface of the fiber so that the fiber becomes cleaner and the surface roughness of the fiber becomes better.

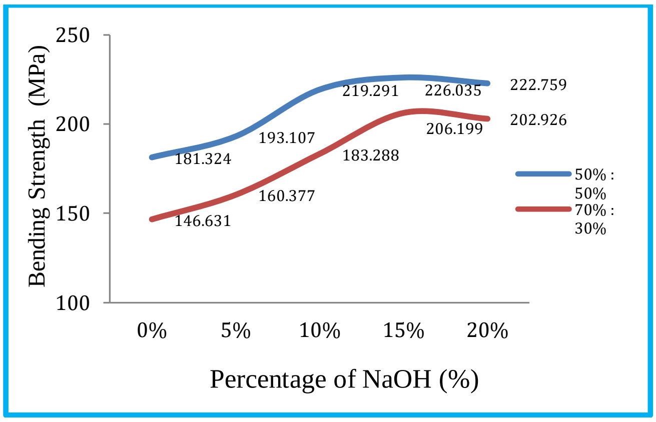


**Figure 3.** Relationship between NaOH percentage against bending strength.

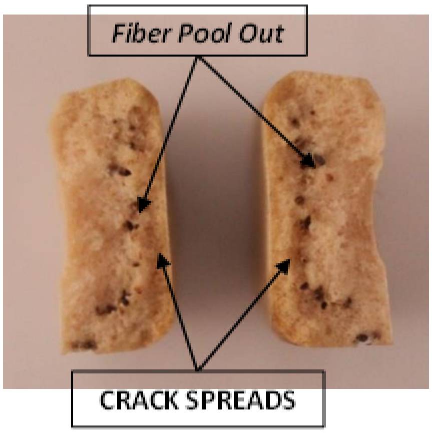


**Figure 4.** Composite fracture mechanism Bending Test at 3% NaOH Percentage at 50% : 50% fiber volume fraction variation.

The introduction of clean and coarse fibers results in a better bonding interface between the fiber and the mantric so that the adhesion properties between the fiber and the matrix get better, this is very affective in the transfer and distribution of the load on the composite. Increasing the volume fraction of the fiber so that the bending strength is also increased due to the strength of the fiber which affects the strength of the composite. The bending test results can be seen in Fig. 3, that the increased bending strength of the composite due to the pressure in the bending testing process received by the composite will be accepted by the matrix which automatically passes on to the fiber, the more fiber content the smaller each load received by each fiber so that the load received by the composite is greater.

### 4.2. Impact Strength Testing

The maximum impact strength is the percentage of 15% NaOH in composites with a variation of 1:1 volume fraction ie 0.0755 J $\cdot$mm$^2$ and the minimum percentage at 0% NaOH at 0.0133 J $\cdot$mm$^2$. Whereas in the composite volume variation fraction of 7:3 with a percentage of 15% NaOH the maximum impact strength is 0.0574 J $\cdot$mm$^2$ and the minimum at the percentage of 0% NaOH at 0.0072 J $\cdot$mm$^2$, this can be seen at Fig. 5.

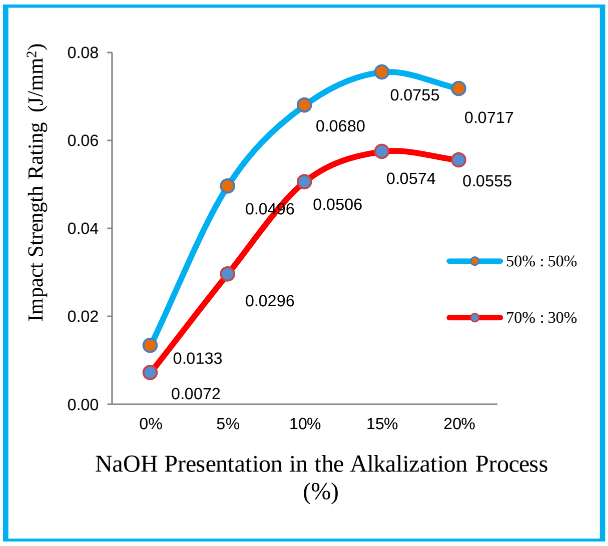


**Figure 5.** Relationship between NaOH percentage against bending strength.

The impact strength value is seen increasing from the percentage of 0% NaOH to the percentage of 15% NaOH in both variations of the fiber volume fraction, this is due to the better bonding interface between the matrix and the fiber. Good interface bonding gives increased absorption energy and impact strength, the alkalization process reduces hydrophilic properties of the fiber by reducing lignin, cellulose and wax which are part of the chemical composition which decreases the bonding capacity between the fiber and the matrix. The increasing percentage of NaOH in the alkalization process, the better the surface condition of the fiber so that the bond between the fiber and the matrix is optimal.

The decrease in hydrophilic properties on the surface of the fiber results in a better interface bond between the fiber and the matrix. the two variations in fiber volume fraction. The impact energy absorption and impact strength values are seen to increase from the percentage of 0% NaOH to the percentage of 15% NaOH.

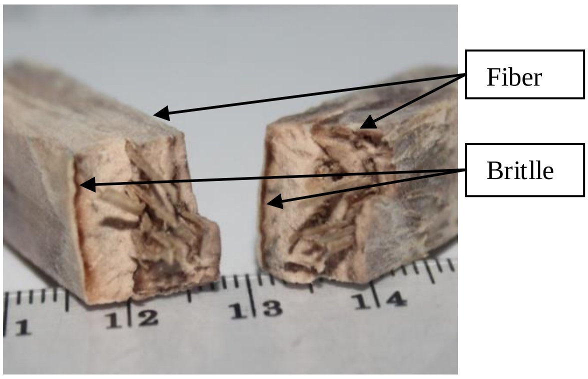


**Figure 6.** Composite fracture cross-section Impact testing on volume fraction variations of 50% : 50% with 3% NaOH alkalization process

### 4.3. Water Absorption Testing

From Fig. 7, it is known that an increase in the maximum weight difference and maximum water absorption occurs in composites with a variation of 1:1 volume fraction is at the percentage of 0% NaOH with a difference in weight gain of 0.357 gram and the percentage of water absorption at 9.62%. While the minimum difference is in the percentage of NaOH 15% with a value of 0.328 gram, with a minimum percentage of water absorption of 8.82%

Whereas on composites with variations in the volume fraction of 7:3 the difference in maximum weight gain is in the percentage of 0% NaOH with a maximum difference of 0.392 gram with a percentage of water absorption of 10.54%. The minimum weight difference in the variation of this volume fraction is in the percentage of 15% NaOH with a difference of 0.340 gram, with a minimum percentage of water absorption of 9.16%.

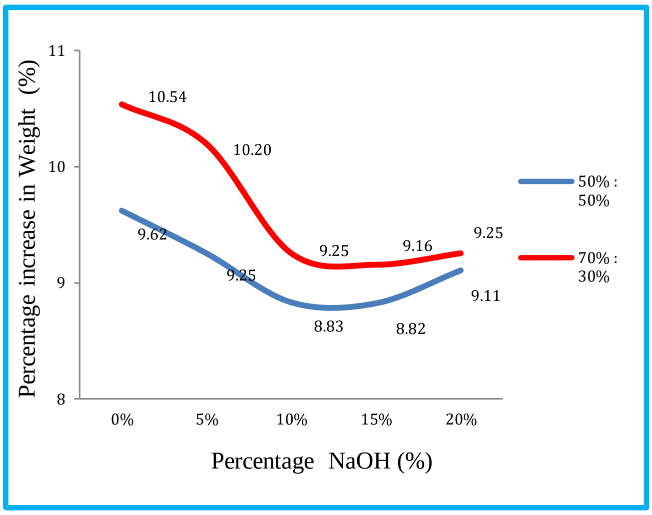


**Figure 7.** Percentage of increase in weight against NaOH percentage.

The decrease in water absorption in composites is influenced by the modification of the surface of the fiber in the alkalization process, the alkalization process can reduce the hydrophilic nature of natural fibers. The small weight gain of the composite results in a small water absorption rate also on the composite and that is better for the composite. This can be seen in Fig. 5 that the smallest percentage increase in composite weight was in the alkalization process with a percentage of NaOH of 15% in each variation of the fiber volume fraction.

# 5. CLOSING

## 5.1. Conclusions

In both variations of the volume fraction, after the fiber has been immersed with NaOH solution, the fiber tends to decrease in chemical composition. The greater the percentage of NaOH in the same immersion process results in the strength of the composite increasing and vice versa the smaller the percentage of NaOH the smaller the strength of the composite.

At the maximum percentage of 15% NaOH, the maximum increase after the increase in NaOH percentage, the strength of the composite gradually decreases, this is because the higher the percentage of NaOH, the more damaged the fiber condition.

## 5.2 Suggestion

Is necessary to carry out further research on various variations in the manufacture of biocomposites, especially for local materials in Maluku Province to obtain a good biocomposite

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