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Manufacturing natural soap-base (Multiclean) with the addition of wuluh starfruit extraction (*Averrhoa*)

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A B S T R A C T

Starfruit extract is used as a base for making natural soap that is more environmentally friendly and beneficial for health. The aim of this study is to identify the optimal conditions for adding starfruit extract to natural soap production, which involves citric acid and surfactant components. The method involves maceration and extraction of starfruit to obtain citric acid by immersing it in 80% ethanol. The soap is produced using a hot process at temperatures between 70-80 °C with three formulas: F1 (200:200:10), F2 (225:175:15), and F3 (250:150:20), representing different ratios of virgin coconut oil (VCO), olive oil, and starfruit extract, respectively. Potassium hydroxide (KOH) is used as an alkali at a concentration of 30%. After the soap is made, MES (Methyl Ester Sulfonate) (a plant-based surfactant), sodium citrate ($Na_3C_6H_5O_7$) as a preservative, and sodium bicarbonate ($NaHCO_3$) as a cleanser are added. Testing of the three soap formulas showed they all meet Indonesian National Standards (SNI). Among 20 respondents, F1 was rated the highest in terms of color, scent, and softness. It had 83% foam stability, 0.85% moisture content, a pH of 8, and 0.001% free alkali content. These results suggest that consumer preference is influenced by the starfruit extract content.

1. Introduction

Soap consists of sodium or potassium compounds, which can be fatty acids from vegetable oils or animal fats in solid, soft, or liquid form, and is foam (Yao et al., 2019). The use of soap is very high in households because the use of soap varies depending on the type of furniture. One household needs dish soap, laundry soap, floor cleaner, WC cleaner, and glass cleaner, which raises the cost of purchasing different cleaning soaps (Speiser et al., 2021). The process of making soap involves a saponification reaction, in which the base hydrolyzes fatty acids to produce glycerin and raw soap, which is subsequently reprocessed until it meets the required quality standards for use (Sukeksi et al., 2021). Quality liquid detergents contain one or more types of synthetic surfactants, namely SLS. SLS can cause skin injury if used directly on the skin continuously and for a long period of time (Klimaszewska et al., 2022). The detergent test results showed that marketplace detergents fulfill the standard, but the pH test parameter yielded results that did not match laundry soap quality, and the presence of surfactants could lower a medium's surface tension (Wołowicz et al., 2022). Surfactants have a negative impact on the environment because they are difficult to degrade naturally by microorganisms (Nagtode et al., 2023).

Compared to other vegetable oils like corn, soybean, palm, sunflower, and so on, virgin coconut oil, or virgin coconut oil (VCO), is licenmonitored with the benefits of high molecular weight and saturated fatty acid content (Song et al., 2023). Soap made from VCO has the property of forming foam more easily in large quantities. VCO is a vegetable oil that has highly complex fatty acids and bioactive compounds in the form of minor components (Kurniawati and Paramita, 2023). The softness of the soap is impacted when using olive oil to make a natural soap base (Chandira et al., 2022). Olive oil's high oleic acid content is beneficial for skin health

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(González-Acedo et al., 2023). Olive oil, when made into soap, is considered an effective remedy for dry skin as it helps to remove dead skin cells and moisturize flaky areas (Nuryanah, 2023). Additionally, olive oil can tighten wrinkled skin and lessen scars (Xie et al., 2024). wuluh starfruit or *Averrhoa* has a high citric acid content, so it will be extracted in a natural soap base and used as a mineral binder and deodorizer. Citric acid is a compound that functions as a chelating agent in binding metal ions (Książek, 2023) and can clear the bathtub of dirt, clothing stains, and water purifiers to overcome crusty pots and pans (Kurćubić. et al., 2024). Adding wuluh starfruit can lessen the number of bacteria and colonies on dishes (Nasution et al., 2020). Starfruit has the highest saponin content. Natural surfactant saponin is a compound that is like soap and is a secondary metabolite (Mursaliyeva et al., 2023). SLS is the most widely used ingredient in detergents. Long-term use of SLS continuously can irritate the skin. Because they are biodegradable, have low foaming, and strong detergency, vegetable oil surfactants have the advantage of being more environmentally friendly (Abdurrahman et al., 2023). In soap, MES (Methyl Ester Sulfonate) is a useful vegetable surfactant (Abd Maurad et al., 2020). Methyl Ester Sulfonate is used as a substitute for texapone, which is made from vegetable ingredients and is environmentally friendly. Soap is produced by the saponification process, which is the hydrolysis of fat into fatty acids and glycerol under alkaline conditions (Prieto Vidal et al., 2018). Moreover, depending on the requirements and preferences of the customers, there are additional supporting ingredients such as fragrances, sodium carbonate, sodium phosphate, and others (Mourelle et al., 2024). In this study, research was conducted on a natural soap base made with minimal chemicals to ensure user safety. The recipe includes a specific ratio of starfruit extract, olive oil, and virgin coconut oil (VCO), along with MES as a substitute for synthetic surfactants. The physical, chemical, and sensory properties of the produced natural soap base will be assessed.

2. Methods

This study utilizes the maceration method to extract starfruit using an ethanol solvent. The natural soap base is produced using the hot process method, combining coconut and olive oils with MES, sodium bicarbonate, and citrate. First, wuluh starfruit is cleaned, thinly sliced, and sun-dried to a stable dry weight before being ground into powder, which serves as the sample. For extraction, the starfruit powder is soaked in ethanol for three days, stirred once daily, and then filtered. The extract is concentrated using a rotary evaporator, and the yield is calculated. To prepare the soap base, each ingredient is weighed individually, and coconut and olive oils are blended and heated to 70°C. KOH, diluted with distilled water, is then added to the oils and stirred until traces appear. The pH is monitored using phenolphthalein; if it turns dark pink, the soap is cooked further until it clears, achieving a neutral pH. MES is mixed with the hot starfruit extract, and once the mixture cools to room temperature, diluted sodium bicarbonate and sodium citrate are added.

In the testing phase, foam stability is evaluated by shaking a liquid soap sample in a distilled water-filled tube for 20 seconds and measuring the resulting foam height. The water content is determined gravimetrically by heating a known sample in a drying cabinet at 105°C for two hours. The soap's pH, measured for compliance with SNI standards, is expected to fall within an 8–11 range. Free alkali is assessed by adding phenolphthalein and alcohol to a soap sample and titrating it with HCl until the purple hue vanishes. Finally, organoleptic testing involves visual and sensory evaluations from 15 respondents, who assess the soap's scent, color, foam quantity, and hand softness after use.

3. Results

Making Natural Soap-base (Multiclean) with the addition of starfruit extract (Fig. 1) in different concentrations and using several complementary ingredients, including MES as a surfactant to remove dirt and produce foam in the product, Sodium Citrate ($Na_3C_6H_5O_7$) as a preservative and thickener, Sodium Bicarbonate as a cleanser and foam maker and distilled water as a solvent (Fig. 2).

The prepared materials have undergone several quality tests, such as organoleptic, free alkali, foam stability, pH, and water content tests. The purpose of this test is to ascertain whether the Natural Soap-base (Multiclean) preparation meets the requirements set forth in the established liquid soap standards. Ten grams (F1), fifteen grams (F2), and twenty grams (F3) of starfruit extract were used in this investigation.

Fig. 1: Extraction stage of wuluh starfruit

Fig. 2: Natural soap-base formulation results of F3, F2, and F1, respectively

3.1. Foam stability test

Because the foam content of soap is one of its draws, foam height testing attempts to measure the amount of foam produced. Because too much foam is used in soap, it can irritate the skin. For cleaning products, foam stability and foam formation speed are crucial factors. When used, foam contributes to the cleaning action and gives the soap its scent. It ranges from 60–90% based on good foam stability standards (Fig. 3). The obtained foam stability value exhibits a progressive tendency to increase, as depicted in Fig. 4. These findings demonstrate that more foam is produced in soaps with higher concentrations of starfruit extract. The saponin content of wuluh starfruit plants indicates that these plants have the highest saponin content. Saponins are called natural surfactants because they are soap-like secondary metabolite compounds (Mursaliyeva et al., 2023).

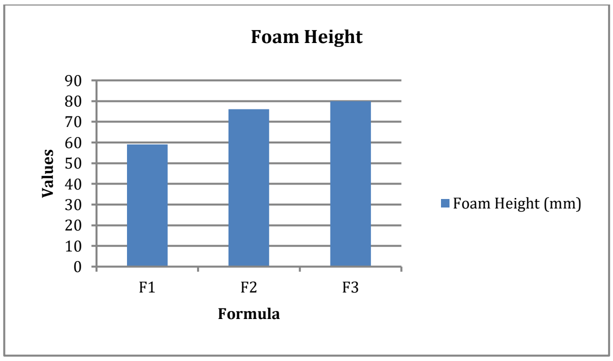

Fig. 3: Graph of foam height values

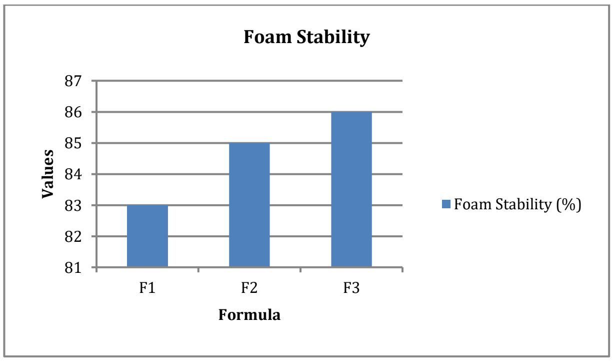

Fig. 4: Graph of foam stability values

It is a common misconception among consumers that high foam production indicates a high-quality soap, even though foam production is not always correlated with cleaning efficacy. The presence of surfactants, foam stabilizers, or soap-active ingredients affects the properties of the foam itself (Zhang et al., 2023). More stable foam is better than less unstable foam. The presence of foaming agents can stabilize foam.

3.1.1. Moisture content test

It is necessary to measure the moisture content of an ingredient because water can have an impact on the final soap's quality (Table 1). According to SNI 06- 3532-1994 testing standards, laundry soap can have a maximum water content of 15%. Fig. 5 illustrates that the percentage of moisture content obtained decreases with increasing extract mass added. Hygroscopic substances like MES are the source of this increased water content. The soap will shrink or run out more easily when used with more water in it (Chirani et al., 2021). The speed and concentration of the mixing have a major impact on the liquid soap's moisture content. This analysis of moisture content is equivalent to the calculation of moisture. It is estimated that when the experiment is run for two hours at 105 °C, the water in the soap evaporates, reducing the amount of water (moisture).

Table 1: Moisture content test results

No.	Sample	Starting weight sample (gr)	Final weight sample (gr)	Water content (%)
1.	F1	1.07	0.16	0.85
2.	F2	1.02	0.30	0.71
3.	F3	1.08	0.38	0.65

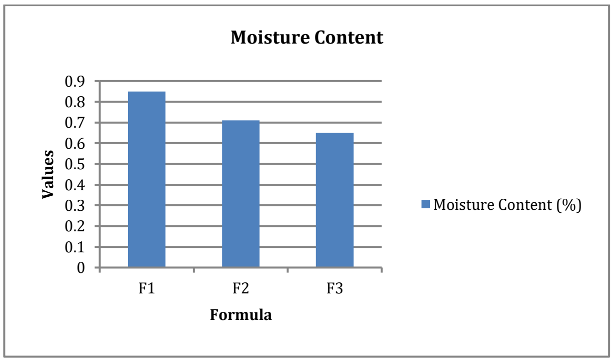

Fig. 5: Graph of moisture content values

3.2. Degree of acidity (pH)

One of the standards for liquid soap quality is the pH test. This is because liquid soap comes into direct touch with the skin and may cause issues if its pH differs from that of the skin. The resulting soap's pH value is still within the range of pH 8–11, which is the range specified by the SNI (Indonesian National Standard) for standard liquid soap that has been set. This means that the soap is safe to apply to the skin because no skin irritation is anticipated at that pH. Starfruit contains acidic compounds, and the average pH value at different concentrations of starfruit extract indicates that the soap's pH tends to decrease or become more acidic (Fig. 6). The more starfruit extract added, the more acidic the soap produced. Although it does not usually cause skin irritation, the pH range of soap between 4 and 10.5 tends to cause changes in skin pH.

3.3. Free alkali content test

Free alkali analysis is a residue that does not react in soap formation. Free alkali tends to decrease due to the length of stirring and due to the water/soap ratio. This is due to the reaction of alkali with fatty acids contained in refined oil, which makes the saponification reaction more perfect, which has an impact on reducing free alkali. The decrease in free alkali is also caused by the ratio of water/soap added because water can reduce the concentration of free alkali in soap. The SNI maximum standard of free alkali content in liquid soap is 0.1% (Table 2).

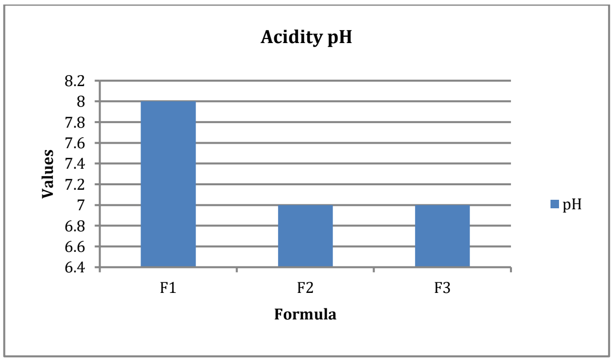

Fig. 6: Graph of acidity degree (pH) values

Excessive alkali content in liquid dish soap formulations can lead to skin irritation and dryness (Fig. 7). This is because surfactants were used in high concentrations. Citric acid can be added to dishwashing liquid soap preparations to achieve SNI-compliant alkali content values, thereby lowering excess alkali levels (Dianursanti et al., 2020). In this study, citric acid was added through the extraction of wuluh starfruit, which has the highest citric acid content, so the free alkali content in natural soap-base is far below the maximum value of 0.1%.

Table 2: Free alkali content test results

No.	Natural formulation soap-base	V HCl (mL)	Alkali content free (%)
1.	F1	1.8	0.01
2.	F2	2.5	0.002
3.	F3	4	0.004

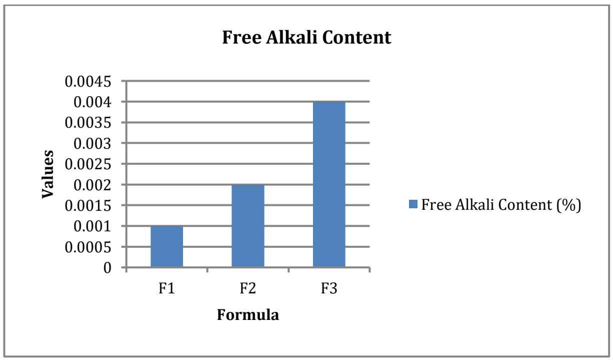

Fig. 7: Graph of free alkali content values

3.4. Organoleptic test color

An ingredient's quality is typically determined by several factors. Taste, texture, color, and nutritional value are some of these components. The color factor will be considered visually before other factors. When selecting an ingredient, color will be considered first. After aroma, color is the most alluring aspect of food or non-food items. Food colorings can boost a product's acceptance among consumers.

Based on the results of the color organoleptic test on 20 respondents, 13 respondents preferred the color of natural soap-base in formula 1, while formula 2 and formula 3 were preferred by 4 respondents each (Fig. 8). This states that the impact of brown color produced from starfruit extraction is mostly disliked by respondents. The more composition of starfruit extraction in the formulation, the lower the respondents' interest in the soap. And vice versa, the lower composition of starfruit extract that does not change the color of the soap has very much interest among respondents.

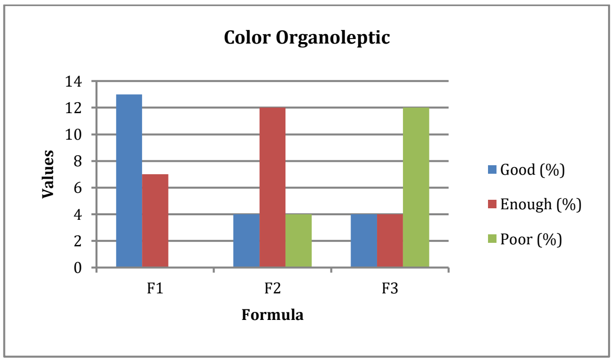

Fig. 8: Color organoleptic test chart

3.5. Aroma organoleptic test

The starfruit extract has an unpleasant aroma, which significantly affects the natural soap base when added (Fig. 9). Essential oils were added to each formula in equal amounts, resulting in varying aromas across samples. Fourteen respondents rated the aroma of formulation 1 positively, while all respondents rated formulation 2 negatively. This indicates that as the amount of starfruit extract increases, the unpleasant aroma becomes stronger, reducing respondents' interest. The essential oil fragrance had a more noticeable effect in formulation 1, which contains the lowest amount of starfruit extract, enhancing its pleasant aroma.

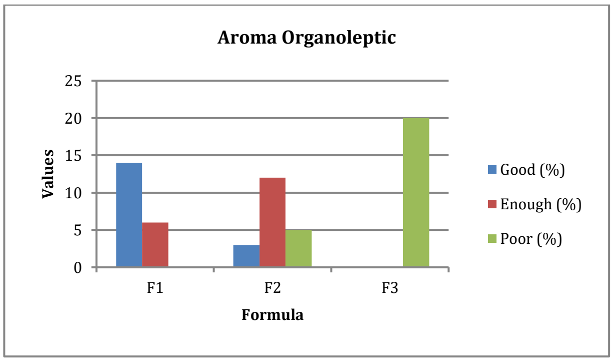

Fig. 9: Aroma organoleptic test chart

3.6. Foam organoleptic test

Foam is the main feature of both liquid and solid soap. The amount of foam produced from soap greatly impacts the level of consumer desire for soap products. Each consumer's opinion also varies on the amount of foam in soap. The organoleptic test of the soap on 20 respondents resulted in Fig. 10.

Based on the results of the physical test for foam stability, it was found that the more wuluh starfruit extract there was in the soap, the more stable the foam. The soap sample has a lot of foam in it as well. According to a graph in Fig. 10, respondents said they preferred soaps with a lot of foam because they believed it would improve the soap's high level of cleaning. The seven respondents who indicated that they preferred soap with a lot of foam scored the lowest because they were aware that a lot of foam could cause their skin to become dry or irritated.

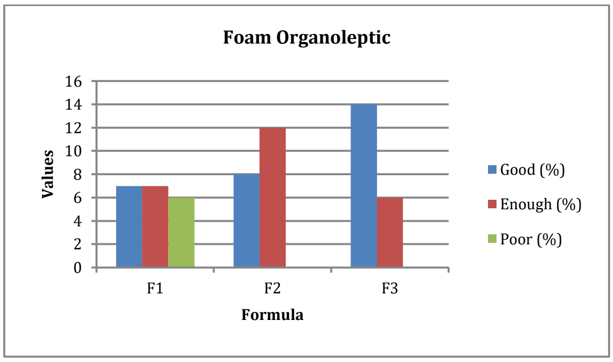

Fig. 10: Foam organoleptic test chart

However, the three sample formulas in this study can be verified as safe because they meet the Indonesian National Standard for foam height and stability percentage, meaning they are suitable for skin irritation-free cleansing.

3.7. Organoleptic test for soap softness

The soap softness test assesses the effect of the natural soap base on hand skin after use. The test results are shown in Fig. 11.

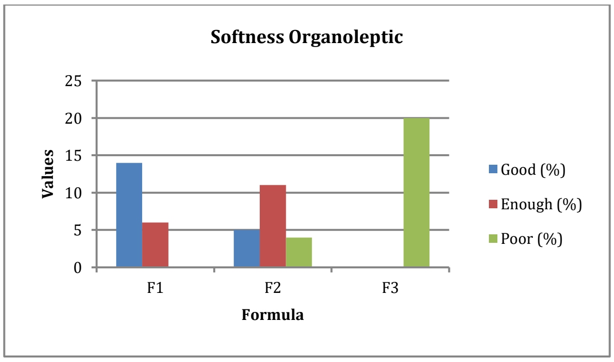

Fig. 11: Organoleptic test for soap softness

Out of all the formulations, Formula 1 was selected by 14 respondents as the most gentle and comfortable for hand skin. This supports the theory regarding olive oil's effect on skin softness after use. Since Formulation 1 contains the most olive oil, this study can conclude that skin softness in natural soap-base users increases with the amount of olive oil in the soap.

4. Conclusion

In research on producing a natural soap base with starfruit extract, three soap formulas were created. Formula 1, containing 200 grams of coconut oil, 200 grams of olive oil, and 10 grams of starfruit extract, has the lowest foam stability at 83% but still meets SNI standards (60–90), the highest water content at 0.85%, a pH of 8, and the lowest free alkali content of 0.001%. Formula 2, with 225 grams of coconut oil, 175 grams of olive oil, and 15 grams of starfruit extract, shows 85% foam stability, 0.71% water content, a pH of 7, and 0.002% free alkali content. Formula 3, composed of 250 grams of coconut oil, 150 grams of olive oil, and 20 grams of starfruit extract, has a foam stability of 86%, the lowest water content at 0.65%, a pH of 7, and a free alkali content of 0.004%. Though the three formulas have varying lab results, all meet SNI standards, allowing an organoleptic test to assess consumer preferences. Among 20 respondents, formula 1 was favored for its color, aroma, and softness, while formula 3 was preferred for its foam production. Future studies could calculate the optimal water amount for each use of the natural soap base and further examine wuluh starfruit extract to achieve the highest saponin content, enhancing foam production.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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