ISSN 2716-0963
e-ISSN 2716-1218

Advancing the Production of Transparent Solid Soaps with Indonesian Natural Oils

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ABSTRACT

Soap is created by combining sodium or potassium bases with fatty acids derived from vegetable or animal fats. Commonly used fats in soap production include palm oil, coconut oil, soybean oil, and peanut oil. The characteristics of the fatty acid or oil, along with the proportions of caustic soda (NaOH or KOH) and water, play a crucial role in determining the quality of the soap. Transparent soap is a solid soap in the shape of a bar that becomes see-through after the addition of a transparent component. This study developed soap by blending natural oils from Indonesia (coconut oil, palm oil, and *nyamplung* oil (Calophyllum Inophyllum)). In addition, glycerine and a granulated sugar solution were added to the soap. Several tests are used to characterize the soap's properties, such as transparency, water content, foam stability, and hardness. According to the test results, the most clear oil is a blend of 60% palm oil, 25% coconut oil, and 15% *nyamplung* oil, with a sugar-to-glycerine ratio of 1:1. The soap does not satisfy the acceptable standards due to its high water content. Palm oil soap contains the least amount of water, with a sugar-to-glycerine ratio of 3:1 and a water content of 30%. Coconut oil is noted for its stable foam and high hardness. The characteristics and weight of soap are what determine its quality. Palm oil in various ratios, such as 2:1, 1:2, and 1:3, combined with a blend of other oils, can produce a high-quality transparent soap that fits specified requirements.

Keywords: Coconut Oil, Palm Oil, *Nyamplung* Oil, Granulated Sugar, Glycerine.

INTRODUCTION

Soap, in its various forms, continues to hold a significant position in contemporary society and is without a doubt the oldest product to be manufactured specifically as a surfactant. Soap can be classified into two varieties based on its shape: solid soap and liquid soap. Solid soap is classified into three types: translucent, opaque, and transparent [1], [2]. Transparent soap has the advantage of being a humectant, which can help keep the skin from drying out. In addition, transparent soap is a bar-shaped soap with transparent properties and the ability to transmit light in the form of microscopic particles, allowing things behind the soap to be seen clearly up to a distance of 6 cm [3]. This soap is also regarded as a luxury soap due to its moisturizing properties.

Transparent soap can be made utilizing a variety of processes and raw materials. The saponification reaction, which involves the alkaline hydrolysis of triglycerides found in lipids and oils, is used in the production of soaps. The primary components of the oil utilized are animal fat, coconut oil, sebum, or lard [4]. Vegetable oils have become increasingly prevalent in recent years as soap precursors, such as castor oil, safflower oil, or synthetic detergents[4]–[6]. Several chemicals can be added to clear soap to boost its transparency, including ethanol, which is a hydrotropic molecule that increases the soap's?. Aside from that, polyol compounds like glycerine, propylene glycol, sorbitol, or sucrose can increase soap solubility and generate soap crystals that can carry clear structure [7]. The amount and type of transparent ingredients used in the soap determine its transparency. The fatty acid concentration of the raw oil utilized determines the appearance of the transparent, solid soap.

Glycerine is a thick, transparent, colorless, odorless, sweet-tasting liquid with hygroscopic qualities[8]. Glycerine is also known as glycerol. Its chemical formula is $C_3H_8O_3$. Glycerol can be produced as a byproduct of the transesterification, hydrolysis, and saponification of triglycerides or fatty acids. Glycerine can also be produced during the propylene synthesis

ISSN 2716-0963
e-ISSN 2716-1218

process. Granulated sugar is often referred to as sucrose. Sucrose is a disaccharide composed of glucose and fructose monomers with the molecular formula $C_{11}H_{22}O_{11}$[9]. Sucrose is commonly found in cane or beet sugar. Sucrose contains an oxygen acetal bridge with an alpha orientation that holds glucose and fructose together. The chemical structure of glycerine and granulated sugar are shown in Figure 1.

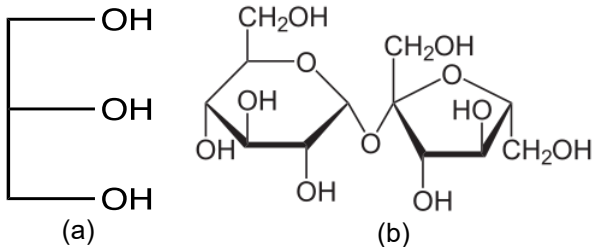


Figure 1. (a) Glycerine and (b) Sucrose

Soap contains two phases: the delta phase and the eta phase. The delta phase is a soap phase made up of soap compositions that are not easily soluble in water, such as long chain fatty acids like palmitic and stearic acid. Meanwhile, the eta phase is a soap phase composed of a soap phase that is readily soluble in water, such as lauric acid and oleic acid [1], [5], [9]. The refraction angles of the delta and eta phases are 1.5 and 1, respectively. As a result, the light that reaches the soap will be in a different phase. Soap with maximum transmission is achieved by lowering the crystal size of the solid soap, minimizing trapped air, and reducing surface roughness.

This study investigated the feasibility of producing transparent soap using authentic oils sourced from Indonesia, specifically *Nyamplung* oil, palm oil, and coconut oil. Varying the proportions of each oil produces a transparent detergent of the highest quality. Sugar (sucrose) and glycerine, which function as transparency agents, were additionally incorporated. A more comprehensive analysis is presented in the subsequent section.

MATERIALS AND METHODS

Materials and Equipments

The ingredients include coconut oil, palm oil, *nyamplung* oil, NaOH, demineralized water, ethanol (96% v/v), glycerine, and granulated sugar. A 500-mL and 250-mL beaker, a mixer, a thermometer, a water bath, a spatula, a stirring rod, a dropper pipette, and a spray bottle are used in the soap production process.

Soap Making Procedure

Raw components used include coconut oil, palm oil, and *nyamplung* oil. Aside from that, the oil mixture was utilized to investigate the influence of the combined oil on the transparent solid soap created. The blended oil is made up of 80% palm oil and 20% coconut oil. Another blend contains 60% palm oil, 25% coconut oil, and 15% *nyamplung* oil. The clear agent employed varies depending on the amount of sugar to glycerine. The ratios of added sugar to glycerine are 2:1, 3:1, 1:2, and 1:3.

The vegetable oil and NaOH, which account for 30% of the total mass, are cooked independently at temperatures ranging from 45 °C to 55 °C. Once the temperature has reached the correct level, add 30% NaOH by mass to the vegetable oil and stir with a mixer for 5 minutes. Add ethanol to the soap stock and mix for an additional 5 minutes. Enclose the beaker with aluminum foil and heat for 2 hours at a temperature range from 70 °C to 80 °C. Add a mixture of glycerine and sugar solution to the soap stock and heat for 15 minutes at 70 °C to 80 °C. The general scheme of soap making is presented in Figure 2.

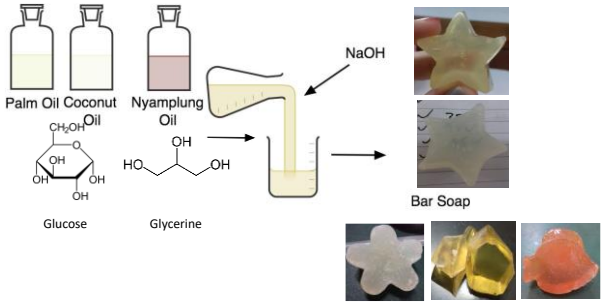


Figure 2. The general scheme of soap making

CHARACTERIZATION

Soap Transparency Test

The transparency test is conducted using a lux meter. A 7 mm-thick soap is placed within an enclosed box that contains a sensor and a light source. A hollow area is created on the surface to aid in the passage of light from the source to the sensor. The sensor monitors the amount of light that passes through the sample. The sample's concentration increases as the number of reads drops, yet its transparency increases as the number of reads grows.

ISSN 2716-0963
e-ISSN 2716-1218

Water Content Test

The quality of transparent soap is mostly determined by its water content. The more water in the soap, the more likely it is that it may shrink and be uncomfortable to use. According to BSN (2016), the water content of soap cannot exceed 15% of its entire mass. The water content of soap can be estimated using Equation 1.

$$\text{Water Content} = (W_1\text{-}W_2) / W \times 100\% \quad (1)$$

W_1 is the initial weight of the sample and cup in grams, W_2 is the weight of the sample and cup after drying in grams, and W is the initial weight of the sample without the cup. The results of this subtraction and division will then be multiplied by 100% to obtain the percentage of water content in the soap.

The addition of ethanol to transparent soap will have a significant influence on the water content and evaporated components in the soap. The more ethanol used in transparent soap, the more components will be evaporated in the transparent soap [10]. The water content analysis was conducted by subjecting the sample to an oven at a precise temperature of 105°C. To calculate the water content lost in the soap, subtract the beginning weight of the sample from its end weight and express the result as a percentage.

Foam Stability Test

Using a mixer, determine the foam's quality and stability. To dissolve soap with a water content of less than 25%, weigh 2 grams and dissolve it in 50 mL of demineralized water at 50°C. Once the soap has dissolved, 300 mL of demineralized water is added. The soap solution was aggressively mixed with a mixer for 2 minutes. Equation 2 calculates foam stability.

$$\text{Foam Stability (\%)} = h' / h_0 \times 100\% \quad (2)$$

Foam stability is the division between the height of the soap after a multiple of 5 minutes (h') and the height of the previous foam (h_0). The quotient is then multiplied by 100% to produce the percentage of foam stability.

The foam stability test was carried out by measuring the weight of 2 grams of soap and then dissolving it in 350 mL of water until completely dissolved. After the soap has completely dissolved, stir it with a mixer for 2 minutes to create a frothy foam. Stability was evaluated every 5 minutes for 15 minutes.

Soap Hardness Test

Soap hardness is determined with a hardness tester. The test is performed by placing the sample under a hardness tester and applying a particular amount of pressure to the tool tip against the sample surface. Press the control button, and the penetrometer will penetrate the soap for 5 seconds[11]. Pressure depth data is collected, measurements are performed at three separate places, and the results are averaged. Soap hardness is calculated by equation 3.

$$\text{Soap Hardness (mm/sec)} = (0.1 \text{ mm} \times h) / t \quad (3)$$

Soap hardness is calculated by multiplying the pressure depth (h) by 0.1 mm and then dividing by the pressing time of the solid soap. After that, the hardness of the soap is obtained in mm/sec. A penetrometer is used to conduct the soap hardness test. Place a soap sample on the base. A 90° conical probe is used to determine soap hardness. The test results are displayed as a graph of the F function in kilograms against time.

Results and Discussion

Transparency Test

Figure 3 displays the highest transparency value of soap resulting from the transparency test conducted on oil with the addition of the transparent agent sugar to glycerine. The mixed oil, composed of 60% mass palm oil, 25% mass coconut oil, and 15% mass *nyamplung* oil, exhibits the highest transparency value.

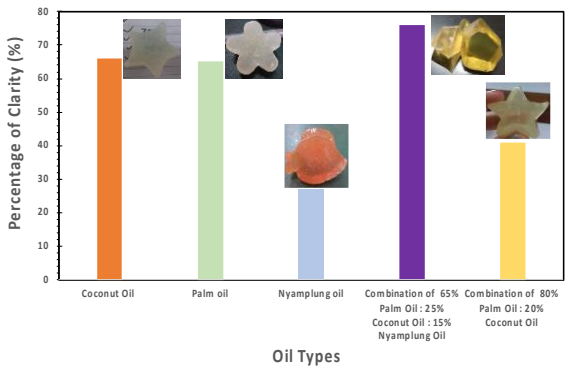


Figure 3. Effect of oil type on soap transparency

The soap manufactured from raw *nyamplung* oil has the lowest transparency value because it contains impurities such as tripalmitin, tristearin,

ISSN 2716-0963
e-ISSN 2716-1218

triarachidin, and other unsaponifiable components. These contaminants are present in the raw *nyamplung* oil, which has not been further processed. Therefore, they can reduce the soap's translucency. The oil with a high transparency value is composed of 60% palm oil, 25% coconut oil, and 15% *nyamplung* oil by mass. Coconut oil has 12.8% free fatty acids, while palm oil contains 0.106 to 0.297%. As a result, coconut oil, specifically palm oil, is more transparent than *nyamplung* oil, which has a free fatty acid concentration of 27.21%. An excessive base will neutralize the high quantities of free fatty acids in vegetable oils, resulting in the formation of granules [12]. Particles larger than 200 nm in clear soap can deflect or absorb light that passes through them[10]. The oils with the best soap transparency include palm oil, coconut oil, and *nyamplung* oil.

Water Content Test

Figure 4 depicts the water content in transparent solid soap based on the added sugar-to-glycerine ratios of 1:1, 2:1, 3:1, 1:2, and 1:3. The soap with the highest water content has *nyamplung* oil as the basic ingredient and a sugar-to-glycerine ratio of 1:2. *Nyamplung* oil contains 37.57% oleic acid (C18:1), 26.33% linoleic acid (C18:2), and 19.96% stearic acid (C18). The main part of fatty acids in *nyamplung* oil, the amount of base used, the type of transparent agent, and the amount of free fatty acids in the oil are all things that cause soap made from *nyamplung* oil to have a high water content and a sugar-to-glycerine ratio of 1:2.

Unsaturated fatty acids in *nyamplung* oil, such as oleic acid, can dissolve in water to generate the eta phase. The solubility of oleic acid in water is 0.05 mg/L (Merck, 2019). The quantity of extra base used in *nyamplung* oil is 5.77x AP, suggesting that there may be a side reaction between the free fatty acids in *nyamplung* oil and NaOH, resulting in ester compounds and water. The free fatty acids in raw *nyamplung* oil are 27.21% (Trisnawati and Siswani, 2018). Furthermore, the ability of glycerine to absorb water from its surroundings increases the water content of soap made with *nyamplung* oil as a basic material.

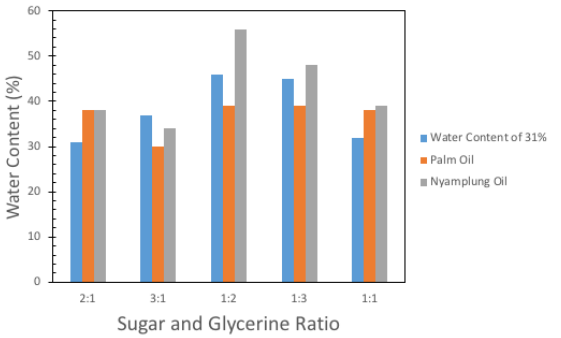


Figure 4. Effect of oil type and transparent agent addition ratio on water content

The soap with the lowest water content is prepared with palm oil as the raw material and a sugar-to-glycerine ratio of 3:1. Palm oil's free fatty acid concentration ranges from 0.106 to 0.297%. Palm oil's side reaction between free fatty acids and excess base produces less water than *nyamplung* oil. Because sugar can readily bind water, the significant amount used in soap reduces its water content (food-info.net, 2019). Sugar is a humectant that reduces a material's water content. The amount of free water released decreases as the humectant utilized increases [13].

Foam Stability Test

The stability of the foam is influenced by the fatty acids in the oil. Saturated fatty acids produce foam with a dense, hard consistency, whereas unsaturated fatty acids moisturize, condition, or nourish the skin[14]. Figure 5 depicts the relationship between oil type and the ratio of transparent agents to foam stability.

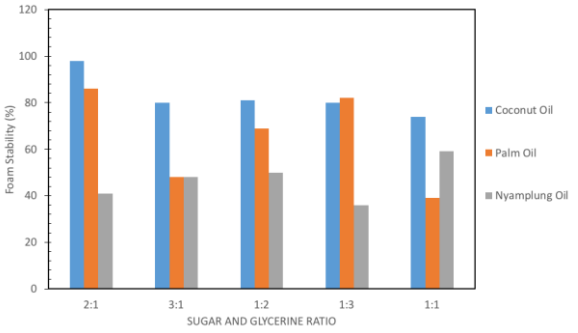


Figure 5. Effect of oil type and Transparent agent addition ratio to foat stability

Coconut oil produces a more stable foam than palm oil and *nyamplung* oil. Oleic acid, the major fatty acid component of coconut oil, has a high detergency and can create and retain foam. Raw

ISSN 2716-0963
e-ISSN 2716-1218

nyamplung oil contains unsaponifiable fatty acids such as tripalmitin, tristearin, triarachidin, and other unsaponifiable components, resulting in a poorer ability to create and stabilize foam than coconut oil and palm oil [10]. Transparent agents, including sugar and glycerine, have do not influence stability because they are not surfactants.

Soap Hardness Test

Soap hardness is defined as the amount of force necessary to modify the shape of the soap[3]. The amount of saturated fatty acids in the soap, as well as the water content, affects its hardness.

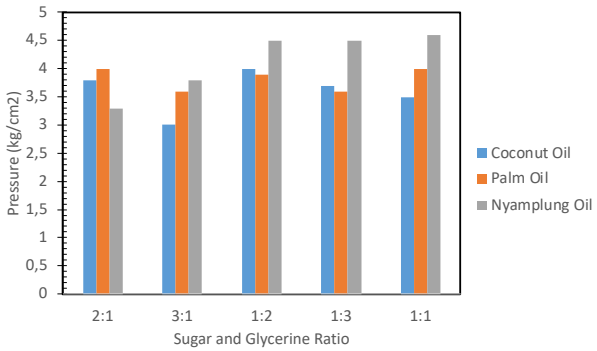


Figure 6. Effect of oil type and transparent agent addition ratio on soap hardness

Figure 6 shows the effect of oil type and transparent agent on soap hardness. The hardest soap is manufactured from coconut oil. Coconut oil's major fatty acids are lauric acid and palmitic acid, both of which are saturated. Coconut oil contains 90% saturated fatty acids, with the remaining 10% unsaturated fatty acids [15]. Saturated fatty acids in oil exceed 98%. Palm oil contains a balanced ratio of saturated and unsaturated fatty acids[16]. Meanwhile, the unsaturated fatty acids in *nyamplung* oil account for 64.58%. The hardness of soap is determined by the unsaturated fatty acids in coconut oil, palm oil, and *nyamplung* oil.

Transparent Solid Soap Weighting

Transparency, water content, foam stability, and soap hardness findings are all weighted. The weighting of transparency demonstrates that the higher the weight value, the more transparent. Water content testing adheres to SNI guidelines, with a maximum soap water content of 15% resulting in the highest weight. Meanwhile, the weight of foam stability, which remains constant throughout the assessment, is the highest. The highest weight for soap hardness is calculated using a normal distribution, with the highest value in the hardness range of 3.5 to 4.5 kg/cm^2.

Table 1. Results of soap quality weighting with variations in raw material types

Sugar and Glycerine Ratio Characteristic	Coconut Oil	Palm Oil	Nyamplung Oil	3 types of oils (65% of palm oil, 25% of coconut oil, 15% of nyamplung oil)	2 types of oils (80% of palm oil, 20% of coconut oil)
2:1	15	16	12		
3:1	15	14	12		
1:2	14	16	9	16	11
1:3	13	17	8		
1:1	12	12	10		

Based on the weighting, transparent soap that has good quality is soap made from palm oil with a ratio of added sugar to glycerine of 2:1, 1:2, 1:3 and mixed oils.

Mapping the Characteristics of Transparent Solid Soap

The soap transparency test was used to map soap features with a homogeneous water content of less than 25%. Figure 7 depicts the results of soap transparency mapping, as well as the ensuing transparency table.

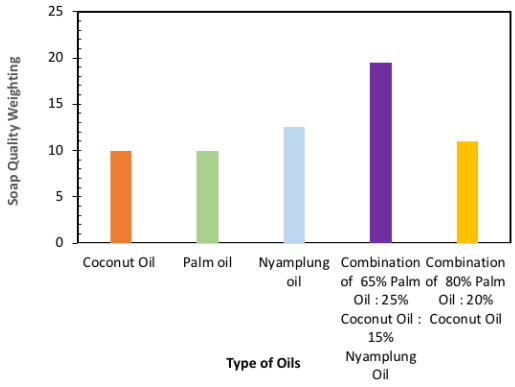


Figure 7. Soap transparency test mapping results

Table 2 shows the transparency of the single oils used, which are coconut oil, palm oil, and *nyamplung* oil. The blended oils presented in the table were measured with a lux meter, whereas the estimated transparency values are based on the transparency figures of the individual oils. The measured mixed oil is less transparent than the mixed oil created from three oils. However, the projected transparency value indicates that the two types of mixed oil are more transparent than the three types of mixed oil. A blend of two oils is more transparent than a mixture of three

oils because palm oil has the highest transparency.

Table 2. Transparent soap test results

Type of Oil	Measured Transparent Value	Predicted Transparent Value
Coconut Oil	11.5	
Palm Oil	21.5	
Nyamplung Oil	9	
2 oils (80% of Palm Oil, 20% of Coconut Oil)	12	19.5
3 oils (65% of palm oil, 25% of coconut oil, 15% of nyamplung oil)	19.5	17.125

CONCLUSION

A blend of oils consisting of 60% palm oil, 25% coconut oil, and 15% *nyamplung* oil by mass, along with palm oil formulations featuring sugar-to-glycerine ratios of 1:2 and 1:3, are optimal raw materials for the production of transparent soap. Palm oil, characterized by its low water content and a sugar-to-glycerine ratio of 3:1, contributes effectively to the soap's properties. Additionally, coconut oil is valued for its ability to generate stable foam.

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