Indonesian Journal of Chemical Research

http://ojs3.unpatti.ac.id/index.php/ijcr Indo. J. Chem. Res., 13 (1), 15-22, 2025

Understanding the Impact of Curing Duration on Characteristics of Durian Extract-Based Solid Soap

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Received: January 2025
Received in revised: February 2025
Accepted: May 2025
Available online: May 2025

Abstract

This study aims to understand the effect of curing duration on the characteristics of durian extract-based solid soap. Durian extract-based soap has unique properties that can be affected by the curing process, namely the duration of drying and maturation of the soap after manufacture. In this study, soap was produced using durian extract as the main ingredient, with curing time variations ranging from 2 weeks to 6 weeks. During the curing process, the water content in the soap decreased, and the saponification reaction between alkali and free fatty acids from durian extract took place further. The characteristics of the soap analyzed included hardness, pH, free fatty acid content, and foam durability and quality. The results showed that the soap became more challenging as the curing time increased, with a more stable pH and lower free fatty acid content. In addition, the durability of the soap increased, and the foam quality became more optimal. Longer curing durations were also associated with increased stability and safety of the resulting soap. This study provides new insights into the development of durian extract-based soap. It can be used as a reference to improve the quality of natural soap products through proper curing process management.

Keywords: curing time durian, cold process, soap, solid soap

INTRODUCTION

Solid soap, one of the oldest personal hygiene products, is significant in modern-day skincare and cleaning routines. The growing demand for natural, eco-friendly products has contributed to a resurgence in the popularity of solid soaps (Félix, Araújo, Pires, & Sousa, 2017). Unlike liquid soaps, which often come packaged in plastic containers, solid soaps usually feature minimal or recyclable packaging, making them more sustainable. Solid soaps can be formulated with fewer chemicals, preservatives, and synthetic ingredients, aligning with consumer interest in organic and environmentally-conscious products (Thevamirtha, Balasubramaniyam, Srithayalan, & Selvakumar, 2023). From a functional perspective, solid soaps can provide a deep clean without stripping the skin of natural oils, mainly when made with nourishing ingredients like shea butter, coconut oil, and essential oils. Moreover, artisanal and handcrafted solid soaps are popular for their wide variety of fragrances, textures, and designs, offering aesthetic and functional benefits (Adigun et al., 2019a; Félix et al., 2017).

The use of fruit essences in solid soaps is often linked to their natural antioxidant, vitamin, and mineral content. For example, citrus fruits such as oranges and lemons are known for their high levels of Vitamin C, which is beneficial for brightening the skin and promoting collagen production. Watermelon and berries like blueberries and strawberries contain antioxidants that help protect the skin from environmental damage, while tropical fruits like mango and papaya are known for their moisturizing and exfoliating properties (Adigun et al., 2019b; Aziz, Jumrah, Agustina, Abubakar, & Zulkarnain, 2023; Glaspole, de Leon, Rolland, & O'Hehir, 2007).

Durian essence solid soap is an emerging trend in the natural skincare market, harnessing the unique properties of durian, often called the "king of fruits," for its beneficial effects on the skin. While durian is primarily known for its strong aroma and nutritional value as a tropical fruit, its essence is now being utilized in beauty products, including solid soaps, due to its rich content of vitamins, antioxidants, and moisturizing compounds (Arlofa, Ismiyati, Kosasih, & Fitriyah, 2019; Arrizqiyani, Hidana, & Agesti, 2020). The fruit durian peel also has many potential nutritional values. Durian peel extract contains significant antioxidants, vitamins, natural fats, and oils, providing deep skin hydration. This makes durian-infused soap particularly beneficial for individuals with dry or flaky skin, as it helps restore moisture balance and softens the skin. The fruit's high sulfur content further contributes to its antibacterial properties, making durian peel extract solid soap an effective cleanser for removing impurities and preventing acne (Ahmad et al., 2024; Arlofa et al., 2019; Said, Nuryanti, Tiaradewi, & Ningsih, 2020).

The percentage of durian fruit to the durian flesh is relatively low, which is only 20-35%, seeds are 5-15%, while the skin reaches 60-75% and currently has not been utilized optimally, so that it becomes waste (Amir et al., 2024; Tambun, Haryanto, Alexander, Manurung, & Ritonga, 2024). Meanwhile, waste from the inner durian skin contains tannin, alkaloid, triterpenoid, and flavonoid compounds as antibacterial agents (Tanasale, Sutapa, & Topurtawy, 2015). In addition to being used as solid soap, durian skin can also be used as liquid soap, biopesticide, edible film, and briquettes. The content of the Durian peel can be seen in Table 1.

Table 1. Durian Peel Content

Compound	Functions
Alkaloid	It can inhibit the work of enzymes to synthesize bacterial proteins or serve as an antibacterial.
Tanin	It acts as an antibacterial because it can form complex compounds with proteins through hydrogen bonds.
Flavonoid	It inhibits nucleic acid synthesis, inhibits the function of the cytoplasmic membrane, and inhibits the energy metabolism of bacteria.
Saponin	It has a bitter taste and foams in water.

The cold process method is one of the most traditional and popular ways of making solid soap, prized for producing high-quality, natural bars of soap with rich moisturizing properties. This method involves mixing oils or fats with a lye solution (sodium hydroxide and water) to initiate saponification, transforming fats and oils into soap. Unlike other soap-making processes, the cold process method allows for greater customization in terms of ingredients and additives, making it ideal for artisanal and handcrafted soaps (Jumrah, Abubakar, Agustina, Karneng, & Gusti, 2023). The cold process method produces luxurious, high-quality soap with natural ingredients, and it remains a favorite among artisanal soap makers for its creative flexibility and skin benefits (Nayak N et al., 2024).

Curing time is one of the important parameters in making solid soap using the cold process method. Curing time in solid soap using the cold process method is needed to dry and reach a fully mature condition after saponification (reaction between oil and alkali, such as NaOH). In the cold process, the soap hardens and completes the chemical reactions that occur slowly. The curing time in the cold process generally lasts 4-6 weeks. During this time, the remaining water in the soap will evaporate, and the soap will become more challenging and produce better foam when used. In this article, a study was conducted on the effect of curing time on the properties and characteristics of solid soap with durian skin extract(Prieto Vidal et al., 2018; Sharma, Pradhan, Pandit, & Mohanty, 2022; Warra, Hassan, Gunu, & Jega, 2010).

METHODOLOGY

Materials and Instrumentals

This research was divided into two (2) procedures; the first procedure was to make durian peel extract, then continued with making soap from durian peel extract.

Durian peel (Montong Gunungpati) was collected from a local durian farmer in Gunungpati, Semarang. The collected durian skin was peeled, and the inside of the durian skin (white part) was taken and then cut into thin pieces using a knife. After that, the durian peel was washed using clean water and dried using an oven with a temperature set at 60 °C for 24 hours. The dried durian skin was then mashed using a blender and sieved using a 100-mesh sieve.

Methods

Durian peel essence extraction procedure

100 g of durian skin powder was put into a maceration vessel with 96% ethanol solution with a

ratio of durian peel powder: ethanol of 1:3. The mixture was stirred using a shaker with a stirring speed of 150 rpm for 2 minutes. The maceration results were collected and squeezed using a filter cloth. The filtrate from the squeezing was then evaporated using a rotary evaporator to obtain durian skin extract.

Procedure for making solid soap using the cold process method

80 g of NaOH solution is mixed with 190 g of distilled water by stirring until homogeneous. The solution was left to stand until the temperature was measured to 400 °C. In parallel, coconut, palm, and virgin coconut oil are mixed in the amount according to the variable. The mixture of oil and 30% NaOH solution is mixed at a temperature of 30- 35 °C. Then, add durian skin extract to the mixture to account for as much as 8% of the weight of the mixture (S1). Soap without the addition of durian extract (S0) was also made for comparison. All ingredients were stirred continuously using a hand whisk or blender until they reached trace. After the soap mixture reached trace, the stirring was stopped. The soap mixture was poured into a mold and stored in a cool place (not exposed to direct sunlight) for 48 hours. After that, the soap was removed from the mold, and the curing process was carried out (stored in a dry place with good airflow) for a time according to the variable (14 days, 21 days, 28 days, and 35 days).

Data Analysis

Degree of acidity analysis

1.05 g of soap is put into a 1000 mL measuring flask. Then, 500 mL of distilled water that had been previously boiled or aerated with CO_2-free air at a temperature of 25 °C was added to the measuring flask. The solution was stirred until homogeneous, and then distilled water was added again until it reached the limit mark on the measuring flask. Then, the flask was closed and stirred until homogeneous. After being homogeneous, 100 mL of the solution is poured into a glass beaker. The acidity of the solution is measured by dipping the calibrated pH meter electrode (SNI 3532:2021).

Water content analysis

The petri dish was dried in an oven at 105 °C for 30 minutes (b0) and then weighed using an analytical balance. Then, in the same petri dish, a test sample of 5.05 g was placed. The sample was then heated using an oven at 105ºC for 1 hour. After completion, the sample was cooled using a desiccator until the temperature reached room temperature and then reweighed (b2). The oven and weighing procedures were repeated until a constant weight was obtained. The water content was obtained by calculation using equation (1) (SNI 3532:2021).

$$\text{Water Content}=\frac{b_1\text{-}b_2}{b_1\text{-}b_0}\text{x}100\% \quad (1)$$

Notes:
Water content in % mass fraction units

b_0	:	weight of empty dish (g)
b_1	:	weight of test sample and petri dish before heating (g)
b_2	:	weight of the test sample and the petri dish after heating (g)

Alkali content analysis

As much as 0.01 g of solid soap was dissolved in 200 mL of ethanol solution. The mixture was then heated until all the soap was dissolved. When it was almost boiling, 0.5 mL of 1% phenothrin indicator was added, and then the titration was continued using HCl solution until the red color disappeared. The calculation of alkali content was done using equation (2), (SNI 3532:2021).

$$\text{Alkali Content}=\frac{40\text{x}N\text{x}b}{b}\text{x}100\% \quad (1)$$

Notes:
Free alkali in % mass fraction units

V	:	volume of used HCl (ml)
N	:	normality of using HCl
b	:	weight of test sample (mg)
40	:	the equivalent weight of NaOH

Free fatty acid content

0.01 g of solid soap was dissolved in 200 mL of ethanol solution. The mixture was then heated until all the soap was dissolved. When it was almost boiling, 0.5 mL of 1% phenolphthalein indicator was added, and then the titration was continued using KOH solution until a stable pink color appeared. Calculating free fatty acid levels was carried out using equation (3) (SNI 3532:2021).

$$\text{FFA Content}=\frac{282\text{x}N\text{x}b}{b}\text{x}100\% \quad (1)$$

Notes:
Free fatty acids in % mass fraction units

V	:	volume of used HCl (ml)
N	:	normality of using HCl
b	:	weight of test sample (mg)
282	:	equivalent weight of oleic acid

Soap foam stability analysis

The foam stability test was done by inserting 1 gram of soap into a test tube containing 10 ml of distilled water, and then the container was closed. After that, the test tube was shaken for 20 seconds. The foam that appeared was then measured for height using a ruler. The tube was left for 5 minutes, and then the height of the foam was measured again. The foam height results were then calculated using equation (4) (Hutauruk, Yamlean, and Wiyono, 2020)

$$\text{Foam stability}=\frac{\text{final height of foam}}{\text{initial height of foam}}\text{x}100\% \quad (4)$$

Organoleptic test

An organoleptic test was conducted to determine the characteristics of the soap produced through observations of 10 untrained panelists with parameters that can be seen in Table 2.

Table 2. Organoleptic test parameters

Parameter	Evaluation
Color	Color was assessed by looking at the color produced on the soap
Smell	The evaluation was divided into three categories, namely unscented (if there is no distinctive soap odor), weak aroma (if a distinctive aroma is smelled when brought close to the nose for more than 15 seconds), strong aroma (if a distinctive aroma is smelled when brought close to the nose for no more than 15 seconds).
Texture	The evaluation is based on the texture of the soap formed. There were three categories in this assessment, namely soft (if when held using the hand, the soap has a soft consistency), relatively soft (if when held using the hand, the soap has a consistency between solid and soft), solid (if when held using the hand the soap has a stiff consistency).

RESULTS AND DISCUSSION

In this study, a solid soap product with durian peel extract has been produced. The product from this study is expected to be a commercial product, so it is required to have quality standards according to the standards set by the Indonesian government, as can be seen in Table 3.

Table 3. Solid soap quality standards

No	Parameters	Standard Requirement
1	Water content	Max. 23%
2	pH	6.0-11.0
3	Alkali content	Max. 0.1%
4	Free fatty acid	Max. 2.5%

Effect on the acidity level

The acidity level or pH of solid bath soap is an important parameter used to assess the suitability of soap for use as a bath soap. The degree of acidity of soap is influenced by the saponification process during soap making (Anggarani, Maharani, and Aktawan, 2023). Soap with a high degree of pH level will irritate the skin, while soap that has a low pH level will cause dry skin. The high pH value of soap results from an imperfect hydrolysis reaction in the saponification process. This can be overcome by adding excess fat or oil (Habib et al., 2016). pH measurements were carried out in weeks 2, 3, 4, and 5 because the process of making soap through the cold process takes 2-4 weeks to reach a stable pH.

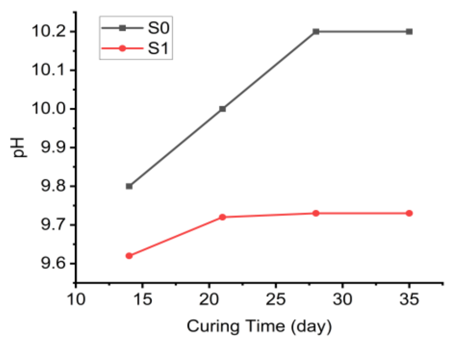

Figure 1. pH level of soap with different curing times

Based on Figure 1, it is known that the longer the curing time, the higher the pH of the soap obtained will increase and reach stability. The curing time of 28 days and 35 days shows that the pH of the soap reaches stability at pH 9.73; this shows that the length of curing time affects the pH value. The addition of durian skin extract causes solid soap to have a lower acidity level (more acidic). This is caused by the organic compounds contained in durian skin. Durian skin contains compounds such as phenolic acids and other organic acids that are acidic. When added to soap, these compounds can lower the pH of the final product. A slightly more acidic pH can increase antibacterial effectiveness because many pathogenic bacteria cannot withstand low pH.

At the beginning of soap making, the pH can be very high due to residual alkali (usually NaOH or KOH). As the curing process progresses, most of the alkali will react and turn into soap, so the pH will decrease and approach a more neutral pH. However, if the curing process takes longer, the pH can rise again due to the influence of residual alkali or the influence of the raw materials used. The optimal curing time is around 4 to 6 weeks when the soap is mature enough and the pH is safer to use.

Basically, solid bath soap made from fat and alkali must have a pH between 9-10. This is because bath soap produced using the cold process method will not be able to reach a normal pH of 7. If the pH of the soap is lowered to 7, the soap will separate back into oil and alkali water. The results of the pH analysis on the products obtained have met the requirements for a safe soap pH, which is in the range of 6 – 11 (Burleson, Butcher, Goodwin, Sharp, & Ruder, 2017).

Effect on moisture content

Water content is a parameter used to assess the shelf life of a product. High water content in soap will trigger a reaction between water and unsaponified fat. This reaction will produce free fatty acids and glycerol, a process called soap hydrolysis during storage. Soap with a very high water content will experience weight loss more quickly, and the amount of water added to the soap will also affect its solubility. The more water added to the soap, the easier the soap will shrink when used. In comparison, soap that has a low water content will increase the shelf life of the soap product (Setiadi, Putri, & Anindia, 2018; Wahyuni, 2021).

Based on Figure 2, it is known that the water content in soap will decrease along with the length of curing time. The curing or maturation process of soap allows the water in the soap to evaporate. The longer the curing time, the more water is lost, making the soap harder and denser. In the early stages of making, solid soap usually contains much water, making it softer. During the curing process, which lasts between 4 to 6 weeks (or more), the water in the soap will evaporate, making the soap texture harder and more durable when used. In addition, this reduced water content also plays a role in improving the quality of the soap because denser soaps generally have more extended durability and better foam quality.

Durian peel extract tends to have a low water content after the extraction process, especially if using extraction methods such as maceration or drying first. Therefore, the addition of this extract does not significantly increase the moisture in the soap formulation. The moisture content of soap is more influenced by the proportion of base ingredients, such as oil (for example, coconut oil or olive oil) and water used in the saponification process, not by additional ingredients such as durian peel extract. With a relatively stable moisture content, solid soap still has a good texture and does not soften easily when used.

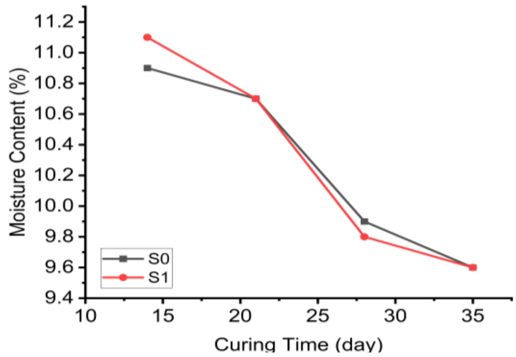

Figure 2. The moisture content of soap with different curing times

The water content value in this research example also shows that most of the soaps analyzed will not support microbial growth. This is because the water content is within the recommended safe value of 10% - 20% from microbes. The results of the water content analysis above have met the requirements for solid bath soap according to SNI 3532:2021, namely with a maximum water content limit of 23%.

Effect on alkali and FFA content

The free alkali content in soap indicates that the oil has been entirely saponified by NaOH, and there is remaining NaOH that cannot be converted into soap. Soap with a lower free alkali content is better for the skin because it does not cause irritation. Free alkali has harsh properties, so soap containing high levels of free alkali can cause skin irritation. It can be seen from Figure 2 that the alkali content in soap, according to curing times of 14, 21, 28, and 35 days, respectively, is 0.1%, 0.05%, 0.02%, and 0.01%.

Meanwhile, FFAs in soap result from incomplete saponification or the breakdown of fats and oils during soap-making. FFAs are unwanted components in the cleaning process. From Figure 2, it can be seen that the longer the curing time, the lower the FFA content. At the beginning of the curing process, the FFA content in the soap was still high and decreased gradually with increasing time. On the 28th day, the FFA content began to stabilize at 2.3%. The longer the curing time of the soap, the free fatty acids (FFAs) content will be. This happens because the saponification process (the reaction between fat or oil with alkali) continues over time.

The results of the study showed that soap containing durian skin extract had a lower FFA content trend when compared to regular soap. Durian skin contains antioxidant compounds such as flavonoids and phenolics that can inhibit fat oxidation. Thus, the process of forming free fatty acids (FFA), which usually occurs due to fat oxidation, becomes slower. Antioxidants in durian skin extract help maintain the stability of fat and oil in soap, thereby reducing the possibility of fat hydrolysis that produces FFA.

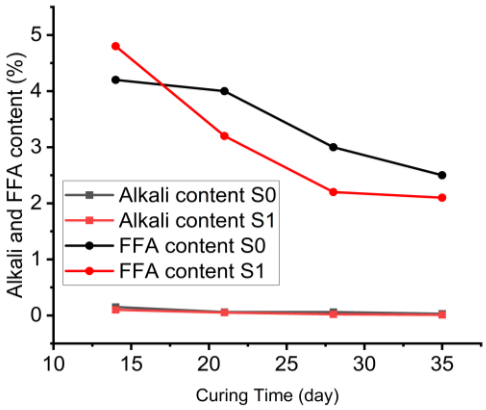

Figure 3. Free fatty acid content of soap with different curing times

According to SNI 3532:2021, the free alkali content in bath soap is a maximum of 0.1%, and the maximum tolerated free fatty acid content in solid bath soap is 2.5%. Based on that reference, the soap produced with curing times of 28 and 35 days met the standards, whereas for 14 and 21 days, it did not meet the standard because the FFA content still exceeded the standard.

Effect on soap Foam stability

Foam is one of the important parameters in determining the quality of soap because the foam in soap lifts fat on the skin. However, an excess amount of foam will make the skin dry and more susceptible to irritation; this happens because the fat on the skin that functions as a skin defense will be lost after being soaped.

Table 4 shows that the longer the curing time, the higher the foam produced. The increase in foam height is relatively stable; this occurs because of the influence of free fatty acids, which decrease the longer curing time. Free fatty acids contained in the soap will inhibit the cleaning power of the soap, which is indicated by the small amount of foam produced. Then, the stability of the foam from durian skin soap is determined by reducing the initial height of the foam and the height of the foam after being left for 5 minutes. Measurements were made because foam stability can indicate the level of effectiveness of the soap's cleaning power, so less stable foam will reduce the level of effectiveness of the soap in terms of cleaning power.

Table 4 also shows that the longer the curing time, the more stable the foam produced. On the 14th day, the foam stability of the durian skin soap was at 85% until on the 28th day, it increased to 91%; the increase in percentage occurred because the foam height increased at each curing time due to the relationship with fatty acids. In addition to free fatty acids, foam stability is also influenced by the saponin content in durian skin, where saponin acts as a natural agent in forming foam.

The addition of durian skin extract to solid soap generally does not affect the stability of the foam. Durian skin extract does not contain active compounds that are surfactants (for example, foaming compounds such as saponins in significant amounts). Therefore, this extract does not directly affect the formation or stability of foam. Foam stability is more influenced by the type and proportion of basic soap ingredients such as coconut oil, olive oil, or sodium lauryl sulfate, which function as foaming agents. As long as the composition of these basic ingredients does not change, the stability of the foam will be relatively the same. Durian skin extract functions more as an antibacterial and antioxidant agent, so its effect is more on skin health benefits than on the physical properties of the foam.

Table 4. Result of soap foam stability test

Curing Time (day)	Initial Soap Foam Height (cm)		Final Soap Foam Height (cm)		Foam stability (%)	
	S0	S1	S0	S1	S0	S1
14	7	6.6	6	5.6	86	85
21	7	6.8	6.3	6	90	87
28	7.3	7	6.6	6.4	90	91
35	7.5	7.1	6.9	6.5	92	91

Organoleptic test of the soap

In organoleptic analysis, untrained panelists were presented with durian skin soap and then visually observed the durian skin soap, including color, texture, and aroma. The appearance of the obtained solid soap can be seen in Figure 4.

Table 5. Organoleptic test result

Curing Time (day)	Color		Smell		Texture	
	S0	S1	S0	S1	S0	S1
14	Light Brown	Brown	Weak	Weak	Soft	Soft
21	Light Brown	Light Brown	Weak	Weak	Solid	Soft
28	Light Brown	Light Brown	Weak	Weak	Solid	Solid
35	Light Brown	Light Brown	Weak	Weak	Solid	Solid

Based on observations by the panelists as it appears in Table 5, the color of the durian skin soap, which was initially brown, changed to light brown along with the length of the curing time; this can happen because the soap begins to solidify. Durian peel soap during curing on days 21 and 14 has a soft texture. During curing on day 14, the inside of the soap still felt soft, while on day 21, the inside of the soap, which was previously soft, began to solidify until, on day 28, the durian skin soap was excellent. On the other hand, the aroma of the durian skin soap did not change from the curing time of 14 days to 28 days; the durian skin soap has a weak aroma with the majority of oil and a little durian extract. In the process of making durian skin soap, there is no addition of essential oils that can add fragrance to the soap, and therefore, the aroma of the durian skin soap is not as strong as the aroma of commercial soaps on the market.

Figure 4. Samples of solid soap

CONCLUSION

This study has produced a solid soap containing durian skin extract. Variations in curing time affect the properties of solid soap. The longer the curing time, the higher the acidity level and the lower the moisture, FFA, and alkali content. Meanwhile, the presence of durian skin extract reduces the acidity level and FFA levels in solid soap. In this study, it was found that soap that met all SNI criteria was produced from curing times of 28 and 35 days.

ACKNOWLEDGMENT

This research was funded by the Faculty of Engineering, Universitas Negeri Semarang, with contract number 159.22.3/UN37/PPK.05/2024.

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