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Tensile Strength of Packaging Materials Made of Rice Fiber with Gondorukem Coating

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ABSTRACT

Packaging is one of the important needs in the food business that is difficult to avoid. Developing packaging products for food is an important thing that must be done to maintain cleanliness, health and the environment. Packaging waste that uses plastic as the basic material causes environmental pollution because it is not easily decomposed. Green packaging is one form of packaging that uses environmentally friendly materials such as rice straw. Bio-foam from straw combined with PVA, Glycerin, corn starch and distilled water is made into sheets for packaging. This sheet is tested with the addition of a coating derived from gondorukem which comes from plants. With this coating, it is expected to increase the tensile strength and hydrophobicity of the material surface. Testing was carried out with variations in the mixture of gondorukem and alcohol as the basic coating material, namely gondorukem concentrations of 20%, 40% and 60%. The tensile test results showed that a coating with a concentration of 60% gondorukem produced the highest tensile strength value. The increase in tensile strength reached 102% of the tensile strength of the sheet without gondorukem coating.

Keywords: Green Packaging, Bio-foam, Rice Straw, tensile Strength.

1. INTRODUCTION

Most of the food packaging materials used today use polymer materials that are less environmentally friendly and can cause environmental damage [1]. This material takes a long time to decompose naturally so that its presence can damage the environment. However, the need for food packaging is increasing with the increasing development of the food business accompanied by increasing community mobility.

Based on this, it is necessary to develop technology to obtain packaging materials that are more easily decomposed and environmentally friendly, known as green packaging. Green packaging is packaging that has basic materials that come from nature and produces waste that is easy to decompose [1]. One of the basic materials for green packaging comes from rice straw fiber, but the level of surface resistance to water is low and has a lower tensile strength than plastic-based packaging.

To qualify as a food packaging material that has surface resistance to water and is stronger, it is necessary to develop a coating method on green packaging materials. [2]. One way of coating can be done by using natural materials derived from gondorukem as the basic coating material with 96% alcohol solvent [3]. This coating method is expected to increase the surface hydrophobicity value, tensile strength and density of products derived from rice straw as the basic material [4][5][6]

This paper shows the results of tensile strength testing on paper made from rice straw coated with gondorukem with alcohol solvent. The concentration of gondorukem in alcohol varies from 20%, 40% and 60%.

2. METHODOLOGY

The research was conducted using an experimental method that aims to gain control over the product [7]. The experimental method is carried out by measuring several variables related to the product or system, then analyzing the data used to draw conclusions about the relevance between the treatment variables and the measurement results of the resulting product.

In this study, the experimental method used is the surface treatment of the product or material which is then continued with data collection from the control variable, where the control variable is the concentration of the coating substance made from gondorukem with alcohol solvent (99%) with a concentration value of 20%, 40% and 60%. The control variables of the rules are given the following identities:

- Specimen 0 or abbreviated as S0: sheets made from rice straw without coating.
- Specimen 1 or abbreviated as S1 is a rice straw sheet specimen coated using a solution of 60% gondorukem and 40% alcohol.
- Specimen 2 or abbreviated as S2 is a rice straw sheet specimen coated using a solution of 40% volume of gondorukem and 60% volume of alcohol.
- Specimen 3 or abbreviated as S3 is a specimen coated with a 20% gondorukem solution and 80% alcohol.

The purpose of coating with variations of gondorukem-alcohol solutions is to determine the effect of the mixture concentration on the values that can describe the mechanical quality of the product, including: hydrophobicity values obtained from measuring the surface contact angle between water and the sheet surface, tensile strength and material density. The steps of the experiment are carried out as follows:

2.1 Material preparation

The preparation of basic materials is the initial procedure in the experimental method, where the basic specimen comes from a mixture of: rice straw, glycerine, distilled water, corn starch and PVA forming a bio-foam mixture with the concentration shown in Table 1. The mixture in the form of bio-foam is heated and then pressed with a pressure of 10 bar [8].

Table 1 shows the composition of the basic specimen, namely the basic material which is made the same in the manufacturing process so that it is not a variable in this study.

Table 1. Bio-foam composition [8]

Element	ρ (g/cm³)	%	Vol. (cm³)	M (g)
Rice straw	0.46	36%	19.66	9.04
Aquadest	0.97	30%	16.38	15.89
PVA	1.19	20%	10.92	12.99
Corn starch	0.83	9%	4.91	4.08
Glycerol	1.26	5%	2.73	3.44

Total volume: 54.6 cm³

2.2 Test specimen preparation

For tensile strength testing purposes, the base material needs to be formed according to the specimen dimension standards required in ASTM D638 [9, 10]. Figure 1 shows a specimen pattern made from the basic material of bio-foam according to the requirements.

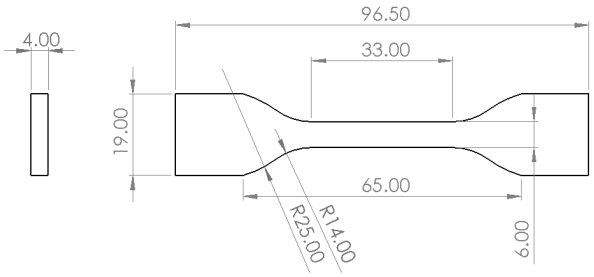

Figure 1. Tensile test specimen dimensions

2.3 Base specimen coating

Surface treatment is carried out using a coating method with a coating substance in the form of a solution of damar resin (gondorukem) with 96% alcohol solvent (ethanol) [2].

The coating material uses a mixture of gondorukem and 96% alcohol with the following coating variations:

S0 : Without coating.
S1 : 60 % Gondorukem + 40% Alkohol
S2 : 40 % Gondorukem + 60 % Alkohol
S3 : 20 % Gondorukem + 80 % Alkohol

Table 2. Composition of coating elements

Element	ρ (g/cm³)	Var.	%	Vol. (cm³)	M (g)
Alkohol	0.78	S1	40%	40	31.2
		S2	60%	60	46.8
		S3	80%	80	62.4
Gondorukem	1.06	S1	60%	60	63.6
		S2	40%	40	42.4
		S3	20%	20	21.2

Total volume: 50 cm³

Table 2 shows the amount of gondorukem and alcohol required to meet the coating requirements for specimens S1, S2 and S3.

2.4 Tensile strength test

The test specimens that have been coated with gondorukem solution are subjected to tensile strength tests in order to determine the tensile strength value of the material [9]. The tensile test was carried out using a tool with the HF-500N series which has a maximum tensile strength specification of 500 N. Figure 2 shows the Tensile Test Tool used.

Figure 2. HF-500 N tensile tester

Each specimen was tested 3 times. The resulting value for each specimen was taken from its average value.

3. RESULTS AND DISCUSSION

3.1 Tensile strength

The results of several tests carried out produced results in the form of numerical data which represent the quality or suitability of a product [12]. Testing for each specimen was carried out 3 times. Figure 6 shows the tensile test results for specimens without coating. While Figures 3 - 6 show the tensile test graphs for specimens: S1, S2 and S3.

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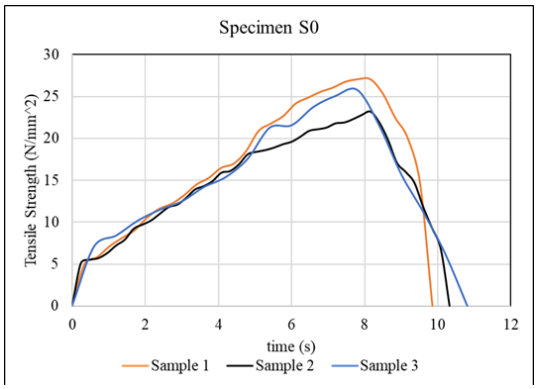

Figure 3. Tensile strength test results for specimen S0 (no coating)

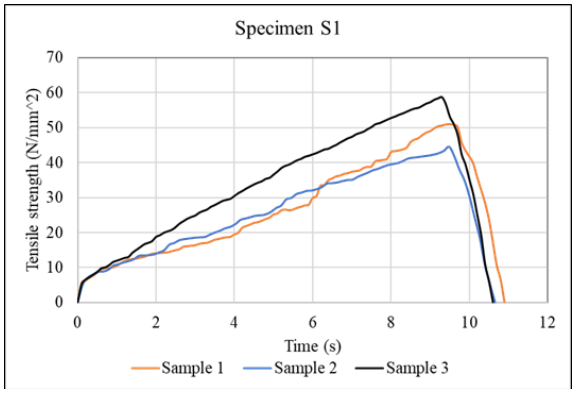

Figure 4. Tensile strength test results for specimen S1 (Gondorukem 60%, Alcohol 40%)

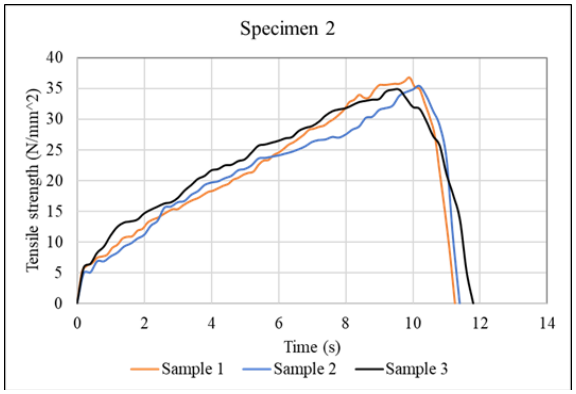

Figure 5. Tensile strength test results for specimen S2 (Gondorukem 40%, Alcohol 60%)

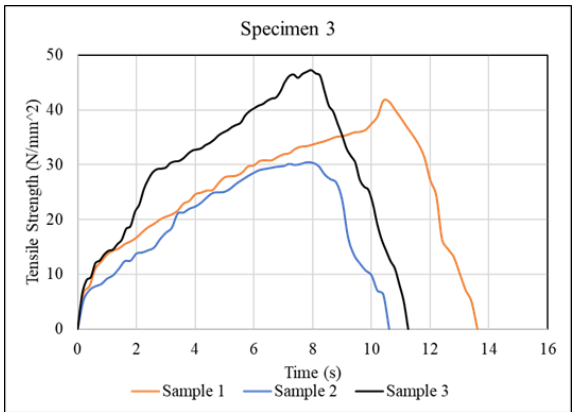

Figure 6. Tensile strength test results for specimen S3 (Gondorukem 20%, Alcohol 80%)

The test result data is data in the form of tensile strength owned by the material of each specimen. To determine the characteristics of other material strengths such as strain and modulus of elasticity of the material, the following calculations need to be carried out.

The strain value (ε) in the material can be obtained using the calculation from equation 1.

$$\varepsilon = \frac{\Delta l}{l_0} \dots\dots\dots [1]$$

Where, Δl is material elongation value, l_0 = initial length value of material

Meanwhile, the value of the elastic modulus (E) can be obtained using Equation 2.

$$E = \frac{\sigma_u}{\varepsilon} \dots\dots\dots [2]$$

Where, σ_u is the maximum tensile strength value of the material, ε is strain value of material.

Table 3 shows the test material characteristics for samples S0, S1, S2 and S3.

Table 3. Material strength values

Specimen	Strength, N/mm²	Strain %	Modulus of Elasticity
S0	25.367	6	399.341
S1	51.333	12	442.194
S2	39.833	8	494.859
S3	35.667	8	472.052

Comparison of the mechanical properties of the test material between uncoated sheets and sheets with 60%, 40% and 20% gondorukem coating is shown in Figures 7, 8 and 9.

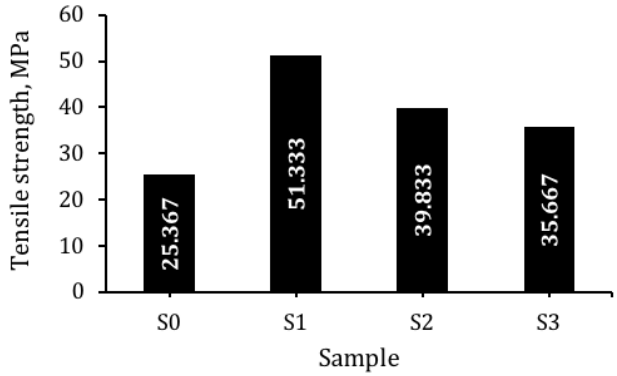

Figure 7. Values of tensile strength

The tensile test results showed a decrease in tensile strength along with the decrease in the concentration of gondorukem in the coating solution. In other words, the addition of gondorukem concentration in the coating solution causes an increase in the tensile strength of the material.

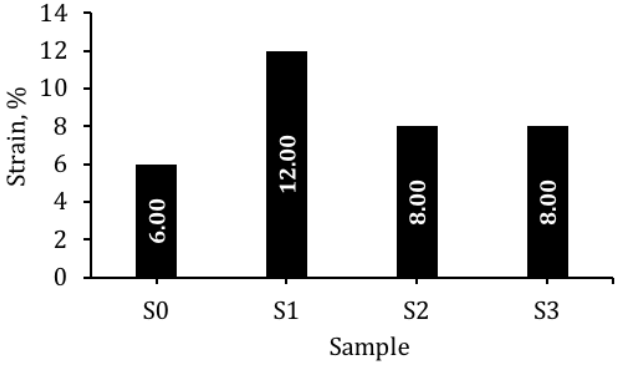

Figure 8. Strain value for each sample

The highest tensile strength value on the rice straw sheet was owned by sample S1, namely the sheet with 60% Gondorukem coating of 51.33 MPa. Coating with 60% gondorukem solution increased the strength of the sheet by 102%. Thus, the packaging of rice straw coated with 60% Gondorukem meets the requirements as a packaging material, where the tensile strength requirements of the packaging material must be higher than 29.16 MPa [14].

The same thing happens to the material strain value, the concentration of gondorukem elements in the coating solution used affects the strain value of the food packaging material. There is a decrease in the material strain value along with the decreasing concentration of gondorukem solution as a coating substance. The highest strain value is owned by sample S1, a sheet with a 60% gondorukem coating, which has a strain value of 12%.

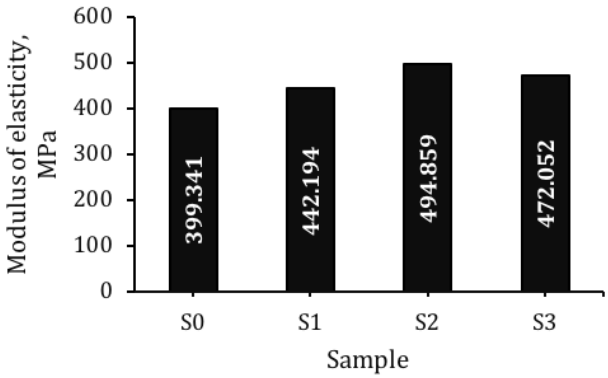

Figure 9. Elastic modulus value of each sample

The modulus of elasticity is the stiffness value of a material. The higher the modulus of elasticity, the less elastic the material. The modulus of elasticity value decreases with increasing concentration of gondorukem solution. With the highest value produced by S2 of 494.859 Mpa. The increase in the modulus of elasticity value along with the decrease in the concentration value of gondorukem solution is because the gondorukem material in solid form is a material with a shape similar to crystals that have brittle characteristics, which is a hard but fragile or easily broken material. So the higher the concentration of gondorukem solution, the smaller the modulus of elasticity value of the material.

3.2 Density measurement

The test of the material density value is determined based on equation (3).

$$\rho = \frac{m}{v} \dots\dots\dots [3]$$

Where density (ρ) is a unit of mass per volume of a material expressed in units of g/cm³. The calculation states m as the mass of the material and

v as the volume of the material. Table 4 shows the results of measurements and calculations of material density for each sample.

Table 4. Density of each sample

Spesimen	Density, ρ (g/cm³)
S0	0.61851
S1	0.7602
S2	0.68707
S3	0.66053

From Figure 13, the difference in density of each specimen can be seen. In S0 as a specimen that did not receive any treatment, it has the lowest density compared to other specimens that received surface treatment in the form of coating. With S1 as a specimen that received coating using the highest concentration solution getting the highest density value and S3 which received coating with the lowest solution concentration showed the lowest density value of the other specimens that were coated. This is because the percentage of coating affects the mass of the base coating material in this case gondorukem, where the highest concentration provides the highest additional mass of the gondorukem itself.

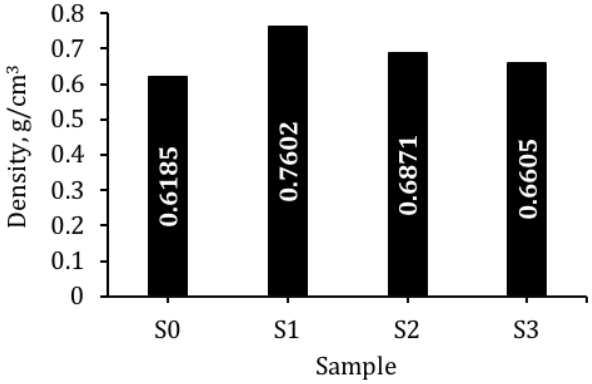

Figure 10. Density value of each sample

4. CONCLUSION

After a series of material manufacturing processes were carried out by taking into account the composition, material manufacturing process, surface treatment, testing, data collection, data processing and data analysis, the research on the mechanical characteristics of rice fiber-based packaging with coating using gondorukem solution led to a conclusion that the packaging material with the highest coating concentration value has a more optimal mechanical strength and characteristics value than materials with other coating percentages. Where the most optimal tensile strength value is found in Specimen 1 with a concentration of 60% gondorukem and 40% alcohol as a solvent. By providing a gondorukem layer on the rice straw packaging, the packaging meets the requirements as food packaging.

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