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Tissue Paper Products From Young Coconut Skin Waste (*Cocosnuciferal)* And Cassava Peel Waste (*Manihoteae*) Using The Sulfate Method (Kraft) According To Standard Sni 3344-2017 And Sni 0698:2010.

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Abstract. Organic waste is the residue or waste from human activities that has not been utilized and therefore does not have economic value. The issue with waste that is often encountered is organic waste, such as young coconut husks obtained from the sale of young coconuts and cassava peels sourced from traditional markets, chip businesses, and fried food vendors. Young coconut husk waste contains cellulose ranging from 21.07% to 34.66% and hemicellulose between 10% and 20%, while cassava peel waste contains cellulose at 43.626% and hemicellulose at 10.384%. With this composition, waste from young coconut husks and cassava peels can be used as raw materials for tissue production. One of the processes for making tissue is the sulfate (kraft) process, which involves the separation of fibers using organic chemicals. In this study, the types of solvents used are Sodium Hydroxide and Sodium Sulfide, with variations in solvent concentrations of 5%, 10%, 15%, 20%, and 25%. The analysis conducted includes the content of cellulose (Alpha, Beta, and Gamma), lignin content, tear resistance, tensile strength, explosiveness, brightness, and grammage. The best formulation obtained is using a Sodium Hydroxide solution with a concentration of 25%, resulting in a grammage of 13 g/m^2, Alpha Cellulose content of 69.95%, Beta Cellulose content of 18.77%, Gamma Cellulose content of 11.28%, Lignin content of 3.49%, Tear Resistance of 343.38 mN, Tensile Strength of 15.38 N/m, Explosive Power of 3.23 kgf/cm^2, and Brightness of 83.4%, in accordance with the standards SNI 3344-2017 and SNI 0698:2010.

Keywords: Organic Waste, Young Coconut Husk Waste, Cassava Peel Waste, Tissue, Sulfate Method (Kraft), Sodium Hydroxide, Sodium Sulfide

1. INTRODUCTION

Tissue is a type of paper that uses chemical pulp that is bleached with the addition of 50% or more mechanical pulp. According to [5], tissue, also known as paper, is a type of light crepe paper produced from paper pulp or recycled materials. In making tissue, the main raw material is fiber. There are two types of fiber that can be used in making tissue, namely natural fiber (virgin pulp) or secondary fiber (waste paper).

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tissue, the main raw material is fiber. There are two types of fiber that can be used in making tissue, namely natural fiber (virgin pulp) or secondary fiber (waste paper).

The raw material is a very important factor because it is related to the tissue results that will be produced. In research by [9], it states that the paper making process essentially involves separating fibers from fiber-rich raw materials using mechanical, chemical, or combined methods. In chemical process, the raw material is cooked in a cooking vessel (digester) and added with chemicals to dissolve unwanted components in the raw material so that paper with a high cellulose content is obtained.

The main goal of making paper is to separate the cellulose (fibers) from other ingredients. Chemical paper aims to separate cellulose fibers from raw materials through delignification (removing lignin) without carbohydrate degradation. Generally, the principle of paper-making involves isolating cellulose from impurities within the compounds found in wood, including lignin, through mechanical, semichemical, and chemical processes [1]. In the sulfate (kraft) process, cooking depends on the desired pulp yield, which aims to chemically separate the fibers and dissolve as much lignin as possible in the fiber walls.

Apart from that, choosing the Kraft process has many advantages when compared to other processes. The advantages include: - Can be used for various types of wood or fiber - Can increase pulp strength - Cooking time is quite short - The resulting pulp can be bleached with a higher level of whiteness (brightness). According [8], in the Kraft process , NaOH and sodium sulfide (Na2S) are used as cooking chemicals. The Kraft process is also called the sulfate process because it uses Na2SO4 as make up in the chemical recovery process, which replaces Na2CO3 in the soda process [13]. These chemical changes are expressed as the weight of the chemical and the weight of the raw material, which is the approximate ratio of leachate to raw fiber.
The reaction that occurs is

$$C_6H_{10}O_5 - CH_3 + NaOH \longrightarrow C_6H_{10}O_5Na + CH_3OH$$

$$(C_5H_{11}O_5COH)3 + 3NA_2S \longrightarrow 3((C_5H_{11}O_5CSHNA_2) + {}^{1}/2\ O_2$$

The active components in cooking leachate are hydroxyl ions and hydrosulfide ions; these results come purely from NaOH and Na2S; the reaction is as below:

$$NaOH \longrightarrow Na^+ + OH^-$$

$$Na_2S \longrightarrow 2Na^+ + S^{-2}$$

$$S^{-2} + H_2O \longrightarrow SH^- + OH^-$$

In this process, the chemicals and cooking liquid penetrate the fiber walls and dissolve the lignin, namely OH^- dan HS^- ions. The reaction that occurs in the cooking process is:

$$Na_2S + H_2O \longrightarrow NaSH + NaOH$$

$$NaSH \longrightarrow Na^+ + HS^-$$

$$NaOH \longrightarrow Na^+ + OH^-$$

Indonesian National Standard (SNI) Tissue Products consist of several types, including:

1. Facial Tissue Paper [11] This facial tissue paper is used as a skin cleanser, especially facial skin, and has a fairly smooth texture.
2. Toilet Tissue Paper [15] Toilet tissue paper is used as equipment in the toilet. Has a soft texture but is quite thin. This type of tissue also crumbles easily when exposed to water and is usually sold in rolls.
3. Napkin Tissue Paper [15] Napkin tissue paper as a cleaner for wiping hands or mouth after eating or as a wrapper for eating utensils can have a pattern that is embossed, crepe, clean, soft, white, or colored (using permitted dyes for food products).
4. Antiseptic Tissue Base Paper for Drinking Water Packaging [15] This type of tissue paper has high absorbency with good strength properties and is used as drinking water packaging.
5. Towel Tissue Paper [15] Towel tissue paper is a type of tissue paper that has high absorbency with good strength properties, especially used as a cleaner and absorbent for liquids.
6. Wet Wipes [15] Wet tissue products are generally used to clean or freshen human and baby skin but are not included for medical use.

The tissue that has the best and safest quality is tissue that meets SNI standards (Indonesian National Standards). The SNI used in the reference in this research is [18]

Table 1.1 Quality Requirements for Tissue Quality

No	Parameter	unit	Condition
1	Condition of the sheet	-	Clean, soft and without holes
2	Gramatur	g/m^2	14
3	WaterAbsorption Capacity	g/g	6

Utilizing young coconut waste in making tissue paper can reduce environmental pollution caused by the accumulation of waste that is difficult to decompose. Paper making is usually made from wood over time the trees in Indonesia will run out, but the need for paper will increase, therefore, the use of waste containing fiber will gain high economic value and can reduce the use of wood.

Table 1.2 Chemical Composition of Young Coconut Skin

Content	Rate %)
Aask	0,4
Lignin	30-36
Hemicellulose	10-20
Fiber	60-70
cellulose	21,07-34,66

Source: (*Sudaryanto, et al*, 2022)

Fig. 1.1 Young Coconut Waste (*CocosNuciferaL*)
Source: (*Community Service*, 2022)

Cassava peel is peeling waste resulting from processing cassava, tapioca flour, tape, sanghai chips, and other cassava-based foods. Cassava peel waste is still not widely used and is simply thrown away.

The potential for cassava peel in Indonesia is very abundant, in line with this country's existence as one of the largest cassava producers in the world, and continues to experience an increase in production every year.

Table 1.3 Chemical Composition of Cassava Peel

Content	Kadar (%)
Cellulose	43,626
--Hemicellulose	10,384
Lignin	7,646
Water	67
Other	1,764

Source: (*Kumar*, 2022)

Fig. 1.2. Cassava Skin Waste (Manihoteae)
Source: (*Gontornews*, 2019)

Assessing the Quality of the Paper Three criteria can often be used to assess the quality of a paper: 1. The cellulose Long-chain carbohydrate polysaccharide cellulose ($C6H10O5$) is derived from beta-glucose. Depending on where it comes from and how it is treated, the price of cellulose, a polyscharide with the chemical formula $C6H10O5$, varies according to the number of sugar unit repeats or the degree of polymerization. The polymerization levels of the majority of papermaking fibers range from 600 to 1500.

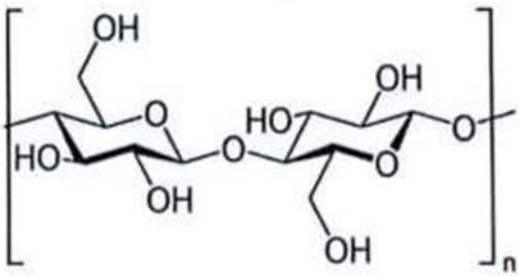

Fig.1.3. Cellulose Molecular Structure
Source: (Rewini, 2017)

Cellulose can be classified into three categories based on the degree of polymerization:

a. α-Cellulose (Alpha Cellulose) is a long-chain cellulose that has a DP (Degree of Polymerization) between 600 and 1500 and is insoluble in a 17.5% NaOH solution or strong base solution. The degree of purity of cellulose is determined by its α content. A paper's durability is mostly determined by its alpha cellulose content; the more alpha cellulose there is, the more durable the paper is, whereas gamma and beta cellulose have more hydrophilic qualities than alpha cellulose [15].
b. β-cellulose (Betha Cellulose), is short-chain cellulose, soluble in 17.5% NaOH solution or strong base solution with a DP (Degree of Polymerization) ranging from 15-90, and can precipitate when neutralized.
c. With a DP (Degree of Polymerization) of less than 15, cellulose (Gamma Cellulose) is a short-chain cellulose that dissolves in a 17.5% NaOH solution or strong base solution. [7].

1.1. Lignin

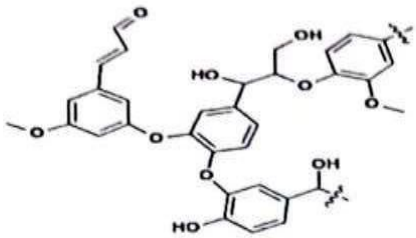

Fig. 1.4. Lignin Molecular Structure
Source: (*Park*, 2008)

Lignin is a complex polymer with a high molecular weight and is composed of phenyl propane units, composed of carbon, hydrogen and oxide, but lignin

is not a carbohydrate. In pulp making, lignin is considered a waste because it is the main obstacle in producing cellulose. Lignin reduces the yield capacity of pulp and cellular biomass.

1.2. Sodium Hydroxide

Sodium hydroxide is a highly caustic base and alkali, capable of decomposing proteins at ordinary ambient temperatures and can cause burns on exposure. This compound is highly soluble in water; it can easily absorb moisture and carbon dioxide from the air. This compound forms an hydrate with the formula NaOH.nH2O [9] . The monohydrate compound NaOH.H2O crystallizes from aqueous solutions at a temperature range between 12.3°C and 61.8°C. Sodium hydroxide is used in many industries in pulp and paper manufacturing, removing or cleaning substances and impurities attached to waste fiber.

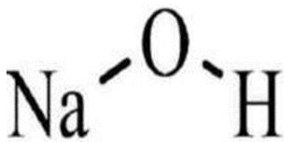

Fig. 1.5. Molecular structure of sodium hydroxide
Source: (*iStock*, 2024)

1.3. Sodium Sulfide

The chemical compound sodium sulfide has the formula Na2S. Sodium sulfide finds application in the textile, pulp and paper, and water treatment industries as well as in a number of manufacturing processes, such as the creation of sulfur colors and rubber compounds.

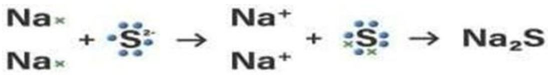

Fig. 1.6. Lewis structure of sodium sulfide
Source: (chemspider, 2024)

2. Experimental Procedure

Raw Material Preparation Process a. Making young coconut skin powder and cassava skin powder. Drying young coconut skin waste and cassava skin waste in the sun until dry, then grinding with a blender and sieving with a size of 80 mesh. b. The tissue-making formulation uses young coconut skin and cassava skin waste with the addition of Sodium Hydroxide and Sodium Sulfide solvents in different concentrations.

Product Analysis The analyses carried out are grammage, cellulose content (Alpha, Beta, and Gamma), Kappa Number (Lignin content), Tear Index Handsheet (Tear Resistance), Breaking Length Handsheet (Attractive Power), Burst Index Handsheet (Explosive Power), and Brightness Sheet Product (Brightness), which refers to the Indonesian National Standard [11] and [15].

2.1 Procedure

In this research, tissue type paper was made from young coconut skin waste and cassava skin waste using the sulfate (kraft) method. The process of cooking young coconut skin waste and cassava skin was carried out using a variety of solvents, namely Sodium Hydroxide and Sodium Sulfide solvents.

Each concentration variation is 5%, 10%, 15%, 20%, and 25% at a temperature of 70 °C to produce pulp. Then the resulting pulp will be bleached with a 50% H202 solution, and the addictive substances Virgin Coconut Oil (VCO) and chitosan will be added. The pulp will be printed using a paper mold measuring 20 x 30 cm.

The experiment was carried out with the following experimental variables: 1. Fixed Variable Fixed variables are variables that are controlled, made fixed, or constant. The fixed variable in this research is the use of raw materials in making tissue paper, namely young coconut shell waste and cassava peel, which are made constant for each formula. 2. Independent Variable The independent variable is the variable that is subjected to measurement**.** The independent variables in this study were the different solvents (Sodium Hydroxide and Sodium Sulfide) and solvent concentrations (5%, 10%, 15%, 20%, and 25%.

2.1.1. Flowchart of Young Coconut Shell Waste

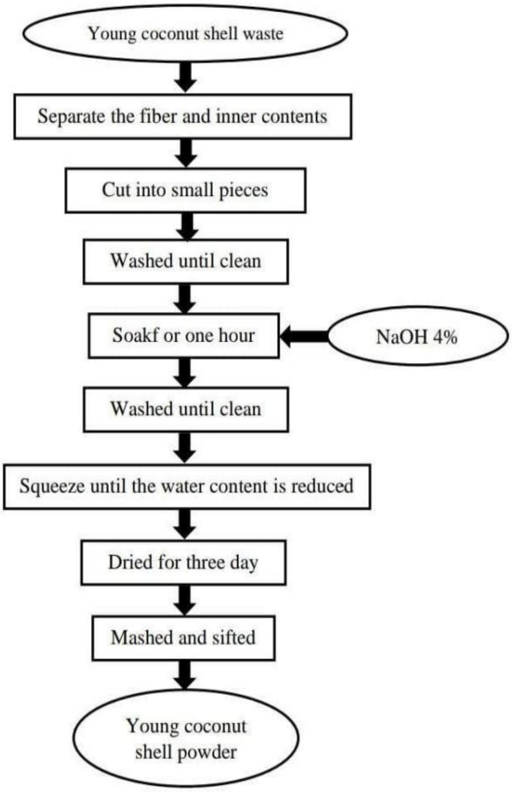

Fig.2.1. Flowchart of Young Coconut Shell Waste

2.1.2. Cassava Peel Waste Flow Diagram

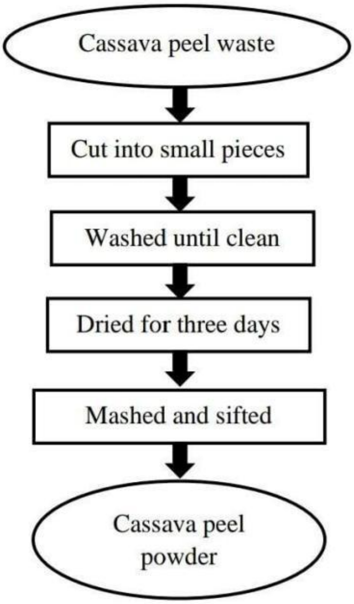

Fig. 2.2. Cassava Peel Waste Flow Diagram

2.1.3. Tissue Manufacturing Flow Chart

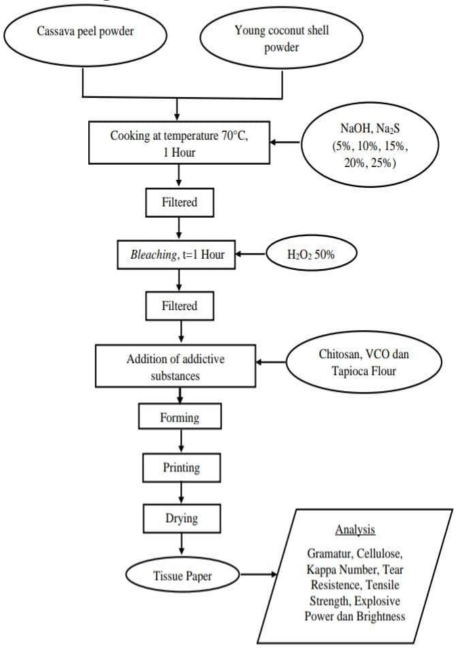

Fig. 2.3. Tissue Manufacturing Flow Chart

3. RESULTS AND DISCUSSION

3.1. Results

From the research that has been carried out and the test results from pulp into tissue type paper products, the following data were obtained:

Table 3.1. Cellulose and lignin content of tissue products using various concentrations of NAOH and Na_2S as solvents

Solvent (%)	Solvent	α Cellulose (%)	ϒ Cellulose (%)	β Celluose (%)	Kappa Number (%)
5		64,47	14,94	20,59	43,50
10		67,21	13,84	18,95	39,84
15	NaOH	67,21	13,11	19,68	37,73
20		68,12	12,01	19,87	10,90
25		69,95	11,28	18,77	3,490
5		63,55	16,03	20,42	69,15
10		64,47	16,03	19,50	45,67
15	Na2s	64,47	16,40	19,13	16,53
20		66,29	16,76	16,95	13,54
25		67,21	16,76	16,03	7,020
SNI			**40**		**25**

Table 3.2. Physical properties of tissue products using various concentrations of NAOH and Na_2S as solvents

Solvent (%)	Solvent	Grammar (gr/m^2)	Resilience Torn (mN)	Power Pull (N/m)	Power Explosion (kgf/cm2)	Brightness (%ISO)
5		31,11	564,57	25,29	1,64	65,90
10		24,30	661,30	29,62	2,02	71,90
15	NaOH	20,30	586,40	26,27	2,36	77,30
20		21,20	561,50	25,15	2,12	77,80
25		13,00	343,38	15,38	3,23	83,40
5		14,00	850,28	38,09	3,71	68,50

10		13,90	963,45	43,16	3,66	68,90
15	Na_2S	12,80	1046,25	46,87	3,67	69,00
20		15,30	1167,05	52,28	2,74	69,10
25		13,40	1443,58	64,67	2,91	78,20
SNI		**14,00**	**392,00**	**130,00**	**2-10**	**80-90**

3.2 Discussion In this research

The effect of variations in solvent type and solvent concentration in making tissue paper from young coconut shell and cassava shell waste consists of several parameters, including: 1. The influence of variations in solvent type and solvent concentration on grammage.

The results of testing the effect of varying solvent types and solvent concentrations on the gram on tissue paper can be seen in Figure 4.1.

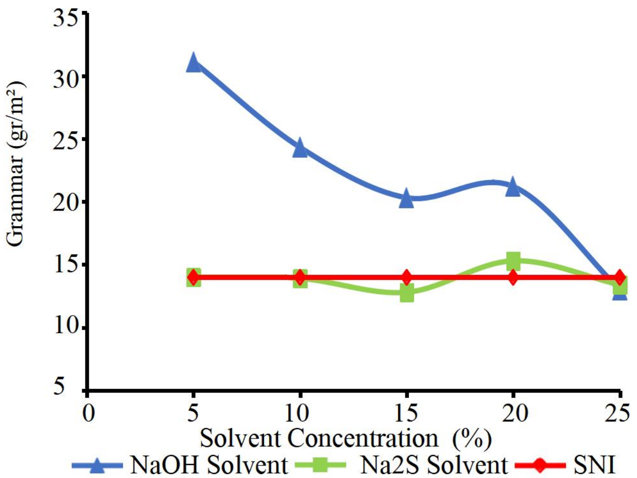

Fig. 3.1. Graph of the Effect of Varying Solvent Types and

Based on Figure 3.1, it can be seen that the grammage for various types of cooking solvents, namely Sodium Hydroxide and Sodium Sulfide, with varying concentrations of 5%, 10%, 15%, 20%, and 25%, is optimal; namely, the 25% concentration of Sodium Hydroxide solvent has a value of 13 gr/m2, and the Sodium Sulfide solvent's 15% concentration is worth 12.8 gr/m2. Based on [11] standard, it is determined that the optimal type of solvent and solvent concentration, namely sodium hydroxide with a concentration of 25%, produces a gram value of 13 gr/m2.

Effect of Varying Solvent Types and Solvent Concentrations on Cellulose Content Cellulose analysis is divided into three types, namely Alpha Cellulose, Beta Cellulose, and Gamma Cellulose. a. Alpha Cellulose The results of testing the effect of variations in solvent type and solvent concentration on the alpha-cellulose content in tissue paper can be seen in Figure 11.

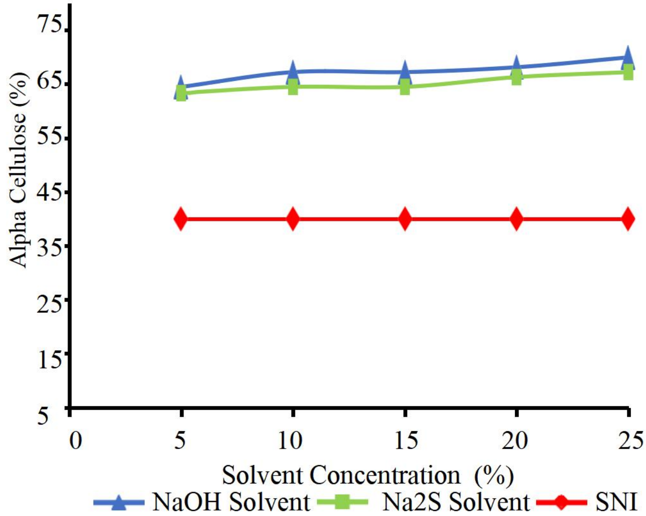

Fig. 3.2. Graph of the Effect of Varying Solvent Types and Solvent Concentration

Based on the Alpha Cellulose Content Based on Figure 3.2. it can be seen, the value of Alpha Cellulose content in various types of cooking solvents, namely Sodium Hydroxide and Sodium Sulfide, with varying concentrations of 5%, 10%, 15%, 20%, and 25%, is optimal, namely in the 25% concentration of the Sodium Hydroxide solvent, the value is 69.95%, and in the Sodium Sulfide solvent, a concentration of 25%, the value is 67.21%. Based on the [18] standard, it is determined that the optimal type of solvent and solvent concentration is sodium hydroxide with a concentration of 25%, and the alpha-cellulose content value is 69.95%.

The results of testing variations in solvent type and solvent concentration on the Betha Cellulose content in tissue paper are shown in Figure 12.

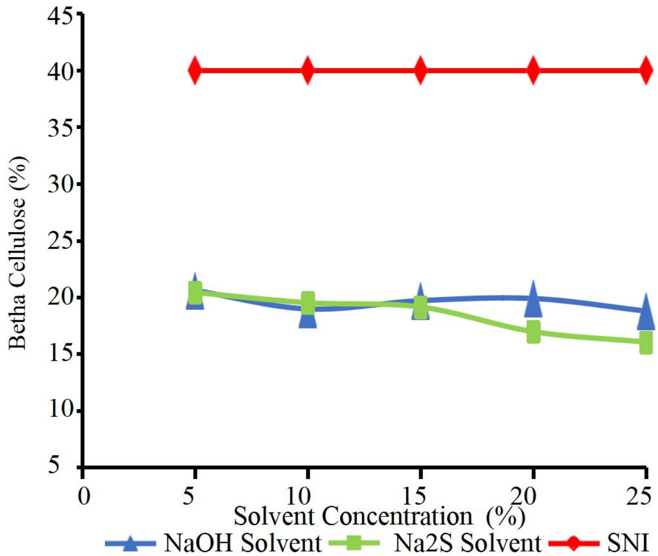

Fig. 3.3. Graph of the Effect of Varying Solvent

Types and Solvent Concentrations on the Beta Cellulose Content Based on Figure 3.3, it can be seen that the value of Betha Cellulose content in various types of cooking solvents, namely Sodium Hydroxide and Sodium Sulfide with varying concentrations of 5%, 10%, 15%, 20%, and 25%, is optimal, namely in the 5% concentration of Sodium Hydroxide the value is 20, 59%, and Sodium Sulfide solvent with a concentration of 25% is worth 20.42%. Based on the [18] standard, it is determined that the optimal type of solvent and solvent concentration, namely sodium hydroxide with a concentration of 25%, produces a beta-cellulose content value of 18.77%.

a. Gamma Cellulose

Test results of variations in solvent type and solvent concentration on content Gamma Cellulose on tissue paper is shown in Figure 13.

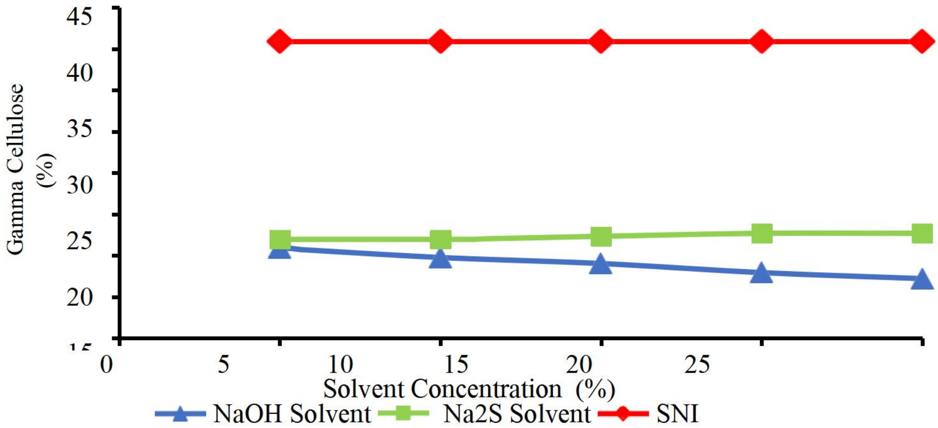

Fig. 3.4. Graph of the Effect of Varying Solvent Types and Solvent Concentrations on the Gamma Cellulose Content

From figure 3.4, it can be seen that the value of gamma cellulose content in various types of cooking solvents, namely Sodium Hydroxide and Sodium Sulfide with varying concentrations of 5%, 10%, 15%, 20%, and 25%, is optimal, namely in the 5% concentration of Sodium Hydroxide the value is 14, 94%, and Sodium Sulfide solvent with a concentration of 25% is worth 16.76%. Based on the [18] standard, it is determined that the optimal type of solvent and solvent concentration are With a concentration of 25% sodium hydroxide, the gamma cellulose content value was 11.28%.

Effect of Varying Solvent Types and Solvent Concentrations on Lignin Content (Kappa Number) The results of testing the effect of solvent type and concentration on the lignin content in tissue paper are shown in Figure 13.

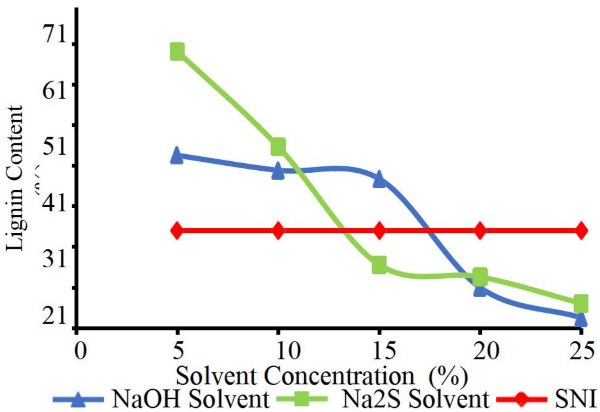

Fig. 3.5. Graph of the Effect of Varying Solvent Types and Solvent Concentration Regarding Lignin Content

Based on Figure 3.5, it can be seen that the value of lignin content in various types of cooking solvents, namely Sodium Hydroxide and Sodium Sulfide with varying concentrations of 5%, 10%, 15%, 20%, and 25%, is optimal, namely in the 25% concentration of Sodium Hydroxide solvent the value is 3.49 % and Sodium Sulfide solvent with a concentration of 25% is worth 7.02%. Based on the [18] standard, it is determined that the optimal type of solvent and solvent concentration, namely sodium hydroxide with a concentration of 25%, produces a lignin content value of 3.49%.

Effect of Varying Solvent Types and Solvent Concentrations on Tear Resistance The results of testing the effect of solvent type and solvent concentration on the tear resistance of tissue paper are shown in Figure 4.6.

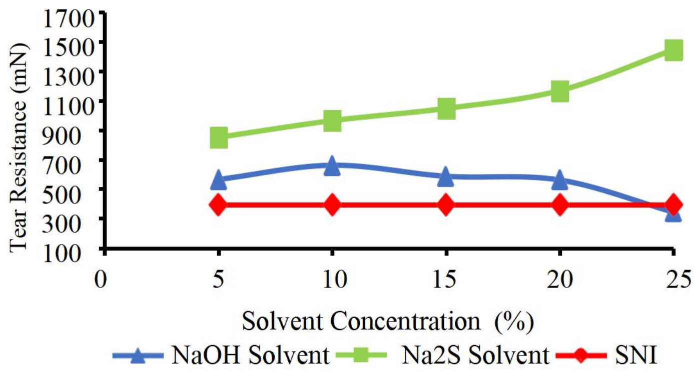

Fig. 3.6. Graph of the Effect of Varying Solvent Type and Solvent Concentration To Tear Resistance

Based on Figure 3.6, it can be seen that the tear resistance value for various types of cooking solvents, namely Sodium Hydroxide and Sodium Sulfide, with varying concentrations of 5%, 10%, 15%, 20%, and 25%, is optimal, namely for the 25% concentration of Sodium Hydroxide solvent, the value is 343.38. M N. Based on the [18] standard, it is determined that the optimal type of solvent and solvent concentration, namely 25% concentration of sodium hydroxide, produces a tear resistance value of 343.38 mN.Effect of Varying Solvent Type and Solvent Concentration on Breaking Length. Test results on the effect of variations in solvent type and solvent concentration on the tensile strength of tissue paper can be seen in Figure 15.

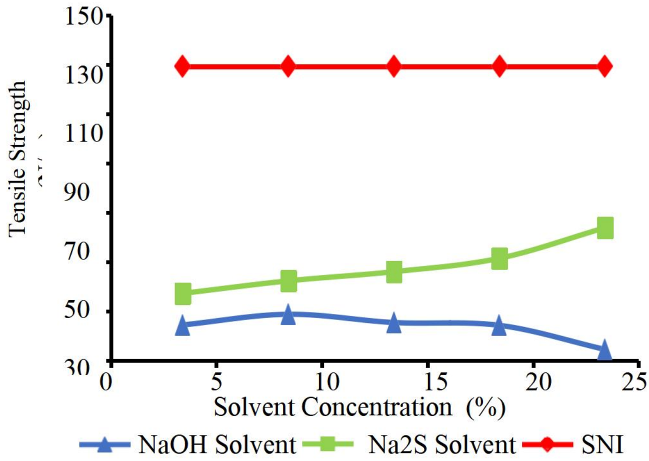

Fig. 3.7. Graph of the Effect of Varying Solvent Type and Solvent Concentration Against Attraction

Based on Figure 3.7, it can be seen that the attractiveness value for various types of cooking solvents, namely sodium hydroxide and sodium sulfide, with concentration variations of 5%, 10%, 15%, 20%, and 25%, is optimal, namely for the sodium solvent. Hydroxide concentration of 25% is 64.67 N/m. Based on the [15] standard, it is determined that the optimal type of solvent and solvent concentration, namely sodium hydroxide with a concentration of 25%, produces a tensile strength value of 64.67 N/m.

Effect of Varying Solvent Types and Solvent Concentration on Explosive Power (Burst Index) The results of testing the effect of variations in solvent type and solvent concentration on the explosive power of tissue paper can be seen in Figure 16.

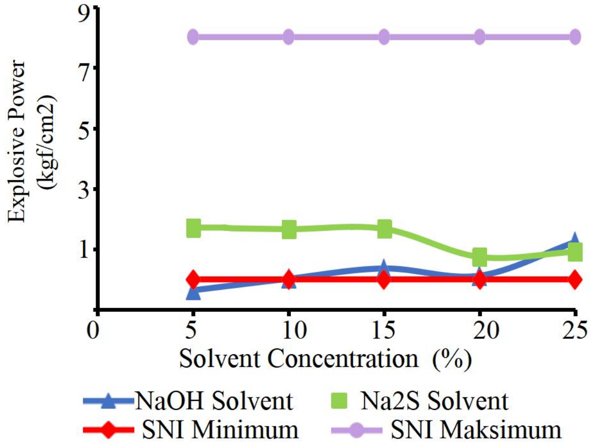

Fig. 3.8. Graph of the Effect of Varying Solvent Type and Solvent Concentration Against Explosive Power

Based on Figure 3.8, it can be seen that the explosive power value for various types of cooking solvents, namely Sodium Hydroxide and Sodium Sulfide, with varying concentrations of 5%, 10%, 15%, 20%, and 25%, is optimal, namely for the 25% concentration of Sodium Hydroxide solvent, the value is 3.23 kgf/cm2. Based on the [15] standard, it is determined that the optimal type of solvent and solvent concentration, namely sodium hydroxide with a concentration of 25%, produces an explosive power value of 3.23 kgf/cm2.

The Effect of Varying Solvent Types and Solvent Concentrations on Brightness, the results of testing the effect of varying types of solvent and solvent concentration on the brightness of tissue paper are shown in Figure 17.

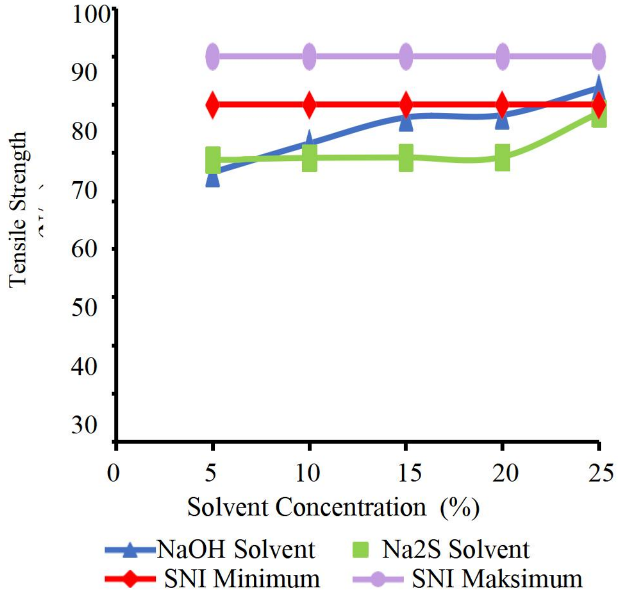

Fig. 3.9. Graph of the Effect of Varying Solvent Type and Solvent Concentration Against Brightness

Based on Figure 3.9, it can be seen that the brightness value for various types of cooking solvents, namely Sodium Hydroxide and Sodium Sulfide with varying concentrations of 5%, 10%, 15%, 20%, and 25%, is optimal, namely for the 25% concentration of Sodium Hydroxide solvent, the value is 83.44%. Based on the [17] standard, it is determined that the optimal type of solvent and solvent concentration, namely sodium hydroxide with a concentration of 25%, produces a brightness value of 83.44%.

Condition of Tissue Paper Product Sheets The results of the condition of tissue paper produced from each variation of solvent and concentration variation can be seen in Figure 18.

Fig. 3.10. Tissue Paper Product Results

On average, tissue paper products produced from each variation of solvent and solvent concentration have a texture that is not too soft, slightly rough, does not have holes, and has a bright white color like tissue in general. The texture is not soft because the addition of virgin coconut oil (VCO) was not optimal. This is in accordance with research [1], which produces tissue with the addition of virgin coconut oil (VCO), which has a maximum soft texture.

4. CONCLUSION

Based on the results of research and observations of the process of making environmentally friendly tissue from young coconut shell waste and cassava peel waste, it can be concluded that: The optimal type of solvent and solvent concentration to produce tissue type paper products from young coconut shell waste and cassava peel waste, namely in a 25% concentration of sodium hydroxide solvent, with a grammage value of 13 gr/m2, Alpha Cellulose content of 69.95%, Beta Cellulose 18.77%, Gamma Cellulose 11.28%, lignin content 3.49%, tear resistance 343.38 mN, tensile strength 15.38 N/m, explosive power 3.23 kgf/cm2 and brightness 83.4% in accordance with SNI standards [15].

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