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# Formulation of Lerak Liquid Extract (*Sapindus rarak* DC.) as a Biosurfactant for Facial Soap

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## ABSTRACT

Sodium lauryl sulfate (SLS) and sodium lauryl ester sulfate (SLES) are components that consumers avoid because they cause skin irritation due to the residue left behind. Lerak (*Sapindus rarak* DC) is a natural product with potential as a biosurfactant with a saponin content of 28%. The purpose of this study was to determine the suitability of Lerak extract facial liquid soap with the Indonesian National Standard (SNI) and its physical quality compared to soap products containing SLS and SLES, as well as to determine the panelist's acceptance of the Lerak facial soap through a hedonic test. The extract was prepared by ultrasonic-assisted maceration. The facial soap was made into four 100 ml size formulas with extract percentages of 5% (F1), 15% (F2), 25% (F3), and 35% (F4). Aspects studied included organoleptic, pH, specific gravity, foam stability, and total plate number (TPN), compared with SNI provisions. The hedonic test was conducted on 30 panelists aged 19-35. The results showed that the Lerak extract facial liquid soap met the physical quality standards set out in SNI. There are several differences in pH, specific gravity, and foam stability compared to the comparison soap product. Formula F1 gets the best score for color parameters, and F3 gets the best score for shape, smell, and usability parameters. Lerak fruit has the potential to be developed as a cleaning cosmetic product that is safe for the skin and environmentally friendly.

***Keywords*:** *Sapindus rarak*; Liquid facial soap; Biosurfactant; Sodium lauryl sulfate

## INTRODUCTION

Cosmetics are pharmaceutical preparations that repair, add, or improve aesthetic properties from the outside when a person is in good condition and healthy.[1] Today's cosmetic products have become essential in people's lives. This perception makes people more observant in choosing products, mainly if used in the long term.[2,3]

Puspitasari et al.[4] and Vijayalakshmi & Raman [5] assert that contemporary consumers develop the perception that cosmetic products should deliver positive results in both the short and long term. This notion significantly influences brand perception and trust. As discerning consumers, people are entitled to transparency regarding product composition and the potential effects of consistent usage. Consequently, consumers become more selective in their product choices.

Sodium lauryl sulfate (SLS) and sodium laureth sulfate (SLES) have been commonly utilized as surfactants in cosmetic products, particularly as foaming agents in facial cleansers.[6,7] These ingredients illustrate the widespread usage of surfactants in the cosmetics industry. However, SLS exhibits moderate toxicity,

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manifesting acute adverse effects, including irritation to the skin, eyes, mucous membranes, upper respiratory tract, and stomach. Persistent and extended exposure to diluted solutions may induce skin dryness and fissuring, possibly culminating in the onset of contact dermatitis.[6–9] Although SLES is considered safer than sodium lauryl sulfate SLS, both of these ingredients still pose a risk of skin irritation, mainly if used over a prolonged period.[10] Due to this risk, the more selective consumers tend to avoid products containing either of these substances.[4] In addition to the unfavorable impact on the skin, several studies have demonstrated the detrimental impact of these two ingredients on the environment.[10–13] Consequently, consumers of cosmetic products, increasingly mindful of environmental sustainability, opt for green cosmetic products that exclude using these two ingredients.[3–5]

Lerak (*Sapindus rarak* DC) is a natural ingredient with potential as a biosurfactant.[14,15] The Lerak plant is indigenous to Indonesia [16,17] and is frequently employed by individuals for washing batik cloth to preserve its color integrity.[16,18,19] The seeds of this plant are rich in saponins, and the plant is recognized for its antibacterial properties.[19,20] In previous studies, it was known that Lerak fruit contains 28% saponins[20–22], which foams and acts as a cleaning agent.[20,23] But its feasibility in facial soap cosmetic products is rarely studied. The saponin content found in Lerak is a viable substitute for SLS and SLES within facial cleansing cosmetics due to its antibacterial properties and cleaning efficacy.

The appropriate mixture of constituents in a formulation decides the quality of the resulting product. Consequently, this research aims to establish the ideal concentration of Lerak liquid extract in a liquid facial soap formula that meets the Indonesian National Standard (SNI) for facial soap. The study compared the physical attributes of Lerak fruit liquid extract facial soap to soap products containing SLS and SLES currently available in the market and evaluated panelists' acceptance of Lerak fruit liquid extract facial soap. These findings serve as a basis for assessing the potential of Lerak extract liquid facial soap for further development into a marketable product.

## METHODS

The research conducted is pure laboratory research with the aim of development, namely formulation and comparative study of the use of Lerak extract surfactant in liquid facial soap formulation with SLS and SLES surfactant facial soap products. The physical quality of the Lerak facial soap was evaluated for its suitability with SNI standards.

### Tools and materials

The ingredients used were Lerak fruit (*Sapindus rarak* DC.) obtained from Kulonprogo, Yogyakarta, Central Java. Lerak fruit has been determined at the Characterization Laboratory of the Bali "Eka Karya" Botanical Garden at the National Research and Innovation Agency, with ID number ELSA 95317. Other materials were *Aquadest*, Cocamidopropyl betaine (CAPB) (Evonik, 39.05%), Xanthan gum (Qindao, 80 mesh), Glycerin (Wilmar, 99.8%), Citric acid, Phenoxyethanol (Innosei, 99.5%) and three comparison soap products brand K, C, and P. The code on the comparison soap is intended to censor the original brand of the product. Each soap product has different types of surfactants used. Soap K uses SLS; Soap C uses SLES, while Soap P uses a combination of SLES and Cocamidopropyl betaine.

Tools used include an oven (MEMMERT GmbH+Co.KG, Germany), a mesh sieve 60 (Standard Test Sieve, CV. Total Equipment Pharmacy, Indonesia), a centrifuge (Oregon), sonicator (Elmasonic®), and universal pH indicator (Macherey-Nagel, Germany).

ISSN: 2085-675X (Print)
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**Lerak fruit liquid extraction**

Lerak fruit is dried in the oven at 100°C for 60 minutes. After that, the Lerak fruit was left to stand for three days to dry and then blended into a coarse powder. A 60-mesh sieve is used to sift the coarse powder until a finer powder is obtained. The powder extraction process adopts research from Nafiunisa, Aryanti, and Wardhani[15] with some modifications. The ultrasonic-assisted extraction (UAE) method was used for the extraction process, with a solvent to Lerak fruit dry powder ratio of 1:5 at 50°C for 120 minutes. The extraction results are filtered with filter paper and separated by centrifugation at 4000 rpm for 15 minutes. Centrifuged supernatants are used as liquid extracts for facial soap formulations.

**Testing of saponin content of lerak fruit liquid extract**

Samples of Lerak fruit liquid extract were taken as much as 1 ml, added with water as much as 9 ml, then shaken vigorously to produce foam. The sample is then added with one drop of HCl 2N, let stand, and observe the formation of stable foam on the sample.[24] The sample is declared to contain saponins when a stable foam with a 1-3 cm height is formed for 30 seconds.

**Formulation of lerak fruit liquid extract face soap**

The liquid extract of Lerak fruit is mixed with CAPB (mixture 1), and xanthan gum is mixed with glycerin in different containers (mixture 2). Mixture 2 was added to mixture 1 and stirred until a uniform consistency was obtained.

**Table 1.** Formula of lerak fruit liquid extract facial soap

| Ingredients | Concentration (%) | | | | Function |
|---|---|---|---|---|---|
| | F1 | F2 | F3 | F4 | |
| Lerak fruit extract | 5 | 15 | 25 | 35 | Primary surfactants |
| Phenoxyethanol | 0.5 | 0.5 | 0.5 | 0.5 | Preservatives |
| CAPB | 5 | 5 | 5 | 5 | Foam booster |
| Xanthan gum | 0.3 | 0.3 | 0.3 | 0.3 | Thickening agent |
| Glycerin | 2 | 2 | 2 | 2 | Moisturizer |
| Citric acid | qs | qs | qs | qs | pH balanced |
| Water | ad 100 | ad 100 | ad 100 | ad 100 | Solvent |

Phenoxyethanol is added to the mixture and stirred; then, a 50% citric acid solution is added last. The amount of ingredient concentration in the formula is described in Table 1.

**Quality evaluation of lerak fruit liquid extract face soap**

The quality of Lerak facial soap tested and evaluated for conformity with SNI is organoleptic, pH, specific gravity, foam stability, and total plate number (TPN).

**Organoleptic Test**

The test is carried out by observing the color, smell, and texture of soap using the senses, namely the eyes, skin, and nose.[25]

**pH value test**

The pH value is measured using universal pH indicator paper smeared with a liquid soap sample until the pH paper changes color. The color on the paper is then matched with the color indicator on the instructions to determine the pH value obtained.[25]

**Specific Gravity Test**

Specific gravity is calculated by comparing the mass of Lerak fruit soap ($W_{soap}$) with water mass ($W_{water}$) at the same temperature and volume measured using a pycnometer.[25,26] The formula used is as follows.

$$Specific\ gravity = \frac{Wsoap}{Wwater}$$

**Foam Stability Test**

The sample is taken as much as 1 g and then dissolved with 9 ml of *aquadest* in a test tube and shaken vigorously to produce foam, then measure the height of the foam produced ($T_{initial}$), reshuffle and re-measure the resulting foam ($T_{final}$).[26] The formula used is as follows.

$$\%foam = \frac{T_{initial}}{T_{final}} x100\%$$

**Total Plate Number (TPN)**

The test was carried out by pouring method on Soybean Casein Digest Agar

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ISSN: 2354-8770 (Electronic)

(SCDA) media and then incubated 32.5±2.5°C for 72±6 hours in the reversed position. Successfully bred bacteria are then counted. The test results used are numbers that show the number of mesophyll bacteria in each 1 ml of the product sample.[27]

**Hedonic test of lerak fruit liquid extract face soap**

The hedonic test was carried out on 30 panelists with male and female criteria with a ratio of 1: 1 aged 19-30 years in the Dental and Oral Hospital (RSGM) Saraswati Denpasar, Bali, who were willing to be panelists in this study. The panelists' level of liking for products was measured using the *Likert* scale with a score of 1 to 5. Increasing scores showed an increased liking for Lerak fruit liquid extract facial soap. Four parameters are tested: liking for color, aroma, shape, and comfort.

The questionnaire filled out by the panelists during the hedonic test is then tabulated in the form of a table with the calculation of the scale value multiplied by the number of scales obtained. The formula used is as follows.

$$Total\ score = T\ x\ Likert\ score$$

T = Total number of panelists who assessed
The maximum value determines the Likert scale by multiplying the highest scale value of 5 by the number of panelists so that a maximum value of 150 for 30 panelists is obtained.

The interval is determined by dividing the maximum percentage value (100%) by the number of scales used. The calculated intervals are described in Table 2.

$$Interval = \frac{100\%}{5} = 20\%$$

Intervals are used to interpret the percentage of the calculation score on each hedonic parameter. The score percentage calculation is calculated using the following formula:

$$\%hedonic = \frac{Total\ score}{maximum\ value}\ x\ 100\% \ldots (5)$$

**Table 2.** Likert scale interval

| Hedonic Percentage Interval (%) | Category |
|---|---|
| 0≤ x ≤20 | Very dislike |
| 20< x ≤40 | Dislike |
| 40< x ≤60 | Neutral |
| 60< x ≤80 | Like |
| 80< x ≤100 | Very Like |

**Data analysis**

The data results from the tests that have been carried out are analyzed using the IBM SPSS 25 program. The test method used is a one-way ANOVA test with post hoc LSD if the normality of the data is $p>0.05$ and if the normality of the data is $p<0.05$ using the Kruskal Wallis test with post hoc Mann Whitney.

## RESULTS AND DISCUSSION

Before formulating facial liquid soap from lerak fruit extract, researchers conducted a plant determination test to verify the identity of the studied plant. The results confirmed that the plants in this study belong to the genus and species *Sapindus rarak* De Candole,[28] of the Sapindus varieties found in Indonesia.

The Lerak fruit extraction procedure was carried out based on the research results from Nafiunisa, Aryanti, and Wardhani[15], with modifications to the ratio of the amount of solvent and simplisia used. Based on this research, it is known that the most suitable solvent for extracting saponins that dissolve in polar solvents is water. Supernatants with good saponin content can be done by maceration with a temperature of not less and no more than 50°C because saponins are more easily extracted at 50°C but easily degraded at temperatures more than 50°C. The Saponin content test on Lerak fruit liquid extract showed positive saponins containing stable foam height. This is evidenced by the high percentage of foam measured at 80%. These findings align with the research results of Aryanti et al.[20], Wijayanti et al.[22], and Hawa et al.[14], which concluded that Lerak extract contains positive saponins, as evidenced by

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the formation of stable foam above 80% for no less than 15 minutes.

The quality test of the Lerak facial soaps consists of organoleptic tests, pH, specific weight, total plate number, and foam stability. Physical quality results compared with SNI 06-4085-1996[25] and SNI 4085:2017[29] standards regarding the standard of bath liquid soap. The organoleptic test results show differences in each formula's dosage characteristics (Table 3). The difference in the percentage of Lerak fruit liquid extract in each formula affects the color and odor characteristics in the Lerak fruit liquid extract facial soap.[22,30] The Lerak extract possesses a distinct brown color and odor. Increasing the concentration of Lerak extract from Formula F1 to F4 deepens the preparation's color from faint to solid brown with a gradually more pronounced odor. These results were similar to the research of Nurrosyidah et al., whose preparation is brown due to the presence of Lerak extract.[23] These findings also align with Wijayanti et al., research indicating that products utilizing Lerak fruit extract exhibit a unique color and scent attributed to the fruit's characteristic qualities when fresh and after drying.[22]

The combination of glycerin and xanthan gum as a thickener results in an increase in viscosity. Specific glycerin and xanthan gum ratios cause optimal expansion of the xanthan gum. It will produce a gel mass with suitable viscosity when mixed with water.[7,30,31] Based on this, the organoleptic characteristics of color, odor, and texture of facial soap liquid extract of Lerak fruit produced have met SNI requirements.[7,22,25,30,31]

According to Rippke et al.[32] and Bigliardi[33], the pH level of facial soap plays a crucial role in preventing and suppressing microbial infections in the skin's epidermis and maintaining the skin barrier ecosystem. Soap with a balanced pH level ensures healthy and protected skin.[6] The recommended pH value in skin soap formulations varies according to the purpose and desired result, but generally, it is in the range of 4.5-6, which tends to be acidic. The bacteria's ability to thrive under specific pH conditions is the basis for its proliferation. For instance, *Propionibacterium acnes*, which causes facial acne, can thrive under normal-alkaline pH. Skin with a pH value of 6 has better self-healing potential than that with a pH value of 7 because *Staphylococcus epidermis*, a beneficial microflora found on facial skin, thrives well on acidic skin. The pH level significantly impacts the safety of using soap on the face. pH values below 4, which are highly acidic, can lead to skin irritation in the form of itching and peeling. However, excessively alkaline pH values (>7) may lead to skin dryness, flakiness, and increased susceptibility to bacterial infections.[32,34] The pH test results indicate that all formulas have a pH of 6 (Table 4). This pH value is comparable to the pH value 6 obtained by Wijayanti et al. in their Lerak extract soap preparations.[22] SNI sets the pH range of bath liquid soap 4-10 so that the Lerak fruit liquid extract facial soap follows the physiological pH of the skin and meets pH standards in the SNI range.[29]

**Table 3.** Organoleptic test results and comparison with SNI

| Organoleptic characteristics | SNI | Formula | | | |
|---|---|---|---|---|---|
| | | F1 | F2 | F3 | F4 |
| **Color** | Distinctive | Transparent, slightly yellowish | Transparent, yellowish | Transparent, brownish yellow | Transparent, amber brown |
| **Odor** | Distinctive | Almost odorless | Weak smell | Distinctive, but does not strong smell | The strong, distinctive smell |
| **Shape** | Distinctive | Liquid, slightly viscous | Liquid, slightly viscous | Liquid, slightly viscous | Liquid, viscous |

F1-F4: Dosage formula with the percentage of liquid extract of Lerak fruit respectively 5%, 15%, 25%, and 35%

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The purpose of measuring specific gravity is to determine the effect of ingredients in soap formulations on the final product's weight.[25] The higher the weight fraction present in the facial soap, the greater the specific weight. Similarly, increasing the weight of the raw materials used will correspondingly increase the weight of the soap produced. The specific gravity also affects the density and mass of the facial soap.[35] The specific gravity of facial soap made from Lerak fruit liquid extract differs between formulas, likely due to varying percentages of the extract and other ingredients. Table 4 shows that the F1 and F2 formulas using Lerak extract are near the minimum 1.01 specific gravity requirement, while F3 and F4 are within the acceptable range specified by SNI. Several studies formulating preparations from Lerak extract yielded specific gravity results within the 1.01 to 1.078 g/ml range.[14,22,36]

The total plate number calculates the total bacterial colony in every 1 ml or 1 g of sample tested. The purpose of this test is to see the presence of bacterial contamination in the facial soaps. The total plate number is expressed as the number of bacterial colonies calculated multiplied by the dilution factor.[37] According to Table 4 results, all facial soap formulas have met SNI's total plate number standard. It can be influenced by several things, namely the level of water content, incubation temperature, pH, oxygen concentration, nutritive content, and active substances in the facial soap.[38,39]

Foam stability is one of the additional physical qualities that support the requirements of good soap quality. The foam quality generally ranges from 60-70% to be declared good.[40] The foaming mechanism is to spread on the pore media, then slowly, the mobility drops, and the quality of the foam will increase. The stability of the foam is influenced by the physical and chemical properties of the surfactant in the formulation. The foam has metastable properties, so the foam formed will break sooner or later. What causes the foam to break is the thinning of the foam-forming liquid layer, temperature, and salinity of the solvent used solvent. The type of surfactant, its concentration, the oil content in the formulation, and its interaction with surfactants also affect foam formation and stability.[41] According to Table 4, the foam stability percentage range of F2, F3, and F4 Lerak fruit liquid extract soap can be deemed satisfactory. The higher the concentration of Lerak extract used in the liquid facial soap formula, the more stable the resulting foam percentage. The liquid soap foam stability test from Hawa et al.'s study indicated a similar result that the highest concentration of Lerak extract produced the highest percentage of foam stability. The outcome falls within the average range of 87.35% to 92.15%.[14]

**Table 4.** Physical quality test results and comparison with SNI

| Parameter | Requirement | Formula | | | | Comparison soap | | |
|---|---|---|---|---|---|---|---|---|
| | | F1 | F2 | F3 | F4 | K | C | P |
| pH[25] | 4-10 | 6±0 | 6±0 | 6±0 | 6±0 | 7±0 | 5±0 | 6±0 |
| SG[25] | 1,01-1,10 | 1,003± 0,002 | 1,009± 0,002 | 1,007± 0,002 | 1,014± 0,003 | 1,468± 0,005 | 1,049± 0,013 | 1,377± 1,230 |
| FS[40] | 60-70% | 58,74 ±6,87 | 62,38 ±4,84 | 84,66 ±6,08 | 88 ±3,75 | 92,28 ±0,60 | 79,6 ±1,68 | 81,94 ±2,00 |
| TPN[25] | $<1x10^3$ | $\leq 1x10^1$ | $\leq 1x10^1$ | $2,5x10^2$ | $8,2x10^2$ | N/A | N/A | N/A |

Information:
SG : Specific gravity
FS : Foam stability
TPN : Total plate number
F1-F4 : Formula of the facial soap with a Lerak extract percentage of 5%, 15%, 25%, and 35%
K, C, P : the brand code of comparison soap
N/A means not available.

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The difference in the physical quality of the sample with the comparison soap was analyzed using the post hoc Mann-Whitney test and the post hoc LSD test. It is due to differences in data normality. The data analyzed are the specific gravity and stability of the foam. pH is not analyzed because the data normality test results do not meet the requirements for further tests. Based on these results (Table 5), it is known that all formulas have differences in specific gravity parameters with the comparison soaps.

**Table 5.** The results of determining the difference in physical quality of Lerak facial soap formulas and comparison soaps

| Parameter | Formula | CS | Sig. |
|---|---|---|---|
| Specific gravity | F1 | K | 0.046* |
| | | C | 0.046* |
| | | P | 0.046* |
| | F2 | K | 0.046* |
| | | C | 0.046* |
| | | P | 0.046* |
| | F3 | K | 0.046* |
| | | C | 0.046* |
| | | P | 0.046* |
| | F4 | K | 0.046* |
| | | C | 0.046* |
| | | P | 0.046* |
| Foam stability | F1 | K | 0.000* |
| | | C | 0.000* |
| | | P | 0.000* |
| | F2 | K | 0.000* |
| | | C | 0.000* |
| | | P | 0.000* |
| | F3 | K | 0.047* |
| | | C | 0.172 |
| | | P | 0.450 |
| | F4 | K | 0.242 |
| | | C | 0.031* |
| | | P | 0.106 |

Information:
F1-F4 : The formula of facial soap with a Lerak extract percentage of 5%, 15%, 25% and 35%
CS : Comparison soap (K, C, and P are the brand code for the comparison soap)
(*) : represent significant differences at $p < 0.05$.

In foam stability, it is known that F1 and F2 have differences with the three comparison soaps. However, F3 has no difference with C and P soaps, while F4 has no difference with K and P soaps. K and P soaps have pHs 7 and 5, which differ from the Lerak facial soap. C soap has the same pH value of 6 as the pH of the Lerak facial soap. The difference between the two variables is due to differences in the type of surfactant used and the large concentration in comparison soap products, as well as additional ingredients that can affect physical quality, for example, pH regulators.[38,42]

The results of the hedonic test on 30 panelists can be seen in Table 6. Based on these results, it is known that each formula received a different rating based on each parameter (color, shape, aroma, and comfort when used), with the "like" category being the most interpreted by the panelists. Formula F1 excels in color parameters with very likes (84.64%), while F3 excelled in shape and aroma parameters with the "like" category (78% and 69.33%) and in comfort parameters with the "very like" category (80.67%).

**Table 6.** Percentage of hedonic test results of lerak liquid extract facial soap

| Parameter | Formula | Total | % value | Interval Category |
|---|---|---|---|---|
| Color | F1 | 127 | 84.64 | Very like |
| | F2 | 109 | 72.67 | Like |
| | F3 | 104 | 69.33 | Like |
| | F4 | 87 | 58.00 | Neutral |
| Shape | F1 | 108 | 71.10 | Like |
| | F2 | 106 | 70.67 | Like |
| | F3 | 117 | 78.00 | Like |
| | F4 | 95 | 63.33 | Like |
| Aroma | F1 | 100 | 66.67 | Like |
| | F2 | 93 | 62.00 | Like |
| | F3 | 104 | 69.33 | Like |
| | F4 | 101 | 67.33 | Like |
| Comfort | F1 | 110 | 73.33 | Like |
| | F2 | 104 | 69.33 | Like |
| | F3 | 121 | 80.67 | Very like |
| | F4 | 110 | 73.33 | Like |

The hedonic test showed that the Lerak facial soap's organoleptic characteristics affected the quality assessment and the panelists' perception of the quality. It is reinforced by the statement of Lestari et al.[43] in their research that product quality has significant results in consumer perception in product selection and purchase decisions. This perception was initially influenced by several factors,

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namely cultural, social, personal, and psychological factors.[44]

Skin care cosmetics today have a unique strategy in developing and marketing their products. The strategy is green marketing, which prioritizes sustainable cosmetic products both for users and the environment.[3,45] Lerak is a natural material that fits this strategy because Lerak meets factors that influence consumer perception, both in cultural, social, personal, and psychological factors.[19,46] The assessment results of the panelists may be influenced by their knowledge that soap made with natural ingredients has a better effect than soap made with animal components. This knowledge may then be reinforced by the decision and availability of opportunities to try the product of interest. Majumdar et al.[47] reviewed herbal soaps and their results align with the panelists' assessment in the hedonic test of Lerak facial soap in this study, specifically that herbal soaps are becoming increasingly popular. The popularity of these soaps is due to their skin-friendly and eco-friendly features. Herbal soaps are also environmentally friendly, as they are made with biodegradable components that do not harm the ecosystem. They are cruelty-free, produced without animal products or by-products, which appeals to conscientious consumers seeking compassionate and ethical choices.

## CONCLUSION

The facial soaps of Lerak fruit liquid extracts exhibit distinct pH values, specific gravities, and foam stabilities relative to comparable soaps in the market. Face soap containing 5% Lerak extract concentration (F1) was rated highest for color parameters, while facial soap with 15% Lerak extract concentration (F3) received the best shape, odor, and comfort ratings. The three formulations of Lerak fruit liquid extract facial soap was found to comply with the SNI facial soap requirements. The Lerak fruit has the potential to be developed as a safe and environmentally friendly facial cleansing cosmetic product for the skin.

### Conflict of Interest

The authors declare no conflict of interest.

### Authors' Declaration

The authors hereby declare that the work presented in this article is original and that they will bear any liability for claims relating to the content of this article.

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