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# The Effect of Concentration of Castor Seed Oil and Banana Peel Extract on The Production of Antiseptic Liquid Soap

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ABSTRACT

*Skin health is an important aspect that must be maintained. The skin can protect the body from dirt, bacteria, and pollution. However, it is vulnerable to pathogenic bacterial infections such as Staphylococcus aureus. Natural-based antiseptic soap can help keep skin clean and prevent bacterial infections. Natural compounds such as saponins, flavonoids, tannins, phenols, and alkaloids possess antibacterial properties that can effectively inhibit bacterial growth. These bioactive compounds are found in various plant-based ingredients, including castor oil and banana peel extract. This study conducted four variations of castor oil and banana peel extract concentrations. Formula A contains 100% castor oil, B contains 93% castor oil with 7% banana peel extract, C contains 86% castor oil with 14% banana peel extract, and D contains 79% castor oil with 21% banana peel extract. The antiseptic liquid soap was tested according to SNI 06-4085-2017 standards. This test includes pH, foam stability, viscosity, free alkali and fatty acid, bacterial growth, and specific gravity. The results showed that Formula C was most effective in inhibiting the growth of Staphylococcus aureus. Formula C inhibited bacterial growth with a 7.53 mm inhibition zone diameter, 77.83% bacterial death rate, and 98 × $10^{-6}$ CFU/mL bacterial growth count after soap application. Meanwhile, Formula A only inhibited bacterial growth with a 6.58 mm inhibition zone diameter, 65.93% bacterial death rate, and a 71 × $10^{-6}$ CFU/mL bacterial growth count after soap application.*



## 1. Introduction

The skin protects the body from dirt, bacteria, and pollution [1]. However, it is vulnerable to infection caused by pathogenic bacteria, such as *Staphylococcus aureus*. These bacterial infections can cause irritation, boils, meningitis, and pneumonia [2]. Maintaining skin hygiene is the first step in preventing skin diseases [1]. Soap, especially antiseptic soap, effectively cleans and reduces harmful bacteria on the skin. Antiseptic soap is produced through the saponification reaction of fatty acids with sodium or potassium [3]. Sodium hydroxide will produce solid soap using the cold process at 30–35°C, while potassium hydroxide will produce liquid soap through a hot process at 70–80°C [3].

Commercial soaps often contain synthetic chemicals that cause side effects, especially for individuals with sensitive skin [1]. Research by [4] showed that commercial liquid soaps containing synthetic chemicals could not inhibit the growth of *Staphylococcus aureus*. Synthetic chemicals such as stearic, lauric acid, titanium dioxide, palmitic acid, and sodium lauryl sulfate resulted in a bacterial growth inhibition zone of 0.00 mm [4]. Therefore, developing antiseptic liquid soap from natural ingredients is an alternative way to reduce the synthetic chemicals and prevent the growth of pathogenic bacteria that cause skin diseases [1].

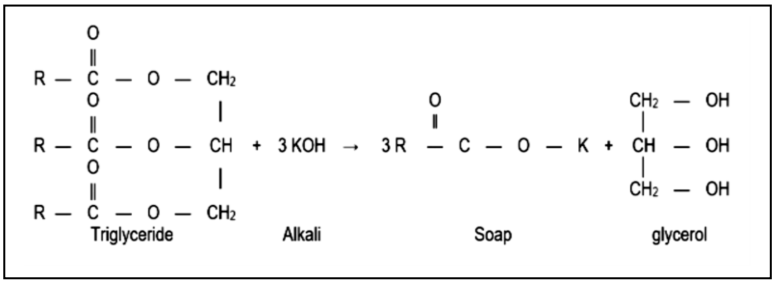


**Fig. 1.** Saponification reaction

Castor seed oil can be used as a raw material for producing liquid soap [5]. Due to the absence of harmful chemicals, castor oil is safe to use. This oil also contains antibacterial compounds such as alkaloids, flavonoids, glycosides, saponins, lectins, and steroids/triterpenoids [6]. A study by [6] showed that liquid soaps made from castor seed oil significantly reduced the growth of *Staphylococcus aureus*. Castor seed oil (*Ricinus communis*) is a triglyceride containing 90% ricinoleic acid, 4% linoleic acid, 3% oleic acid, 1% stearic acid, and less than 1% linolenic acid [5]. The high ricinoleic acid content makes this oil suitable as a cleanser [5].

According to the research [7], banana peel extract can be used as a supporting ingredient in antiseptic liquid soap to inhibit the growth of *Staphylococcus aureus* bacteria. This research used a 100% banana peel extract concentration and showed an inhibition zone diameter of 7.60 mm. Banana peel extract contains alkaloids, saponins, flavonoids, phenols, and tannins, which effectively inhibit the growth of *Staphylococcus aureus* bacteria [2]. This compound can also reduce inflammation and itching, help protect against damage caused by free radicals, reduce acne scars, speed up wound healing, and aid in treating various diseases [8].

Castor seeds and banana peels are often discarded as waste [9]. Therefore, utilizing castor oil and banana peel extract as raw materials for antiseptic liquid soap presents a significant opportunity [10]. Previous research on antiseptic liquid soap formulation typically used only one of these ingredients without combining both, and did not conduct comprehensive testing of the soap product. Moreover, antiseptic liquid soap products made from castor oil and banana peel extract are still hard to find on the market.

This study aims to create an antiseptic liquid soap using castor seed oil and banana peel extract with complete testing according to SNI 06-4085-2017 standards. In addition, this study will evaluate the effect of different concentrations of castor seed oil and banana peel extract on the growth of *Staphylococcus aureus*. The study will include tests for homogeneity, organoleptic properties, pH, viscosity, specific gravity, foam stability, free alkali and fatty acid content, moisture content, and bacterial growth inhibition. By incorporating these concentration variations, the study is expected to develop an antiseptic liquid soap formula that is effective in caring for the skin and preventing the growth of *Staphylococcus aureus*.

## 2. Research Methodology

### 2.1. Materials

In this research, the materials used, banana peels, were purchased from local sellers around the Universitas Muhammadiyah Surakarta, Indonesia. Castor oils were purchased from Lansida Group, Indonesia. The chemicals used in this study, including HCl, KOH, nutrient agar, and phenolphthalein indicator, were purchased from Merck. The other chemicals, such as Coco DEA, foam booster, glycerin, and propylene glycol, were purchased from Cipta Kimia, Central Java Province, Indonesia. This study also used technical ethanol (96% purity, CV. Prima Jaya Indonesia, Indonesia), distilled water (PT. Duta Kaisar Pharmacy, Indonesia), and *Staphylococcus aureus* bacteria (UNS Hospitals, Central Java, Indonesia).

### 2.2. Procedures

*1) Preparation of Raw Materials*

One kilogram of banana peels is thoroughly blended and sieved. Banana peels are macerated using a 96% ethanol solvent at room temperature for a week. During the maceration process, the mixture is stirred once a day, and then the mixture is filtered using filter paper. The macerated filtrate is concentrated using a rotary evaporator at 70°C for 3 hours [9]. Subsequently, a 30% KOH solution is prepared by dissolving 30 grams of KOH in 100 mL of distilled water.

*2) Soap Making*

Heat the castor seed oil to 80°C, then add KOH 30%. After 1.5 hours, add distilled water, glycerine, and propylene glycol. Stir the mixture for 2.5 hours at 400 rpm. Lower the soap temperature to 40°C, then add Coco DEA, foam booster, fragrance, coloring agent, and banana peel extract according to the specified formula. Stir the mixture for 1 hour at 400 rpm. The final step is to store the soap for 24 hours to ensure the soap is homogeneously mixed [6].

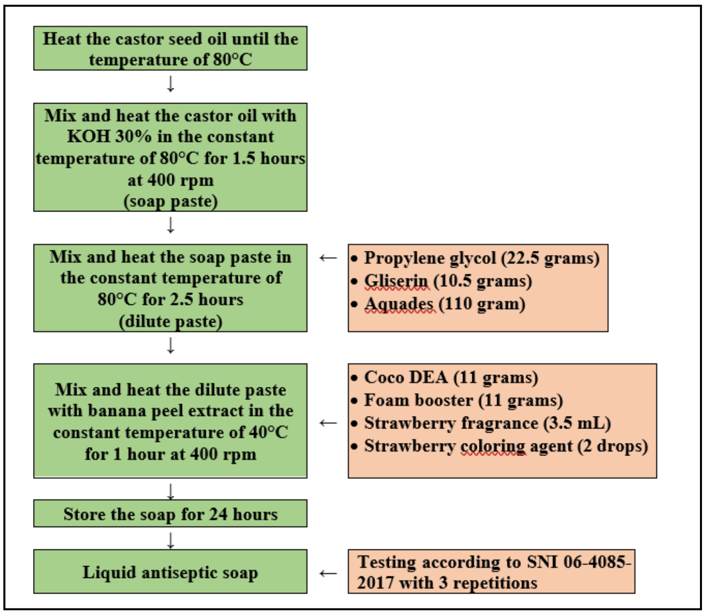


**Fig. 2.**Steps of antiseptic liquid soap making.

**Table 1.** Variations in the concentration of antiseptic liquid soap

| Variations in Concentration | Antiseptic Liquid Soap Formulation | | | |
|---|---|---|---|---|
| | *A (%)* | *B (%)* | *C (%)* | *D (%)* |
| Castor seed oil | 100 | 93 | 86 | 79 |
| Banana Peel Extract | 0 | 7 | 14 | 21 |

*3) Data Analysis of Antiseptic Liquid Soap Standard Test*

Banana peel extract tests include detection of alkaloids, flavonoids, tannins, phenols, saponins, and steroids [9]. The alkaloid detection is tested by adding 0.5 grams of extract with 3 drops of Dragendorff's and Mayer's reagents [9]. Detection of flavonoids is tested by mixing 1 g of extract with 0.05 mg of magnesium and 1 mL of HCl [9].

Detection of tannins is tested by 3 drops of 10% iron(III) chloride are added to 2 mL of the extract Detection of phenols by 2 mL of extract is treated with 3-4 drops of 0.1% iron(III) chloride solution [9]. The detection of saponins is indicated by the stable formation of foam after shaking the mixture of 0.5 grams of extract and 10 mL of hot water [9]. Steroid detection is tested by mixing 2 mL of extract, 2 mL of chloroform, 2 mL of acetic acid, and 1 mL of concentrated sulfuric acid [9].

Antiseptic liquid soap standard tests are based on SNI 06-4085-2017 [3]. The pH test is conducted by dipping a pH meter into the liquid soap solution [10]. The viscosity test for liquid soap is performed using a Rion VT-04 viscometer with rotor number 3 [11]. The moisture content test is conducted by weighing 5 grams of soap and then drying at 105°C for 1 hour [12].

$$Moisture\ content = \frac{\left(W_{after\ drying\ (g)} - W_{before\ drying\ (g)}\right)}{5\ \mathrm{g}} \times 100\% \qquad (1)$$

The specific gravity test is conducted by weighing an empty pycnometer. Pour the distilled water into the pycnometer and weigh it. Repeat the step with antiseptic liquid soap [13].

$$Specific\ gravity = \frac{\left(W_{pycnometer+liquid\ (g)} - W_{empty\ pycnometer\ (g)}\right)}{\text{Volume of pycnometer } (cm^3)} \tag{2}$$

The foam stability test is conducted by shaking 1 gram of liquid soap in 10 mL of distilled water for 20 seconds [13]. After that, the mixture is left undisturbed for 5 minutes [12].

$$Foam\ stability = \frac{\mathrm{H}_{final\ foam\ (mm)}}{\mathrm{H}_{Initial\ foam\ (mm)}} \times 100\% \tag{3}$$

The free alkali and fatty acid test is conducted by mixing 5 grams of soap with 100 mL of 96% alcohol and 3 drops of *phenolphthalein* indicator. Heat it for 30 minutes at 180°C [12]. A pink color indicates the presence of free alkali, and it is titrated with 0.1 N alcoholic HCl solution. If it does not, the solution contains free fatty acid and it is titrated with 0.1 N alcoholic KOH solution [12].

$$Free\ alkali = \frac{Volume\ of\ titrant\ (mL) \times 0.1 \times 0.282}{5\ \text{gram}} \times 100\% \tag{4}$$

$$Free\ fatty\ acid = \frac{Volume\ of\ titrant\ (mL) \times 0.1 \times 0.282}{5\ \text{gram}} \times 100\% \tag{5}$$

The disk diffusion method was used to conduct the total plate count test on bacterial activity. *Staphylococcus aureus* bacteria were diluted and spread on nutrient agar [3]. A disk of paper was soaked in liquid soap and placed on that media after then incubated for 48 hours at 37°C [3].

$$Inhibition\ zone\ (mm) = \frac{(Horizontal\ diameter - disk\ paper) + (Vertical\ diameter - disk\ paper)}{2} \tag{6}$$

The safe limit for bacterial colonies in liquid soap is ≤ $1x10^3$ CFU/mL [3]. The *Staphylococcus aureus* bacteria were cultured and incubated on nutrient agar at 37°C for 24 hours [14]. After that, bacterial growth before and after adding soap is counted [14].

## 3. Results and Discussion

### 3.1. Screening Antibacterial Agent in Banana Peel Extract Result

Phytochemical screening used the maceration method to identify secondary metabolite compounds in banana peel extract [15]. This technique was chosen due to the simplicity of the equipment and does not involve heating, so this method can protect the thermolabile compounds [15]. Ethanol 96% was used as a solvent because it can extract polar compounds such as flavonoids, tannins, phenolics, alkaloids, terpenoids, and steroids [15]. According to Table 2. the test result is consistent with the previous research [9].

**Table 2.** Screening antibacterial agents in banana peel extract results

| Antibacterial Compounds | Result |
|---|---|
| Alkaloids | + |
| Flavonoids | + |
| Tannins | + |
| Phenols | + |
| Saponins | + |
| Steroids | - |

### 3.2. Homogeneity and Organoleptic Test Result

The purpose of the homogeneity test is to ensure raw materials are evenly mixed without component separation, and ensure the quality of the soap remains stable during storage [15], and maintain the consistency of active ingredients and texture [3]. Fig. 3. showed that all soap formulas were homogeneous and had no texture changes.


**Fig. 3.**Results of antiseptic liquid soap products.

The organoleptic test evaluates the soap's visual appearance, aroma, texture, and user impression [3]. Based on texture, observations are made on the viscosity and consistency of the soap [13]. Castor oil and banana peel extract dissolve perfectly in the distilled water, resulting in a consistent product with no significant variation in texture or phase separation. Visually, each formula has differences in color and viscosity caused by variations in the concentration of castor oil and banana peel extract. Castor oil is rich in ricinoleic acid, which contributes to a thick and viscous structure [5]. Lowering the castor oil concentration makes the soap thinner and more transparent. Statistical analysis of user responses confirms that all formulations have an appealing color and scent.

### 3.3. pH Test Result

The pH test determines the acidity or alkalinity of a product [3]. Antiseptic liquid soap that is safe for the skin has a pH range of 4 to 10. Based on these results, the liquid soap can clean the skin without causing irritation, itching, or peeling [3].

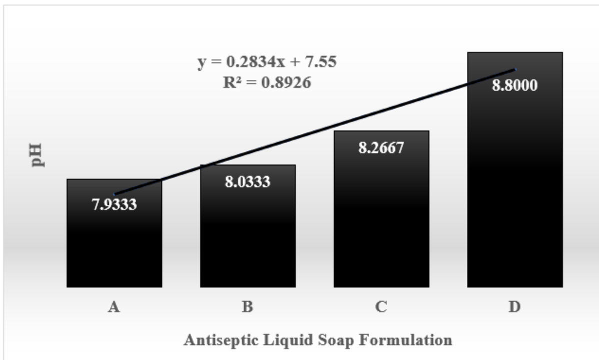


**Fig. 4.** Graph of pH test results for antiseptic liquid soap.

Fig. 4. indicates that the pH of the soap increases linearly as the concentration of castor oil decreases and banana peel extract increases. This trend is represented by the linear equation $y = 0.2834x + 7.55$ with $R^2 = 0.8926$. Banana peel extract contains alkaline alkaloids that raise the pH [15]. However, the increase in pH is not very significant because phenolic compounds in the banana peel extract are acidic, reducing the alkaline effect of excess KOH and alkaloid compounds [12].

### 3.4. Viscosity and Specific Gravity Test Result

Antiseptic liquid soap must have a viscosity between 400 to 4000 cps for effectiveness and longer shelf life [10]. Antiseptic liquid soap also must have a specific gravity of 1.01 to 1.10 g/cm³ to ensure proper consistency and optimal stability [3]. All formulas meet SNI standards, demonstrating sufficient thickness, stability in use, and indicating a well-balanced composition [10].

Fig. 5. indicates that the viscosity and specific gravity of the soap decrease linearly as the concentration of castor oil decreases and banana peel extract increases. Viscosity trend is represented by the linear equation $y = -129x + 1256.7$ and $R^2 = 0.9674$. This trend indicates a strong correlation

between ingredient composition and soap viscosity. The reduced castor seed oil concentration means there is less oil to bind with KOH [3]. The soap becomes thinner when the highly liquid and non-viscous banana peel extract is added, reducing its viscosity.

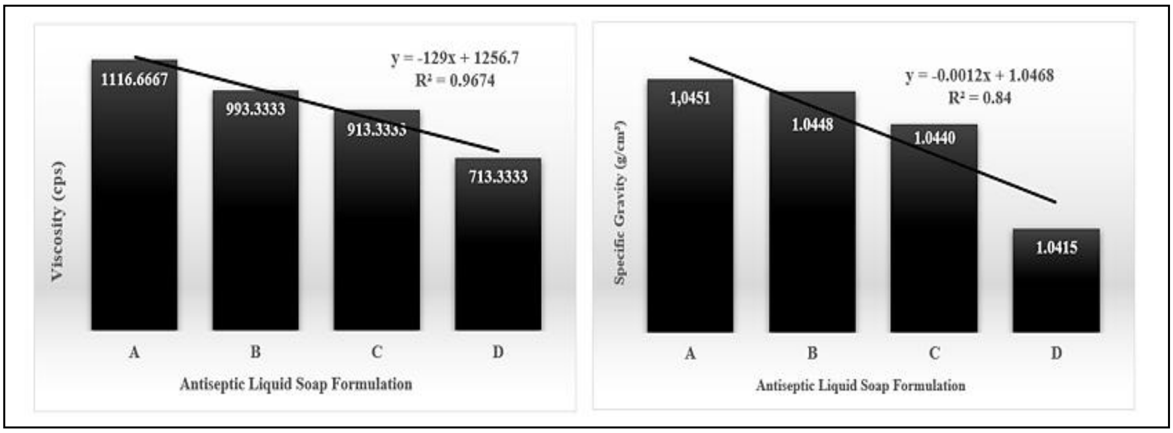


**Fig. 5.** Graph of viscosity and specific gravity test results for antiseptic liquid soap.

Meanwhile, at Fig. 5. the specific gravity trend is represented by the linear equation y = -0.0012x + 1.0468 with a coefficient of determination $R^2$ = 0.84. This reduction in oil concentration results in a lower specific gravity of the soap paste mixture due to larger intermolecular spaces. Additionally, adding banana peel extract, which is more liquid, decreases the specific gravity by loosening the mixture's structure [16].The decrease in specific gravity corresponds with the reduction of viscosity Fig. 5. and the increase in moisture content Fig. 6. Higher moisture content makes the soap more diluted, reducing both viscosity and specific gravity [12]. Lower viscosity may also affect foam stability and antibacterial agent dispersion, influencing the soap's effectiveness during use [16].

### 3.5. Moisture Content and Foam Stability Test Result

Antiseptic liquid soap must have a moisture content below 60% and a range of foam stability of 13 to 220 mm [3]. Higher moisture content makes the soap rancid more easily, reducing its shelf life [3]. Based on the research findings, all soap formulations comply with SNI standards, ensuring product stability, indicating effective cleaning performance, and providing a clean sensation for users [3].

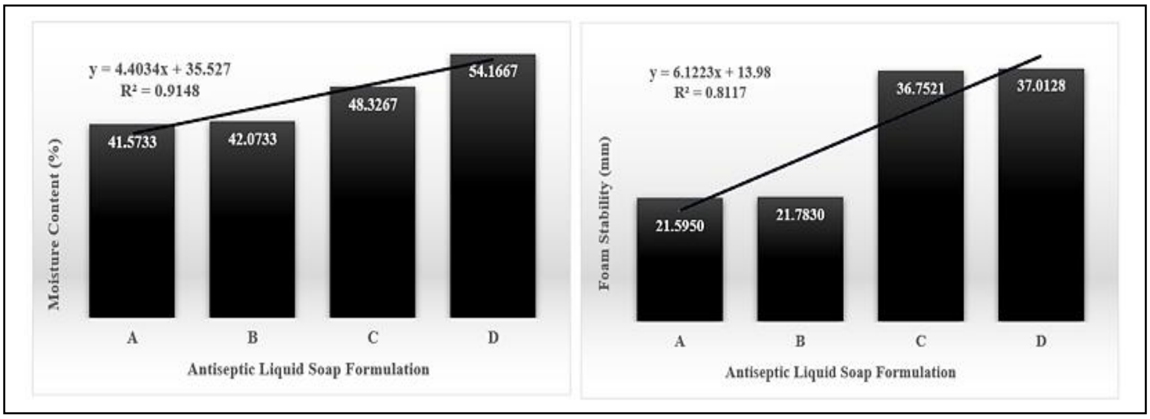


**Fig. 6.** Graph of moisture content and foam stability test results for antiseptic liquid soap.

According to Fig. 6., moisture content with $R^2$ = 0.9148 and foam stability coefficient of $R^2$ = 0.8117 indicate a strong correlation between ingredient composition, moisture content, and foam stability. In this study, the volume of distilled water in the mixture remained constant. As the concentration of castor oil decreases, the volume of soap paste formed also decreases. As a result, the soap paste is dissolved in a large volume of distilled water, increasing the moisture content and foam stability. Additionally, as the concentration of extract increases, the moisture content also increases. Formulations with higher moisture content produce a more fluid soap, which may affect foam stability and the dispersion of antibacterial agents [17]. A higher moisture content also increases the risk of product degradation over time [18].

This moisture content and foam stability trend correlate with the viscosity test results shown in Fig. 5. Reducing viscosity can lead to better distribution of active ingredients but may also decrease the soap's adhesion to the skin, potentially affecting its antibacterial effectiveness [17]. Meanwhile, high viscosity inhibits foam formation because it restricts air movement within the liquid. Conversely, air bubbles form more easily at lower viscosity, producing more abundant and stable foam [16]. This enhanced foam stability is further supported by adding banana peel extract, which contains saponins. Saponin has foaming characteristics, so when mixed with water, it forms a long-lasting foam [19].

### 3.6. Free Alkali and Fatty Acid Test Result

The antiseptic liquid soap must have a maximum free alkali content of 0,1% and free fatty acid of 4% according to the SNI 06-4085-2017 standard. The alkali test measures the amount of KOH that does not react with oil during saponification [12]. Meanwhile, the fatty acid test measures the soap's cleansing effectiveness [6]. Based on these results, all soap formulas are approved by SNI, so that the soap is safe and does not cause skin irritation [3].

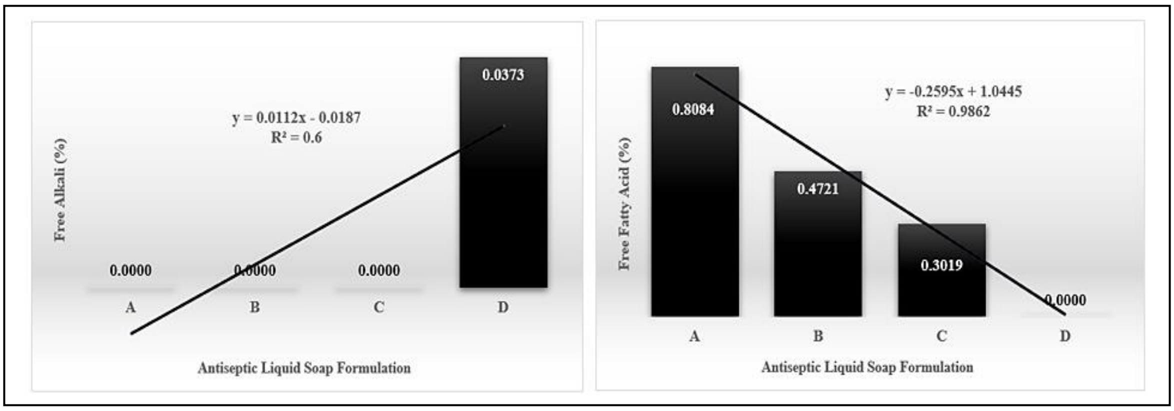


**Fig. 7.** Graph of free alkali and fatty acid test results for antiseptic liquid soap.

Free alkali content of the soap according to Fig. 7. increases linearly as the concentration of castor oil decreases and the banana peel extract increases. This trend is represented by the linear equation $y = 0.0112x - 0.0187$ with $R^2 = 0.6$. Formula D, with 79% castor oil and 21% banana peel extract, shows higher free alkali levels, while other formulas show no free alkali, only free fatty acids. Low concentration of castor oil leads to excess KOH during the saponification process, resulting in unreacted KOH that does not bind to fatty acids [6].

Free fatty acid content of the soap according to Fig. 7. decreases linearly as the concentration of castor oil decreases. Formula A with 100% castor oil has the highest free fatty acid content, 0.81%, while formula D, with 79% castor oil and 21% banana peel extract, contains 0.00%. The equation $y = -0.2595x + 1.0445$, with $R^2 = 0.9862$, indicates a strong correlation between formulation composition and free fatty acid content.

The reduction in free fatty acids is due to a lower concentration of castor oils, allowing KOH to react with fatty acids fully [3]. The content of free fatty acids also decreases due to the increased concentration of banana peel extract. The flavonoids and saponins in the extract bind to fatty acids, reducing the amount of non-reactive fatty acids [15].

### 3.7. Antibacterial Activity Test Result

According to the SNI 06-4085-2017 standard, the diameter of the clear zone is used to classify the antibacterial activity as weak, which is lower than 5 mm, moderate from 5 to 10 mm, strong from 10 to 20 mm, and very strong, which is more than 20 mm [3]. According to SNI 06-4085-2017, all formulations exhibit moderate antibacterial activity. These results suggest that the combination of castor oil and banana peel extract effectively inhibits the growth of *Staphylococcus aureus*.

Meanwhile, according to SNI 06-4085-2017, the fewer the colonies left, the more effective the soap is. Antiseptic liquid soaps have been reported to remove about 65% to 85% of microbes from the human skin [14]. Table 3. shows that all soap formulas met SNI standards, with the number of bacterial colonies below $1x10^3$ CFU/mL. After that, Fig. 9. shows that the percentage of bacterial mortality is above 65%.

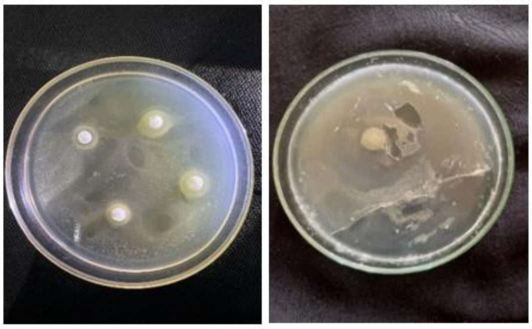

**Fig. 8.** Bacterial inhibition zone diameter and bacterial mortality test result for antiseptic liquid soap.

**Table 3.** The bacterial mortality test result.

| Bacterial Count ($1 \times 10^{-6}$ CFU/mL) | Antiseptic Liquid Soap Formulation *A* | *B* | *C* | *D* |
|---|---|---|---|---|
| Before adding soap | 238 | 317 | 442 | 289 |
| After adding soap | 71 | 108 | 98 | 76 |

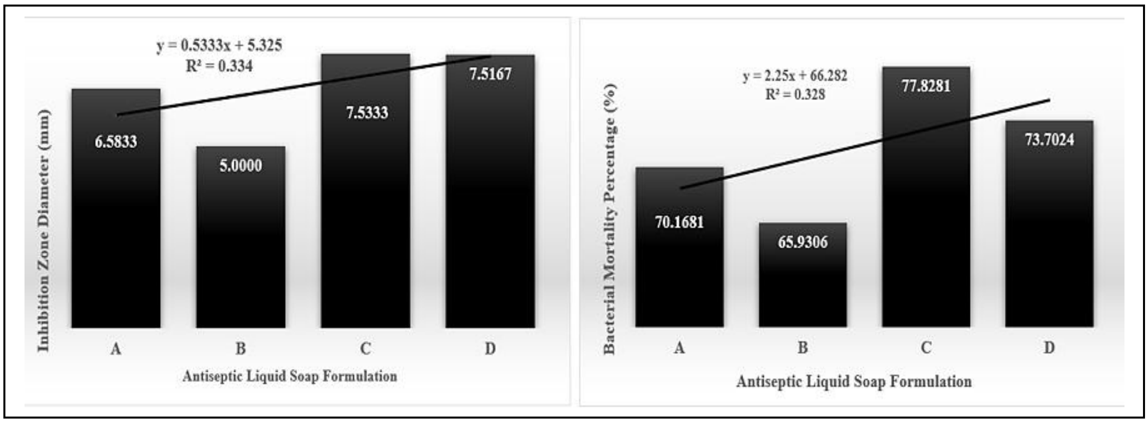


**Fig. 9.** Graph of bacterial inhibition zone diameter and bacterial mortality test result for antiseptic liquid soap.

Fig. 9. shows that Formula C, with a concentration of 86% castor oil and 14% banana peel extract, has the highest inhibition zone against *Staphylococcus aureus*. This formula can inhibit bacterial growth with an inhibition zone diameter of 7.53 mm and 77.83 % of bacterial mortality. The bacterial inhibition zone diameter trend is represented by the equation $y = 0.5333x + 5.325$. Meanwhile, the percentage of bacterial mortality trend is represented by the equation $y = 2{,}25x + 66.282$.

The coefficient of determination $R^2 = 0.334$ and $R^2 = 0.3286$ in bacterial testing can be caused by several factors, such as inconsistencies in the production process, the possibility of contamination during testing, or variations in banana peel extract composition based on ripeness and source. The differences may also influence inhibition zone variations, resulting in interactions between the extract's active compounds and other soap components. So, increasing the banana peel extract did not always correspond proportionally to higher antibacterial activity.

Castor oil and banana peel extract contain different antibacterial compounds, which contribute to inhibiting bacterial growth. Alkaloids disrupt the formation of the peptidoglycan layer in bacterial cell walls [20], inhibit the enzyme dihydrofolate reductase, and have a high affinity for the FtsZ protein [21]. Flavonoids inhibit nucleic acid synthesis, disrupt cell membrane function, and impede energy metabolism and protein formation, resulting in the death of *Staphylococcus aureus* bacteria [22].

Saponins disrupt cell membranes and destabilize bacterial proteins, affecting membrane permeability and morphology [19]. Tannins inhibit or kill bacteria by damaging bacterial cell membranes and forming complexes with metal ions, particularly iron. This disrupts various bacterial functions, including DNA synthesis, enzyme production, and enzymatic reactions, ultimately leading to bacterial death [21]. Glycosides damage the bacterial cell walls [23]. Phenols or polyphenols bind to bacterial enzymes and DNA, causing hyperpolarization and reducing membrane integrity [24].

Steroids/triterpenoids inhibit biofilm formation and disrupt bacterial metabolism [22]. Antibacterial lectins form ion channels in the bacterial membrane, causing ion leakage and disrupting cell balance. Lectins also inhibit bacterial protein adhesion to host receptors, preventing infection and causing bacterial death. Antibacterial lectins kill bacteria by binding to glycoconjugates on the bacterial cell membrane, disrupting its structure and causing leakage of proteins and other compounds. Some lectins also cause bacterial agglutination [25].

## 4. Conclusion

The conclusion of this study confirms that castor oil and banana peel extract are effective active ingredients for antiseptic liquid soap. The soaps successfully inhibit the growth of *Staphylococcus aureus*. The Formula C (86% castor oil and 14% banana peel extract) showed the best results. This formula meets the SNI 06-4085-2017 standard, achieving a pH of 8.27, viscosity of 913.33 cps, water content of 48.33%, specific gravity of 1.044 g/cm³, foam stability of 36.75 mm, free alkali content of 0.00%, free fatty acid content of 0.30%, an inhibition zone diameter of 7.53 mm, and a bacterial mortality rate of 77.83%. Future research should focus on optimizing formulations to improve long-term product stability. In addition, further testing of the broader range of bacteria could enhance the effectiveness of the soap and expand its applications.

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**References**

[1] S. Oh, H. Kim, M. Kim, X. Jin, S. Zheng, and T. H. Yi, "The effects of Jawoongo soap on skin improvement," *J. Cosmet. Dermatol.*, vol. 23, no. 5, pp. 1862–1874, Jan 2024, doi: 10.1111/jocd.16199.

[2] D. Kerdsiri, N. Kengpanich, B. Duangsombat, P. Kamchai, and W. Worapamorn, "The efficacy of handwashing gel containing banana peel extract in reducing bacterial load on dentists' hands," *Mahidol Dental Journal*, vol. 41, no. 2, pp. 113–121, Jun 2021.

[3] A. S. Rusdianto, F. Nizhomia, G. Giyarto, and A. E. Wiyono, "The characteristics of liquid soap with varied additions of moringa leaf extract (*Moringa oleifera L.*)," *Int. J. Food, Agric. Nat. Resour.*, vol. 3, no. 1, pp. 33–39, Feb 2022, doi: /10.46676/ij-fanres.v3i1.38.

[4] J. F. Nova, S. Z. Smrity, M. Hasan, D. Tariquzzaman, M. A. A. Hossain, M. T. Islam, M. R. Islam, S. Akter, M. S. Rahi, M. T. R. Joy, and Z. Kowser, "Comprehensive evaluation of physico-chemical, antioxidant, and antimicrobial properties in commercial soaps: A study on bar soaps and liquid hand wash," *Heliyon*, vol. 11, no. 4, pp. 1–14, Feb 2025, doi: 10.1016/j.heliyon.2024.e41614.

[5] V. R. Patel, G. G. Dumancas, L. C. K.Viswanath, R. Maples, and B. J. J. Subong, "Castor oil: properties, uses, and optimization of processing parameters in commercial production," *Lipid Insights*, vol. 9, no. 1, pp. 1–12, Sep 2016, doi: 10.4137/LPI.S40233.

[6] A. Widyasanti, S. Junita, and S. Nurjanah, "Effect of virgin coconut oils and castor oils to the physicochemical and organoleptic characteristics of liquid soap," *J. Teknol. dan Ind. Pertan. Indones.*, vol. 9, no. 01, pp. 10–16, Apr 2017, doi: 10.17969/jtipi.v9i1.6383.

[7] D. F. M. Santy, Q. Fadillah, R. S. Bt. Hasan, and J. Lina, "The antibacterial potential of ethanol extract from banana peel (*Musa paradisiaca*) on the growth of *Staphylococcus aureus* and *Streptococcus pneumoniae*," *Riwayat Educ. J. Hist. Humanit.*, vol. 6, no. 3, pp. 936–941, Aug 2023, doi: 10.24815/jr.v6i3.33660.

[8] M. R. Zaki, T. E. Farrag, A. H. Mohamedin, and W. I. A. Saber, "Antibacterial activity of fruit peels extracts against pathogenic bacteria," *Ajbas Journals*, vol. 3, no. 2, pp. 230–238, Jul 2022, doi: 10.21608/ajbas.2022.127957.1094.

[9] A. A. Kibria, Kamrunnessa, Md. M. Rahman, and A. Kar. "Extraction and evaluation of phytochemicals from banana peels (*Musa sapientum*) and banana plants (*Musa paradisiaca*)," *Malaysian J. Halal Res.*, vol. 2, no. 1, pp. 22–26, Jan 2020, doi: 10.2478/mjhr-2019-0005.

[10] S. Bakhri, A. Suryanto, Z. Zainal, and N. Fidya, "Saponification process of coconut oil and banana peel extract for the production of antibacterial liquid soap and wound healing," *JTIP Indones.*, vol. 16, no. 01, pp. 1–7, Apr 2024, doi: 10.17969/jtipi.v16i1.31920.

[11] D. Saryanti, and I. Setiawan, "Utilization of secang (*Caesalpinia Sappan L*) wood extract in optimization of liquid soap formulation," *Pharmacon: Jurnal Farm. Ind*., vol. 15, no. 1, pp. 1–12, 2018, doi: 10.23917/pharmacon.v15i1.5702.

[12] S. N. Zahra, R. N. Rafah, V. J. Lestari, Nurhalizah, F. Kenaya, A. A. Fazri, T. H. Kurniati, and S. Muhab, "Preparation of liquid soap utilising used cooking oil with aloe vera as an antibacterial agent," *Chem. Mater*., vol. 3, no. 1, pp. 9–20, Feb 2024, doi: 10.56425/cma.v3i1.71.

[13] R. Yuniarti, H. M. Nasution, Z. Rani, and Fahmi, "Utilization of buas buas leaf (*Premna Pubescens Blume*) ethanol extract as liquid soap with anti-bacterial activity," *Inter. Journal of Sci. Tech. & Manag.*, vol. 3, no. 1, pp. 733-743, May 2022, doi: 10.46729/ijstm.v3i3.510.

[14] S. A. Upula, E. E. Bassey, and U. E. Ije, "Antiseptic soap and body cleansing agents and its effects on the normal flora of the human skin," *World Jour. of Phar. and Med. Research*, vol. 7, no. 4, pp. 28-34, Jan 2021.

[15] D. N. Afifah, R. F. Maulidina, N. Astuti, and R. A. Wahyadi, "Application of saponins from ambon banana petiole (*Musa paradisiaca var. sapientum L.*) as natural surfactants in bio-hand soap," *RiCE: Research in Chem. Eng*., vol. 2, no. 1, pp. 8-13, Aug 2023, doi: 10.30595/rice.v2i1.80.

[16] A. Barkovic, T. Botic, D. Drljaca, D. Dragic, M. Brdar, S. Pilipovic, and P. Dugic, "Optimization of liquid soap formulation," *Tech. ACTA*, vol. 17, no. 1, pp. 49-57, Nov 2024, doi: 10.51558/2232-7568.2023.17.1.49.

[17] S. Nazdrajic, A. Bratovcic, D. Alibegic, A. Micijevic, and M. Mehovic, "The effect of mixed surfactants on viscosity, pH, and stability of synthesized liquid soaps," *Inter. Jour. of Mate. and Chem*., vol. 14, no. 3, pp. 31-36, Jun 2024, doi: 10.5923/j.ijmc.20241403.01.

[18] V. Chandel, D. Biswas, S. Roy, D. Vaidya, A. Verma, and A. Gupta "Current advancements in pectin: extraction, properties and multifunctional applications," *Foods*, vol. 11, no. 17, pp. 1–30, Sep 2022, doi: 10.3390/foods11172683.

[19] M. Rojas, Y. Ortiz, D. Arturo, Y. Navarro, and F. Chejne, "Saponins: natural surfactants and their alternative sustainability in the formulation of bio-based detergents to mitigate environmental pollution," *Was. and Bio. Val.*, vol. 15, no. 10, pp. 5965-5982, May 2024, doi: 10.1007/s12649-024-02549-6.

[20] N. Susanti, E. Situmorang, and W. Fitri, "Effectiveness of the antibacterial activity of n-hexane andaliman (*Zanthoxylum Acanthopodium* DC) extract against *Bacillus subtilis*, *Salmonella typhi*, and *Staphylococcus aureus*," *J. Phys.: Conf. Ser*., vol. 1462, no. 1, pp. 1-7, 2020, doi: 10.1088/1742-6596/1462/1/012072.

[21] K. C. Jaimes, C. A. F. Hernandez, F. H. Sedano, P. C. Sanchez, J. M. Jimenez, B. Q. Garcia, and J. S. Chavez, "Antibacterial activity and *Ab*FtsZ properties of fungal metabolites isolated from mexican mangroves," *Rev. Bras. de Farm.*, vol. 34, no. 3, pp. 565-576, 2024, doi: 10.1007/s43450-023-00507-2.

[22] K. Nisyak, A. Hisbiyah, and A. Haqqo, "Antibacterial activity of ethanolic extract and green piper betle leaf essential oil against *Methicillin resistant Staphylococcus aureus*," *J. Pharm. Care Anwar Med.*, vol. 5, no. 1, pp. 1–14, Dec 2022, doi: 10.36932/jpcam.v5i1.82.

[23] H. J. G. Al-shattrawi, "Effect of willow bark extract on the activity of gram-negative intestinal bacterial: A review," *C. Asian Jour. Of Med. And Nat. Scien.*, vol. 6, no. 2, pp. 659–678, March 2025.

[24] K. Ecevit, A. A. Barros, J. M. Silva, and R. L. Reis, "Preventing microbial infections with natural phenolic compounds," *Fut. Phar.*, vol. 2, no. 4, pp. 460-498, Nov 2022, doi: 10.3390/futurepharmacol2040030.

[25] E. H. E. Konozy, M. E. M. Osman, A. I. Dirar, and G. G. Kwansah, "Plant lectins: A new antimicrobial frontier," *Biomed. Pharmacother.*, vol. 155, no. 1, pp. 1–13, Nov 2022, doi: 10.1016/j.biopha.2022.113735.