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Formulation and Characterization of Herbal Solid Soap Enriched with Cinnamon (*Cinnamomum burmanii*) and *Aloe Vera* Peel Extract

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Abstract— This study aimed to develop a solid soap formulation using natural ingredients by combining cinnamon (Cinnamomum burmanii) extract and Aloe vera peel extract, both recognized for their antibacterial and moisturizing properties. The research involved several stages, including the extraction of cinnamon and Aloe vera peal, soap formulation with varying cinnamon and Aloe vera extract concentrations, and testing of the physicochemical properties and antibacterial activity against Escherichia coli. The formulated soaps were evaluated for moisture content, free alkali levels, pH, foam stability, antibacterial inhibition zones, and skin irritation potential. The results showed that increasing the concentrations of cinnamon and Aloe vera peel extracts significantly affected the characteristics of the soap. The optimal formulation was obtained with 15% cinnamon extract and 6% Aloe vera peel extract (A3B3), yielding a moisture content of 2.44%, a free alkali content of 1.70%, a pH of 11.8, and an antibacterial inhibition zone of 1.28 mm, all without causing any skin irritation. FTIR analysis identified several functional groups, such as aldehydes, alkanes, aromatics, and hydroxyls, corresponding to the bioactive compounds, responsible for the antibacterial and moisturizing effects. Specifically, the presence of cinnamaldehyde in cinnamon and saponins in Aloe vera enhanced the antimicrobial and skin-conditioning properties of the soap. The findings suggested that incorporating herbal extracts into soap formulations can improve their functional benefits, offering a promising alternative for natural skincare products with antibacterial protection and skin health.

Keywords— *Aloe vera; Antibacterial activity; Cinnamon; Herbal formulation; Solid soap*

1. INTRODUCTION

Soap is a cleansing agent derived from the reaction between a base and fats or oils. It is used for cleansing and maintaining skin health by removing dirt, germs, and other contaminants. It is produced through a chemical process known as saponification, which utilizes alkali to optimize foam formation—an essential indicator in quality soap products [1]. Nowadays, soap is not only used for body cleansing but has also expanded into cosmetics, serving to maintain skin moisture, softness, and overall skin health. Modern soap production no longer relies solely on chemical ingredients but is complemented by herbal components derived from organic materials, enhancing the skin's physiological protective function.

Among the various natural ingredients used in soap production, plant-based extracts have gained attention due to their beneficial properties. Cinnamon and Aloe vera, for instance, may offer potential advantages as herbal additives in soap formulations, contributing to skincare benefits and functional properties of the final product. Cinnamon generally contains cinnamyl alcohol, coumarin, cinnamic acid, cinnamaldehyde, anthocyanins, and essential oils, along with sugars, proteins, simple fats, pectin, and key antioxidant compounds, such as polyphenols (tannins, flavonoids), essential oils, and phenolic compounds. Intan et al. [2] stated that these compounds exhibit antiviral, antioxidant, antitumor properties, and the ability to lower blood pressure and cholesterol. Additionally, cinnamon contains low-fat compounds and antimicrobial agents, primarily eugenol and cinnamaldehyde.

The use of cinnamon as a herbal ingredient in soap making has not been widely adopted on an industrial scale. However, previous studies have explored soap formulations using cinnamon. Husni et al. [3] have reported that a cinnamon bark lotion formulated with triethanolamine can protect the skin without irritating at a 5% concentration. Meanwhile, Nafisah and Antari [4]

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combine essential oils of lemongrass and cinnamon in the production of transparent solid soap. The chemical structure of Cinnamaldehyde is presented in **Fig. 1.**

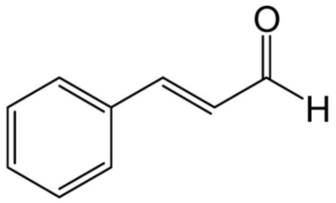

Fig. 1. Chemical structure of Cinnamaldehyde [5]

Meanwhile, *Aloe vera* contains saponins, which function as antiseptics and foam-forming agents when reacted with water [6]. *Aloe vera* peel also contains saponins and other antioxidant compounds [7]. Narsih and Agato [7] have reported that the appropriate extraction temperature and duration for *Aloe vera* peel yield bioactive compounds that serve as functional ingredients for food and non-food products. For cosmetic production, *Aloe vera* peel serves as protection against skin damage and improves skin hydration. Furthermore, Dissanayake et al. [8] have added that *Aloe vera* compounds act as skin moisturizing agents. Another study by Intan et al. [2] have demonstrated that soap containing *Aloe vera* can offer moisturizing and soothing effects on the skin, making it an ideal alternative for daily skincare routines. The chemical structure of saponin is presented in **Fig. 2**.

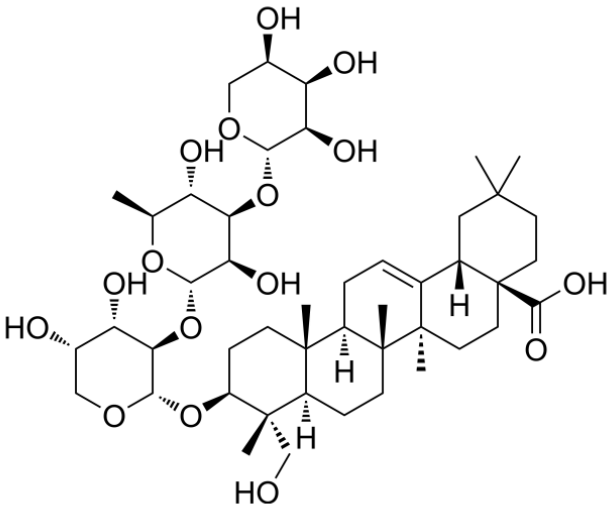

Fig. 2. Chemical structure of Saponin [9]

Although soaps made from *Aloe vera* peel and cinnamon have been previously developed, they are usually formulated separately, limiting their combined effects. This study focuses on the exploration, innovation, and novelty of the formulation of soap that integrates both organic herbal ingredients—cinnamon, which contains dominant antibacterial compounds, and *Aloe vera* peel, which is rich in bioactive phenolic components, foaming agents, moisturizers, and skin softeners. The combination of these ingredients is expected to produce a soap with enhanced skin protection due to the synergistic effects of their bioactive compounds.

2. EXPERIMENTAL SECTION

This research was conducted from June to August 2024 in four laboratories. The Engineering and Process Laboratory at the Politeknik Negeri Pontianak (Polnep) was responsible for preparing all materials and carrying out the soap production process. The Chemistry Laboratory at Polnep focused on testing the chemical properties of the soap. The Microbiology Laboratory at Polnep assessed the antibacterial activity; while the Material Characterization Laboratory at the Institut Teknologi Sepuluh Nopember (ITS) identified the functional group components of the active compounds in the soap.

2.1. Materials

The materials used in this study were palm oil, *Aloe vera*, cinnamon, aquadest, stearic acid, NaOH, ethanol, glycerin, coco-DEA, texapon, EDTA, BHT, NaCl, perfume, sugar, and glycerin. For analysis, the substances involved were alcohol, aquadest, phenolphthalein (PP) indicator, NaCl, HCl, Nutrient agar, *Escherichia coli* bacterial culture, gold for FTIR sample coating, and phenolic compounds.

2.2. Instrumentation

The instruments used in this study were plastic basins, scales, knives, cutting boards, wooden stirrers, hot plates, blenders, thermometers, stirrers, measuring cups, beaker glasses, soap molds, cloths, tissues, thin spatulas, and evaporators. For analysis, the equipment includes beaker glasses, test tubes, clamp holders, pH paper, analytical balances, porcelain dishes, weighing bottles, ovens, desiccators, Erlenmeyer flasks, autoclave, spectrophotometer, FTIR instrument (Shimadzu Prestige 21), Petri dishes, thin trays, mortars, dropper pipettes, water baths, weighing bottles, inoculation needles, and filter paper.

Data were obtained from laboratory testing results on all samples based on predetermined parameters. The research variables included cinnamon extract concentration at 3 levels and *Aloe vera* peel extract concentration at 3 levels. This combination resulted in 9 treatment groups, with each treatment replicated 3 times, yielding a total of 27 experimental units. The product development for the samples consisted of 3 stages: preparation of cinnamon extract, preparation of *Aloe vera* extract, and herbal solid soap production process.

2.3. Preparation of Cinnamon Extract

Cinnamon bark was cleaned from inedible impurities, ground using a hammer mill, and sieved to a size of 80 mesh. The extraction process was carried out using maceration for 60 min, followed by evaporation. The resulting product was a ready-to-use cinnamon extract.

2.4. Preparation of *Aloe vera* Peel Extract

The *Aloe vera* peels separated from the gel was washed and mixed with water in a 1:1 ratio. The mixture was blended for 10 min and then filtered to obtain a ready-to-use *Aloe vera* peel extract.

2.5. Herbal Solid Soal Production Process

The process started with mixing palm oil, NaOH and stearic acid solutions, followed by heating and stirring at 65 °C for 5 min. Subsequently, glycerin, 96% ethanol, and various additional materials, such as Coco-DEA, BHT, EDTA, NaCl, Texapon, granulated sugar, and perfume were added, and the mixture was stirred at 60 °C for 10 min. Next, cinnamon extract was added in concentrations of 5, 10, and 15%, along with *Aloe vera* peel extract at concentrations of 2, 4, and 6%. This mixture was stirred at 50 °C for 5 min until a homogenous soap mixture was formed. The mixture was then poured into a mold and left to harden at room temperature (25 °C) for 36 h before being removed from the molds to produce solid soap. The sample codes for each factor combination are provided in **Table 1**. Each sample was tested for moisture content, free alkali, pH, antibacterial activity, foam stability, and skin irritation. The data obtained from the chemical and physical tests were analyzed using Analysis of Variance (ANOVA) to determine statistical significance.

Table 1. Sample codes for each factor combination

Cinnamon extract	*Aloe vera* peel extract		
	2%	4%	6%
5%	A1B1	A1B2	A1B3
10%	A2B1	A2B2	A2B3
15%	A3B1	A3B2	A3B3

3. RESULT AND DISCUSSION

3.1. Moisture Content

The results of the moisture content analysis in solid soap, as shown in **Fig. 3**, revealed that the A1B1 treatment had the highest average value at 2.60%, while the A2B1 treatment had the lowest average value at 1.65%. According to the SNI 06-3532-2016 [8], the maximum moisture content in solid soap is 15%. These findings indicate that as the concentration of cinnamon extract and *Aloe vera* peel extract increases in the solid soap, the moisture content also increases. Conversely, the lower the concentration of *Aloe vera* peel extract, the lower the moisture content in the solid soap. The analysis of variance (ANOVA) conducted in this study indicated a significant difference in moisture content (α=0.05). Therefore, the combination of cinnamon extract and *Aloe vera* peel extract significantly affects the moisture content of solid soap.

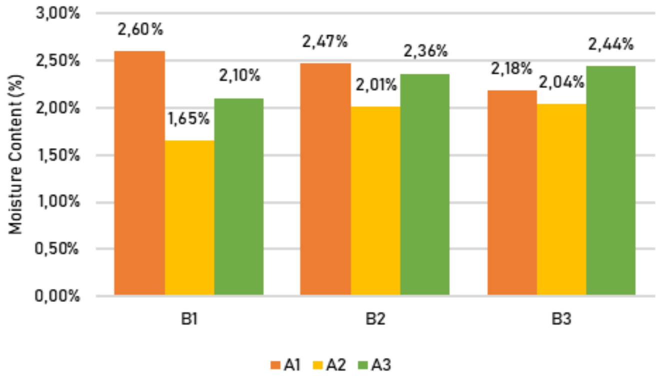

Fig. 3. Moisture content of the herbal soap samples

Based on **Fig. 3**, The graph shows the trend of moisture content changes for all of the factor combinations. For A1, the moisture content showed a decreasing trend from B1 to B3, starting from the highest value and declining gradually. In contrast, A2 maintained a relatively stable trend with only slight fluctuations, consistently recording the lowest moisture content among the 3 groups. Meanwhile, A3 showed an increasing trend, where the moisture content increased from B1 to B3, eventually surpassing A1 at B3. This pattern indicates that A1 tends to lose moisture over time or under different conditions, A2 remains steady, and A3 gradually gains moisture. In general, these results indicate that the treatment involving varying concentrations of cinnamon and *Aloe vera* extracts affects the moisture content of the solid soap. Both cinnamon and *Aloe vera* extracts contain a certain amount of water. When these extracts were added to the soap mixture, the total volume of water in the mixture increased. This condition can directly contribute to the final moisture content of the soap.

In a previous study by Yansen and Humaira [11], the moisture content of solid soap range from 7.8% to 10.35%. In this study, the solid soap produced has met the SNI 06-3532-2016 [10], which is less than 15%. Several components in the extracts had high hygroscopic properties especially from *Aloe vera*. This finding indicate that they have the ability to attract and retain moisture from the air. This condition can cause the soap to absorb more water, thus increasing its moisture content [11].

3.2. Free Alkali

The free alkali test was conducted to determine the presence or absence of free alkali in solid soap to prevent potential skin irritation. According to Zulkifli and Estiasi [12], the level of free alkali in soap is due to unreacted alkali that does not combine with fatty acids during the saponification process. Based on the SNI 06-3532-2016 for solid soap [10], the maximum allowable free alkali content is 0.1%. The data presented in **Fig. 4** indicated that the highest average free alkali content was observed in the A3B3 treatment at 1.70%, while the lowest was recorded in the A1B1 treatment at 0.96%.

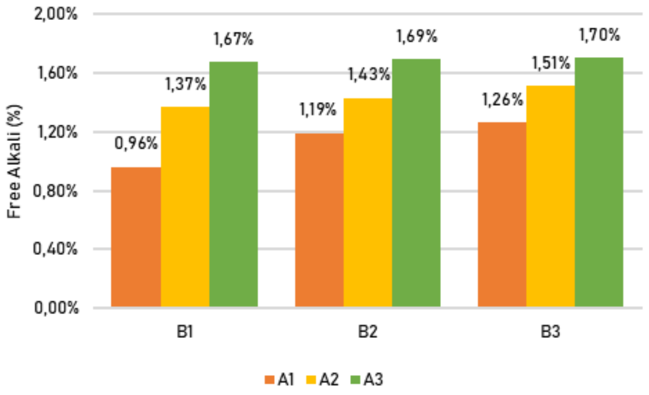

Fig. 4. Free alkali content of the herbal soap samples

The results suggested that increasing the concentration of cinnamon and *Aloe vera* peel extracts in solid soap leads to a higher percentage of free alkali. Conversely, lower concentrations of cinnamon and *Aloe vera* peel extracts resulted in a lower percentage of free alkali in the solid soap. Based on the analysis of variance (ANOVA), the free alkali content in this study showed a significant difference (α=0.05). Therefore, the treatment involving the combination of cinnamon extract and *Aloe vera* peel extract had a significant effect on the free alkali content in solid soap.

Based on **Fig. 4**, the free alkali content in solid soap increased with the rising concentration of cinnamon extract and *Aloe vera* peel. Cinnamon and *Aloe vera* contain natural compounds that can affect the saponification reaction, either by acting as catalysts or by enhancing the reaction efficiency between fat and alkali. The equation of the saponification reaction is as follows:

$$C_3H_5(OOCR)_3 + 3NaOH \rightarrow 3RCOONa + C_3H_5(OH)_3 \quad (1)$$

The compound in cinnamon that contributes to the free alkali formation in soap is cinnamaldehyde. During the soap-making process, cinnamaldehyde can function as a catalyst that increases the reaction rate by affecting the activation energy of a chemical reaction, including free alkali formation. Meanwhile, the compound in *Aloe vera* peel that plays a role in free alkali formation is saponin. The high free alkali content in solid soap is also attributed to the alkaline nature of cinnamon extract.

The presence of free alkali in soap is caused by an incomplete saponification reaction. The increase in free alkali content occurs because NaOH does not fully react with excess oil, leaving unreacted alkali in the soap. This condition can be influenced by the soap-making process, including sufficient heating and stirring, allowing NaOH to react with fatty acids or oils [13].

3.3. Potential of Hydrogen (pH) Level

The pH level is used to determine the acidity and alkalinity of solid soap preparations made from a combination of cinnamon extract and *Aloe vera* peel using a pH indicator. The pH level is one of the quality requirements for solid soap, as it directly contacts the skin and can cause irritation if the pH is not compatible with the skin's pH.

Based on the data in **Fig. 5**, the analysis results of the acidity level or pH in solid soap showed that the highest average pH value was found in the A2B3, A3B2, and A3B3 treatments, which was 11.8, and the lowest average value was in the A1B1 treatment, which was 11.2. The pH of the solid soap increased as the concentration of cinnamon extract and Aloe vera peel increased. According to the SNI 06-3532-2016 [10], the standard pH for solid soap is between 9 and 11. Based on the analysis of variance (ANOVA), the moisture content in this study showed a significant difference (α=0.05). This findings suggested that the addition of a combination of cinnamon extract and *Aloe vera* peel had a significant effect on the pH value of solid soap.

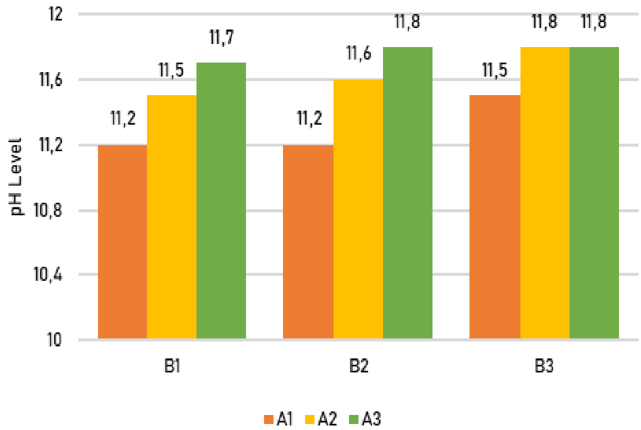

Fig. 5. pH level of the herbal soap samples

In general, the pH value increases with the increasing alkalinity of solid soap. The results of the study on solid soap with a combination of cinnamon extract and *Aloe vera* peel showed basic pH value. The higher the extract concentration, the more compounds compete with fats to react with alkali, leaving unused alkali and raising the pH value of the soap. As the concentration of the added extract increases, the pH of the solid soap tends to become more alkaline, which can affect the quality and properties of the soap.

The basic pH value is due to the presence of NaOH, a strong alkali and a main ingredient in soap production [14]. Therefore, the addition of cinnamon extract also affects the basic pH value, as cinnamon is an alkaline substance with a pH value of 8.5. Additionally, research by Yansen and Humaira [11] have found that the pH of solid soap with *Aloe vera* extract is 10.15, indicating an alkaline nature.

3.4. Antibacterial Activity

The antibacterial activity test was carried out using the disc diffusion method by measuring the diameter of the clear zone, which indicates the inhibition of bacterial growth by an antibacterial compound in the extract. The antibacterial activity of solid soap with a combination of cinnamon extract and *Aloe vera* peel was tested using the paper disc diffusion method. The purpose of the antibacterial activity test is to determine the ability of the solid soap with a combination of cinnamon extract and *Aloe vera* peel to inhibit the growth of *Escherichia coli* bacteria [15].

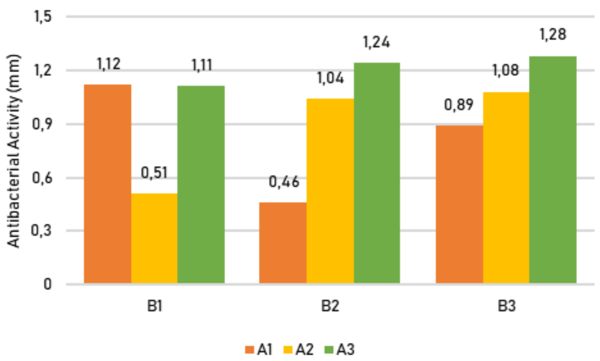

Fig. 6. Antibacterial activity of the herbal soap samples

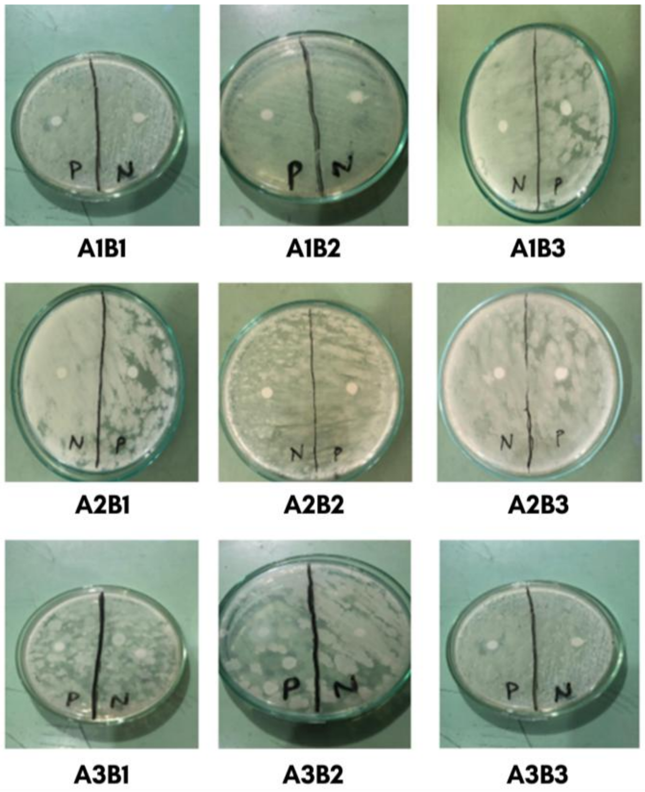

Fig. 7. Photographs results in antibacterial analysis

Based on the results presented in **Fig. 6** and **Fig. 7**, the highest average clear zone of solid soap containing cinnamon extract and *Aloe vera* peel in inhibiting the antibacterial activity of *Escherichia coli* was observed in the A3B3 treatment, with a value of 1.28 mm. In contrast, the smallest value was found in the A1B2 treatment at 0.46 mm. Additionally, in this study, aquadest was used as a negative control treatment. Upon observation, the negative control treatment had an average clear zone diameter of 0.00 mm, indicating no clear zone around the paper disc. These findings suggest that the negative control (aquadest) had no effect on the diameter of the antibacterial inhibition against *Escherichia coli*.

Based on the analysis of variance (ANOVA), the antibacterial activity of the soaps in this study showed a significant difference (α=0.05). Therefore adding a combination of cinnamon extract and *Aloe vera* peel significantly affect the antibacterial activity of solid soap. The higher the concentration of the cinnamon extract and *Aloe vera* peel combination, the greater the inhibition against *Escherichia coli* growth. However, the antibacterial activity in this study was categorized as weak. Several factors may influence this outcome, as both *Aloe vera* and cinnamon extracts contain active compounds and enzymes that are highly sensitive to temperature and air, and are easily oxidized, leading to a reduction in the amount of antibacterial agents in the solid soap [16].

The antimicrobial compounds found in cinnamon include essential oils, flavonoids, saponins, tannins, and alkaloids. The cinnamaldehyde content of cinnamon is also known for its antibacterial properties. On the other hand, the compounds in *Aloe vera* have antibacterial properties, including alkaloids, flavonoids, and tannins. The results of this study are consistent with the research of Suryati et al. [17] regarding the antibacterial activity test using *Aloe vera* extract against *Escherichia coli* growth. In addition, this study also aligns with previous research by Noviano et al. [18], which also demonstrated that cinnamon has antibacterial activity capable of *inhibiting Escherichia coli.*

3.5. Foam Stability

The foam stability test is conducted to determine the foam height produced by the soap preparation with cinnamon extract by shaking and allowing it to stand for 5 min [19]. Foam stability refers to the ability of foam to maintain its presence and structure over a certain period. Soap with good foam stability means that the foam does not disappear or degrade quickly after formation. The higher the percentage of foam loss, the less foam remains from the initial foam after a certain period. This indicates that the foam is unstable and quickly dissipates [11].

Based on the data shown in **Fig. 8**, the foam stability of solid soap with cinnamon extract and *Aloe vera* peel showed the highest average value of 18.38% in the A3B3 treatment, and the lowest average value of 4.50% in the A1B1 treatment. The higher the concentration of cinnamon extract and *Aloe vera* peel added to the solid soap, the higher the foam stability percentage. A lower foam stability percentage indicates better foam stability in the solid soap. Based on the analysis of variance

(ANOVA), the foam stability of the soaps in this study showed a significant difference (α=0.05). Therefore, the addition of a combination of cinnamon extract and *Aloe vera* peel significantly affects the foam stability of the solid soap.

Fig. 8. Photographs results in antibacterial analysis

The higher the percentage of foam loss, the less foam remains from the initial foam after a certain period. This indicates that the foam is unstable and disappears quickly [14]. The amount of foam produced can be influenced by pH leves; generally, higher pH values lead to greater foam stability [20]. Furthermore, increasing the concentration of cinnamon extract and *Aloe vera* peel enhanced foam stability. Previous research by Hambali et al. [21] have shown that the addition of *Aloe vera* concentration could enhance the foam stability in soap. Saponins, one of the secondary metabolites, possess soap-like properties and are considered natural surfactant. Saponins have foaming characteristics, so when shaken with water, they produce foam that can last longer [22].

3.6. Skin Irritation Testing

Skin irritation testing is an important process of product safety procedures [23]. This test is a parameter used to observe the effects or reactions caused on the skin. In this study, an irritation test was conducted using solid soap with the highest and lowest antibacterial activity inhibition treatments. The results of the skin irritation test are presented in **Table 2**.

The results of this study indicated that the solid soap treatment with the highest antibacterial activity inhibition, A3B3, did not cause skin irritation on the panelists' hands. Similarly, the A1B1 treatment, which had the lowest antibacterial inhibition, also did not cause skin irritation. Overall, none of the soap products used in this study caused any skin irritation. This condition can be attributed to the fact that the pH and free alkali content in the solid soaps are not excessively high, which prevented any irritation. Skin irritation is caused by a high pH and high free alkali content. The pH value is not the main parameter causing skin irritation. The main contributor to skin irritation in soap is free alkali.

Table 2. The results of skin irritation testing

Cinnamon extract	*Aloe vera* peel extract		
	2% (B1)	4% (B2)	6% (B3)
5% (A1)	Not irritating	Not irritating	Not irritating
10% (A2)	Not irritating	Not irritating	Not irritating
15% (A3)	Not irritating	Not irritating	Not irritating

Skin irritation is generally caused by high pH and free alkali content. However, pH value is not the primary factor responsible for skin irritation. The main factor causing skin irritation is the free alkali content in soap. According to Widyasanti et al. [14], a high level of free alkali can lead to skin irritation, which is often indicated by an extremely alkaline pH value of the soap.

3.7. FTIR Analysis

FTIR analysis is performed to identify the functional groups present in the solid soap using Fourier Transformed Infrared (FTIR) spectroscopy. FTIR is an instrument used to detect functional groups, identify compounds, and analyze mixtures in a sample without destroying the sample.

The FTIR spectrum of the functional groups from the solid soap with cinnamon extract and *Aloe vera* skin extract for A3B3 is presented in **Fig. 9A**. The results showed a wave peak at 3342.84 cm^{-1}, indicating the presence of the amide functional group, a peak at 2916.53 cm^{-1} for the methyl ($-CH_3$) alkane functional group, a peak at 2849.10 cm^{-1} for the methylene ($-CH_2$) functional group, a peak at 1643.83 cm^{-1} for the alkene functional group, a peak at 1556.16 cm^{-1} for the aromatic functional group, a peak at 1469.55 cm^{-1} for the nitro ($-NO_2$) functional group, a peak at 1419.64 cm^{-1} for the aldehyde functional group, a peak at 1111.57 cm^{-1} for the ether functional group, a peak at 1042.31 cm^{-1} for the primary alcohol (-OH) functional group, a peak at 922.67 cm^{-1} for the aliphatic acid halide functional group, and a peak at 668.59 cm^{-1} for the aldehyde functional group.

Furthermore, the FTIR spectrum of the functional groups of the solid soap with cinnamon extract and *Aloe vera* skin extract for A1B2 is presented in **Fig. 9B**. The results showed a peak at 3345.81 cm^{-1}, indicating the presence of the amide functional group. The peak at 2916.17 cm^{-1} was attributed to the presence of the methyl ($-CH_3$) alkane group, while the peak at 2849.25 cm^{-1} corresponded to the methylene ($-CH_2$) alkane group. The peak at 1647.97 cm^{-1} indicated the presence of an alkene functional group, and the peak at 1556.58 cm^{-1} was attributed to the aromatic functional group. The peak at 1420.26 cm^{-1} showed the aldehyde functional group, the peak at 1111.46 cm^{-1} indicated the ether group, and the peak at 1042.44 cm^{-1} corresponded to the primary alcohol (-OH) group. Additionally, the peak at 922.96 cm^{-1} belonged to an aliphatic acid halide functional group, and the peak at 717.73 cm^{-1} was associated with an alkene functional group.

The results obtained in this study are aligned with the research of Sembiring et al. [24], who have identified

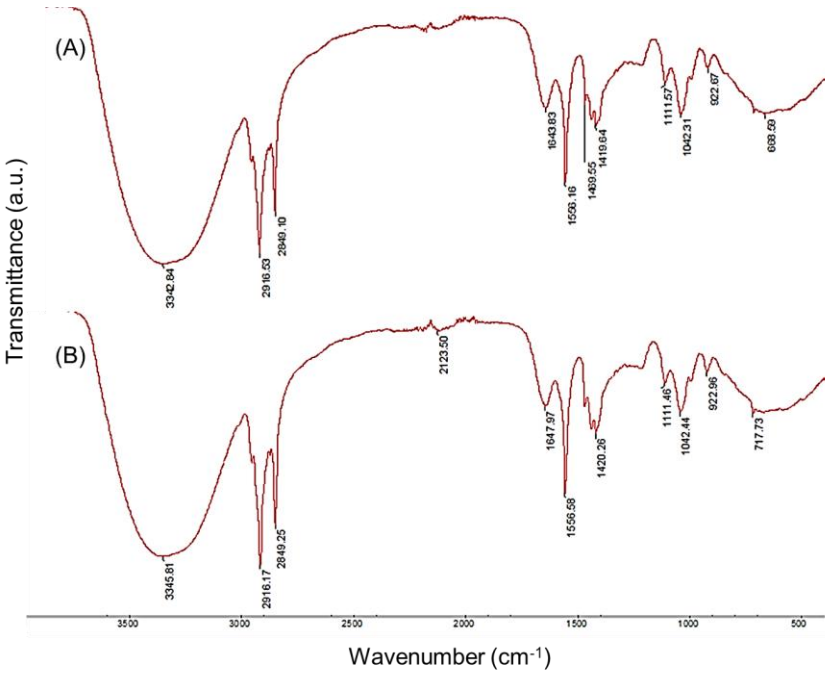

Fig. 9. FTIR Spectrum of (A) A3B3 and (B) A1B2

functional groups in cinnamon extract with wave numbers of 4403.49 and 393.48 cm⁻¹, including wave numbers of 4403.49 cm⁻¹, 3630.03 cm⁻¹, 2981.95 cm⁻¹, 2879.72 cm⁻¹, 2355.08 cm⁻¹, 1689.64 cm⁻¹, 1475.54 cm⁻¹, 1309.67 cm⁻¹, 1163.08 cm⁻¹, 837.11 cm⁻¹, 717.52 cm⁻¹, and 393.48 cm⁻¹. This result also aligns with the research by Waliha et al. [25], which have identified functional groups in *Aloe vera* extract within the wave number range of 1735.12 cm⁻¹ to 1042.91 cm⁻¹. Specifically, the wave number at 1735.12 cm⁻¹ was associated with the aldehyde functional group, 1372.44 cm⁻¹ belonged to the aromatic functional group, 1233.40 cm⁻¹ corresponded to the amine functional group, and 1042.91 cm⁻¹ was correlated to the ether functional group.

The results of this study indicated the presence of functional groups classified as cinnamaldehyde compounds in cinnamon extract, especially aldehyde and alkene groups. Cinnamaldehyde is a compound found in cinnamon known for its antibacterial properties. Furthermore, the C-N (amine) functional group arising from alkaloid compounds found in *Aloe vera*. Alkaloids are one of the compounds in *Aloe vera* that have antibacterial properties. Moreover, flavonoids and tannins in *Aloe vera* also contribute to its antibacterial activity.

CONCLUSION

Based on the research results, the best formulation recommended for producing solid soap from cinnamon extract and *Aloe vera* extract was the A3B3 treatment, with cinnamon extract at a 3% concentration and *Aloe vera* extract at a 3% concentration. The optimal formulation containing cinnamon and *Aloe vera* extracts exhibited the following characteristics: water content of 2.44%, free alkali of 1.70%, pH of 11.8, antibacterial activity of 1.28, foam stability of 18.38%, the presence of 11 functional groups, and no skin irritation. These findings demonstrated the success of this formulation in producing safe and effective soap.

SUPPORTING INFORMATION

There is no supporting information in this paper.

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CONFLICT OF INTEREST

The authors declared that no conflicts of interest regarding the publication of this article.

AUTHOR CONTRIBUTIONS

All authors actively contributed in all stages of the research, from design, data collection, and analysis, as well as writing to manuscript revision. All authors have read and approved the final version of the manuscript. The authors declare that there is no conflict of interest in this research.

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