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The Effect of KOH Concentration Variations on the Physical Characteristics of Liquid Dishwashing Soap Made From Tangenore Peel Charcoal (Citrus Reticulata)

Siti Fatimah[1], Salima Aurelia[2]
Chemical Engineering Study Program, Faculty of Engineering, Muhammadiyah Surakarta University
Email: sf120@ums.ac.id, d500220010@student.ums.ac.id

Orange peel waste, which is usually wasted, has great potential as a value-added raw material. Orange peel contains natural compounds with antimicrobial properties and is able to remove oil and dirt, making it an ideal ingredient for soap making. This study examined the effect of varying KOH concentrations on the physical characteristics of liquid dishwashing soap made from tangerine peel charcoal (Citrus reticulata). The charcoal was produced through a carbonization process using varying temperatures (150°C, 175°C, and 200°C). The liquid soap was then formulated with varying KOH concentrations (12%, 14%, and 16%) and tested for physical characteristics including viscosity, organoleptic properties, homogeneity, foam stability, and pH. The results are expected to determine the optimal formulation of high-quality liquid soap and provide innovative solutions for managing organic waste into sustainable, value-added products.
Keywords: Tangerine Peel, Liquid Dishwashing Soap, KOH Concentration

Corresponding Author:
Siti Fatimah
Chemical Engineering Study Program, Faculty of Engineering, Muhammadiyah Surakarta University
sf120@ums.ac.id

1. Introduction

Oranges are a fruit that not only offers health benefits but also offers bright development prospects (UNICEF Report, 2013). In Indonesia, oranges have high commercial value and a large market share, indicating that this commodity is widely consumed and highly competitive. To maintain and enhance this competitiveness, oranges must meet market quality standards, both domestically and internationally, and be well-received by consumers (Pawening et al., 2020).

National orange production showed a significant increase, particularly between 2012 and 2014. In 2012, orange production was recorded at 1,611,768 tons. This figure then increased to 1,644,808 tons in 2013, and continued to rise again in 2014 to 1,926,543 tons. This increase in production reflects the positive development of the citrus agricultural sector in Indonesia. In Indonesia itself, various local citrus varieties are widely cultivated, including tangerines, Siamese oranges, large oranges, limes, sweet oranges, and lemons, each with its own unique advantages and high market demand (Aluhariandu et al., 2016).

Citrus peel waste, which undergoes fermentation and decomposition, can pose environmental problems. However, this waste has significant potential for use in the beverage, cosmetics, and pharmaceutical industries. Besides being abundant and readily available, orange peel is a cheap, renewable biomass source. One way to reduce this waste is by processing it into useful products (Wardhani et al., 2024).

In recent decades, public interest in natural and organic products has increased significantly. This is driven by growing awareness of the risks of synthetic chemicals to human health and their negative impact on the environment. Organic soap is one product that is increasingly in demand, especially among those seeking safer, more environmentally friendly alternatives for daily hygiene needs (Rusdi et al., 2024).

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Soap is essential for hygiene and is a staple household commodity, particularly dishwashing soap and laundry soap. The use of liquid soap continues to increase in line with cultural changes. Liquid soap is preferred due to its practicality, water dissolution, and ease of application. Furthermore, its liquid nature facilitates storage and helps maintain product quality from contamination (Kusmiyati et al., 2024).

Soap is produced through a chemical process called saponification, a hydrolysis reaction of fats or oils that produces fatty acids and glycerol when exposed to alkaline conditions. To create this alkaline condition, chemicals such as sodium hydroxide (NaOH) or potassium hydroxide (KOH) are typically used. When sodium hydroxide (NaOH) is used in the saponification process, the resulting product is a hard or solid soap, often found in bar soap form. Conversely, when potassium hydroxide (KOH) is used, the reaction produces a liquid soap, commonly found in liquid soaps for handwashing, bathing, and dishwashing (Anggraeni et al., 2024).

Variations in KOH concentration affect the physical properties of liquid soap made from tangerine peel (Citrus reticulata) extract, such as viscosity, organoleptic properties, homogeneity, foam stability, and pH. Adjusting the KOH concentration can optimize the soap's quality for effective cleaning. Utilizing tangerine peel also offers an environmentally friendly solution by converting organic waste into value-added products. This research encourages innovation in the development of liquid soap based on natural ingredients.

Based on the above background, this study aims to: (1) Examine the effect of variations in KOH concentration on the physical characteristics of liquid soap made from tangerine peel (Citrus reticulata) charcoal. (2) Determine the optimal KOH concentration formulation to produce liquid soap with the best physical properties, such as viscosity, organoleptic properties, homogeneity, foam stability, and pH.

2. Method

This study used a one-group post-test design. The independent variable was the variation in KOH concentrations of 2%, 3%, and 4%. The dependent variables were the characteristics of liquid dish soap made from tangerine peel charcoal (Citrus reticulata), including viscosity, homogeneity, organoleptic properties, pH, and foam stability. This study aimed to determine the effect of varying KOH concentrations on the quality of the liquid soap and to determine the best formula that meets the Indonesian National Standard (SNI) for liquid soap quality standards.

The tools used in this study included a blender, grater, cutting knife, aluminum foil, analytical balance, spoon, spatula, stirring rod, beaker, measuring cylinder, oven, dropper, 40-mesh sieve, and soap packaging containers. The materials used included tangerine peel, Texapon, sodium sulfate, Camperlan, foam booster, EDTA, glycerin, perfume, KOH, and distilled water. According to Rahmawati et al. (2022), selecting the right tools and materials is crucial in researching cosmetic and liquid soap product formulations to ensure stable and replicable results.

The research process begins with the preparation of raw materials: cleaned tangerine peels, which are then oven-dried at varying temperatures of 150°C, 175°C, and 200°C. This drying process removes water and other volatile compounds, resulting in charcoal. Next, the charcoal is ground using a blender and sieved through a 40-mesh sieve to obtain a homogeneous powder. According to Suryani & Putri (2023), powder sieving is essential to ensure uniform particle size, which affects the consistency and stability of the final product.

The tangerine peel charcoal dish soap manufacturing process involves creating three different formulas based on KOH concentration. The technique begins by weighing the texapon and tangerine peel charcoal, then mixing them with sodium sulfate, stirring until homogeneous, and gradually adding water. Camperlan

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was added while stirring, followed by dissolving KOH in distilled water according to the concentration of each formula. The process continued with the addition of the remaining sodium sulfate, NaCl, foam booster, EDTA, and water, before finally adding the dye, glycerin, and perfume. According to Lestari et al. (2024), gradual addition of ingredients and consistent stirring are important to ensure the homogeneity and stability of the soap formulation.

Testing of the characteristics of liquid soap included organoleptic tests, homogeneity, pH, viscosity, and foam height. The organoleptic test was performed visually on the soap's texture, aroma, and color, while the homogeneity test was performed by observing one gram of sample on a glass slide under light to ensure even color and texture. The pH test was performed by dissolving one gram of sample in 10 mL of distilled water and measuring the pH value using a calibrated pH meter. The viscosity test was conducted by inserting 200 mL of sample into a Brookfield viscometer using spindle number 2, while the foam height test was conducted by dissolving one gram of sample in 10 mL of distilled water, shaking for 20 seconds, and measuring the foam height with a ruler. According to Prasetyo et al. (2021), testing physical properties such as these is important to ensure that liquid soap meets quality standards and can be used optimally.

Data analysis was conducted by comparing organoleptic and homogeneity test results with literature parameters. Data on pH, viscosity, and foam height were analyzed using SPSS version 20. Data normality was tested using the Shapiro-Wilk method. If the data were normally distributed, the analysis continued with a one-way ANOVA to detect significant differences between formulas. If the data were not normally distributed, the Kruskal-Wallis test was used. The analysis results were concluded based on the significance value (p-value) and the data's trend towards expected liquid soap quality indicators. According to Widjaja et al. (2023), this statistical analysis is essential for evaluating the effect of ingredient variations on product quality and supporting the validity of the study.

This research is expected to produce liquid soap with optimal quality and the best KOH formula that meets SNI standards. The use of tangerine peel waste as a raw material shows potential in supporting sustainable organic waste management. The research schedule was carried out in stages, starting with raw material preparation, carbonization, soap making, and testing the soap's physical properties. This was carried out over four consecutive months according to the research time allocation.

3. Result and Discussion

Results

Liquid dishwashing soap formulated with tangerine peel charcoal (Citrus reticulata) has undergone a series of tests to evaluate its quality and physicochemical characteristics. These tests include organoleptic testing to assess appearance, aroma, and color; a homogeneity test to ensure the stability and uniformity of the mixture; a pH test to determine the soap's acidity or alkalinity; a viscosity test to measure the product's thickness; and a foaming test to assess the soap's ability to produce foam when used.

Table 2. Tangerine Peel-Based Dishwashing Soap Formula.

Formula	KOH concentration	Oven Temperature
F1	2%	150°C
F2	2%	175°C
F3	2%	200°C
F4	3%	150°C
F5	3%	175°C
F6	3%	200°C
F7	4%	150°C

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Formula	KOH concentration	Oven Temperature
F8	4%	175°C
F9	4%	200°C

Table 3. Organoleptic Test Results

Formula	Texture	Aroma	Color
F1	Slightly thick	Strong citrus aroma	Orange
F2	Slightly thick	Citrus aroma	A little black
F3	Slightly thick	Weak citrus aroma	Black
F4	Thick	Strong citrus aroma	Orange
F5	Thick	Citrus aroma	A little black
F6	Thick	Weak citrus aroma	Black
F7	Very thick	Strong citrus aroma	Orange
F8	Very thick	Citrus aroma	A little black
F9	Very thick	Weak citrus aroma	Black

Table 4. pH Test Results.

Formula	Average
F1	10,7
F2	10
F3	10,4
F4	11,05
F5	11
F6	10,95
F7	11,65
F8	11,55
F9	11,55

Table 5. Viscosity Test Results

Formula	Average
F1	100
F2	100
F3	105
F4	150
F5	150
F6	142,5
F7	142,5
F8	145
F9	145

Table 6. Foam Height Test Results

Formula	Average
F1	7,2
F2	4,75
F3	7,25
F4	7,35

Formula	Average
F5	5,25
F6	8
F7	7,5
F8	6
F9	8,5

Discussion

Organoleptic Test Results

Organoleptic testing was conducted to assess the physical characteristics of liquid soap based on sensory perception, including texture, aroma, and color, as assessed by a number of respondents using a subjective approach. Based on the test results, formulas F1, F2, and F3 had slightly thick textures. Formulas F4, F5, and F6 had thick textures, while formulas F7, F8, and F9 exhibited very thick textures. These results demonstrate a direct relationship between increasing the KOH concentration in the liquid soap formulation and increasing the product's viscosity. The higher the KOH concentration, the thicker the soap tends to be. This is because KOH, as the primary alkali in the saponification process, influences the formation of the soap's molecular structure, which plays a role in determining the final viscosity of the liquid soap product.

Furthermore, the aroma test for each formula showed quite striking differences. F1, F4, and F7 had a strong citrus aroma that was clearly detected by the panelists, while F2, F5, and F8 exhibited a weak citrus aroma. Meanwhile, F3, F6, and F9 exhibited almost no citrus aroma. This phenomenon can be explained by the presence of activated charcoal from tangerine peel in the formulation, which has a high adsorbent capacity for volatile compounds such as citrus essential oils. As the concentration of charcoal in the formula increases, the adsorption capacity for aroma components also increases, resulting in a decrease in the intensity of the detectable aroma.

The color of the liquid soap also showed consistent changes with increasing temperature and charcoal concentration. Formulas F1, F4, and F7 appeared orange, while F2, F5, and F8 showed a color that began to turn black, and F3, F6, and F9 appeared jet black. The resulting color was influenced by the increasing content of activated charcoal from tangerine peel and the heating process, which can cause degradation of the color compounds and interactions between the charcoal and other components.

From these observations, it can be concluded that variations in KOH concentration play a significant role in influencing the physical (organoleptic) characteristics of liquid soap, including texture, aroma, and color. Table 3 presents a summary of the organoleptic test data for all liquid soap formulas tested.

Homogeneity Test Results

The homogeneity test was conducted to evaluate the uniformity of the liquid soap preparations, specifically to ensure the absence of coarse particles or unevenly mixed phases that could affect stability and ease of use. Visual observation results showed that all liquid dish soap formulas containing tangerine peel charcoal had a homogeneous appearance, with no visible coarse particles or sediment. According to Kindangen et al. (2018), a preparation can be considered homogeneous if all components are thoroughly mixed and no coarse particles are observed upon visual inspection. Therefore, it can be concluded that variations in KOH concentration within the range of 2% to 4% did not significantly affect the physical homogeneity of the resulting liquid soap, as all formulas showed uniform results.

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Figure 2. Homogeneity Test Results

pH Test Results

pH is an important parameter in evaluating the quality of liquid soap because a pH value that is too low or too high can cause skin irritation. Based on the Indonesian National Standard (SNI), liquid soap that is safe for daily use should have a pH value in the range of 8–11. The pH measurement results showed that the pH value for F1 was (10.7); F2 was (10); F3 was (10.4); F4 was (11.05); F5 was (11); F6 was (11.45); F7 was (11.65); F8 was (11.55); and F9 was (11.55). It can be seen that the higher the KOH concentration used, the higher the pH value of the liquid soap. This is because KOH is a strong base that increases the level of OH^- ions in the solution, thereby increasing the pH value of the final product.

The results of data processing using the Two-Way ANOVA Without Replication method. Based on the test results, a significance p-value of 1.92E-05 was obtained for the KOH concentration factor, and a p-value of 0.704 for the heating temperature factor. Since the p-value for KOH concentration was <0.05, it can be interpreted that there is a significant difference in pH in papaya leaf extract liquid soap based on variations in KOH concentration. Conversely, the p-value for temperature was >0.05, indicating that there is no significant difference in pH based on variations in heating temperature. Thus, it can be concluded that KOH concentration has a significant effect on the pH of liquid soap, while heating temperature has no significant effect within the temperature range of 150°C–200°C.

Viscosity Test Results

Viscosity testing aims to determine the flow resistance of liquid soap, which is an important indicator of comfort of use and product quality. Too low a viscosity will make the soap runny, while too high a viscosity can make it difficult for users to remove the product from the container. Based on Table 6, the viscosity test obtained an average of F1 (100 dPa.s); F2 (100 dPa.s); F3 (105 dPa.s); F4 (150 dPa.s); F5 (150 dPa.s); F6 (142.5 dPa.s); F7 (142.5 dPa.s); F8 (145 dPa.s); and F9 (145 dPa.s).

The results of data processing using SPSS (Statistical Product Service Solution) showed that the data were tested using the Two-Way ANOVA Without Replication method. Based on the test results, a significance value of p-value = 0.00042 was obtained for the KOH concentration factor, and p-value = 0.208 for the heating temperature factor. Since the p-value for KOH concentration is <0.05, it can be interpreted that there is a significant difference in the viscosity (or other parameters as appropriate) of the tangerine peel charcoal liquid dish soap based on variations in KOH concentration. Meanwhile, the p-value for temperature >0.05 indicates that there is no significant difference based on variations in heating temperature. Thus, it can be concluded that KOH concentration significantly influences the final liquid soap result, while heating temperatures in the range of 150°C–200°C do not show a significant effect.

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Foam Height Test Results

The foam height test was conducted to determine the volume of foam produced by the liquid soap after shaking. Foam is an important indicator of perceived soap quality, although technically it is not always directly proportional to cleaning effectiveness. The standard foam height for liquid soap ranges from 1.3 to 22 cm (Kasenda et al., 2016). Based on Table 9, the foam height measurement data obtained were average F1 (7.2 cm); F2 (4.75 cm); F3 (7.25 cm); F4 (7.35 cm); F5 (5.25 cm); F6 (8 cm); F7 (7.5 cm); F8 (6 cm); and F9 (8.5 cm).

Data processing using SPSS (Statistical Product Service Solution) showed that the data were tested using the Two-Way ANOVA Without Replication method. The test results yielded a significance value of p-value = 0.009974 for the KOH concentration factor, and p-value = 1.3E-05 for the heating temperature factor. Since both p-values are less than 0.05 ($p < 0.05$), it can be interpreted that there is a significant difference in the pH value of the liquid soap based on the differences in KOH concentration and heating temperature. Thus, both variations in concentration and temperature significantly influence the high-quality foam of the tested tangerine peel charcoal dish soap.

4. Conclusion

The results showed that variations in KOH concentration significantly affected the pH, viscosity, and foam height of liquid soap. The higher the KOH concentration, the thicker the soap, the higher the pH, and the more foam. Texture, aroma, and color were also affected by the combination of KOH and oven temperature, where high temperatures tended to reduce the citrus aroma and darken the color. Homogeneity was not affected because all formulas were homogeneous. The best formula was found at 3–4% KOH and a carbonization temperature of 175°C. This study proves that tangerine peel charcoal can be used as an environmentally friendly and value-added liquid soap additive.

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