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The Effect of Temperature and Extraction Time of Cinnamon (*Cinnamomum burmannii*) on Physicochemical and Organoleptic Properties of Herbal Paper Soap

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Abstract. This study aims to examine the effects of cinnamon (Cinnamomum burmannii) extraction temperature and duration on the physicochemical and organoleptic characteristics of herbal paper soap. The experiment involved three extraction temperatures (60°C, 70°C, and 80°C) and two extraction durations (15 and 20 minutes), resulting in six treatment combinations. The findings indicate that an extraction temperature of 60°C for 15 minutes produced the best moisture content, and foam stability, while the optimal free alkali content was obtained at 80°C for 20 minutes. The highest antibacterial activity was observed at 70°C for 15 minutes. In the organoleptic evaluation, the best color scoring was achieved at 60°C for 20 minutes, aroma scoring at 80°C for 20 minutes, and thickness scoring at 60°C for 15 minutes. Further analysis revealed that extraction temperature and duration significantly influenced the physicochemical properties, including free alkali content, foam stability, and skin irritation, as well as organoleptic characteristics such as color, aroma, and thickness. However, these factors had no significant effect on moisture content and antibacterial activity. Overall, the paper soap met the quality standards outlined in SNI 06-3532-2016, except for free alkali content, which exceeded the maximum allowable limit of 0.1%, making it non-compliant with soap quality standards.

Keywords: Cinnamon Extraction, Extraction Temperature, Paper Soap, Physicochemical Properties, Organoleptic Evaluation.

1 Introduction

Soap is a product used to remove dirt from the skin, including both grease and water-soluble impurities. It is an alkaline salt derived from high molecular weight fatty acids, which undergoes partial hydrolysis in water, giving soap its basic properties [1]. Beyond cleansing the skin, modern soaps offer additional benefits such as brightening, softening, and maintaining skin health. Soap molecules have a hydrophilic (polar) head and a hydrophobic (non-polar) tail, making them amphiphilic. This dual nature allows soap to bind with oils and dissolve them in water. The production of soap involves a saponification reaction, which occurs when fatty acids are combined with sodium or potassium salts [2]. Society highly depends on the use of soap in daily life. With advancements in technology and knowledge, soap has been extensively modified to enhance its convenience. One such innovation is the development of soap in thin sheets resembling paper, know as paper soap. Paper soap is one of the most innovative soap formulations due to its thin, sheet-like form. Paper soap is a solid soap in the form of thin sheets that dissolve into foam when exposed to water. Due to its small and lightweight design, it is easy to carry and ideal for outdoor use. To maintain its overall quality, paper soap is intended for single-use per sheet [3][4].

The formulation of paper soap is based on the saponification reaction between oils or fats and alkali. The type of oil used affects the soap's properties, including foam production and its impact on the skin. In paper soap production, palm oil is commonly used. Palm oil contains phospholipids, glycolipids, diglycerides (4.5%), and monoglycerides (0–9.9%) as its main glyceride components, making up 93% of its total composition. Its fatty acid content includes 42–44% palmitic acid, 35–40% oleic acid, 10% linoleic acid, 0.3% linolenic acid, 0.3% arachidonic acid, 0.3–5% lauric acid, and 0.5–1% myristic acid. The high content of palmitic acid ($C_{16}H_{32}O_2$) helps produce stable and abundant foam while also increasing the soap's hardness. Consumers often perceive rich-lathering soap as more effective for cleansing [5][6].

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In addition to cleansing the dirt on the body, soap can also help eliminate and inhibit the growth of bacteria on the skin's surface. Soap with antibacterial properties is known as antiseptic soap. A good antiseptic soap should effectively remove dirt and bacteria without harming skin health. One potential material as an antibacterial component in soap is cinnamon extract. The cinnamon plant, also known as *Cinnamomum burmanni*, is a plant with strong antibacterial properties. It contains various chemical compounds such as essential oils, tannins, resins, flavonoids, saponins, and triterpenoids. Beyond its use as a cooking ingredient, cinnamon offers numerous benefits for the skin due to its anti-inflammatory, antioxidant, and antimicrobial properties. These qualities help reduce inflammation, combat free radicals, protect the skin from infections, provide essential nutrients, and minimize the appearance of acne and scars. Additionally, cinnamon's antioxidant activity is linked to cinnamaldehyde, an active compound known for its antibacterial effects [7].

Research on the production of solid soap with the addition of cinnamon extract and coconut oil as the main ingredient has been conducted by Nurani et al. [8]. Further, Neswati et al. [9] developed a transparent solid soap using palm oil and gambier microparticle extract and analyzed its chemical and antibacterial properties against *Staphylococcus aureus*. Putra et al. [10] manufactured solid soap using palm oil with the addition of grapefruit peel (*Citrus maxima*) and analyzed its antibacterial properties against *Staphylococcus aureus* and *Pseudomonas aeruginosa*. Luthfiyana et al. [11] developed antibacterial paper soap made from olive oil and nanochitosan for inhibiting the growth of *Staphylococcus aureus* and *E. coli*. However, no study has specifically examined the development of paper soap using palm oil as the base ingredient and incorporating cinnamon extract as an active component. Therefore, this study aims to develop a paper soap formulation based on palm oil with the addition of cinnamon extract and to evaluate the physicochemical and organoleptic characteristics of the resulting product.

The development of paper soap products is expected to enhance the added value of cinnamon as one of the agricultural products, in line with previous studies by Marjanah et al. [12] on the utilization of agricultural commodities as raw materials for paper soap production, which also serve as entrepreneurial opportunities for local communities. Moreover, this research highlights the potential of agricultural raw materials—particularly cinnamon—as sustainable inputs for innovative, bio-based consumer products, particularly in the production of paper soap.

2 Method

2.1 Equipment and Materials

The equipment used in the paper soap production process includes an analytical balance, blender, thermometer, stove or stirring hotplate, magnetic stirrer, stirring rod, spatula, measuring cylinder, beaker glass, knife, brush, and container. For the analysis of paper soap, the equipment used includes an analytical balance, pH meter, beaker glass, hot plate, test tubes, porcelain crucible, weighing bottle, oven, desiccator, 250 mL Erlenmeyer flask, water bath, dropper pipette, burette, glass funnel, measuring cylinder, autoclave, incubator, disc paper, inoculating needle, Erlenmeyer flask, tweezers, cotton swab, Bunsen burner, petri dish, spatula, caliper, FTIR-8400S spectrophotometer, agate mortar, and hydraulic vacuum press.

The materials used in the production of paper soap include palm oil, cinnamon, water, stearic acid, 30% NaOH, 96% ethanol, glycerin, coco-DEA, NaCl, EDTA, BHT, texapon, granulated sugar, wax paper, and filter paper. The materials used for the analysis process include distilled water, 96% alcohol, phenolphthalein (PP) indicator, 0.1 N HCl, Nutrient Agar (NA) media, *Escherichia coli* bacteria, Nutrient Broth (NB) media, NaCl, and anhydrous KBr.

2.2 Experimental Design

The experimental design used in this study is a Completely Randomized Design (CRD) with two factors: temperature variation and extraction time of cinnamon. The temperature factor consists of three levels: 60°C, 70°C, and 80°C, while the time factor consists of two levels: 15 minutes and 20 minutes. Each treatment level is repeated three times, resulting in a total of 18 experimental sample units. The combination of treatments in this study is presented in Table 1. All data obtained from this study were analyzed using the statistical method ANOVA (Analysis of Variance) at a 5% significance level and Least Significant Difference (LSD) test.

Table 1. Treatment Combinations

Temperature (T)	Time (W)	Treatment Combination
T_1 (60°C)	W_1 (15 minutes)	T_1W_1
T_1 (60°C)	W_2 (20 minutes)	T_1W_2
T_2 (70°C)	W_1 (15 minutes)	T_2W_1
T_2 (70°C)	W_2 (20 minutes)	T_2W_2

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T_3 (80°C)	W_1 (15 minutes)	T_3W_1
T_3 (80°C)	W_2 (20 minutes)	T_3W_2

2.3 Paper Soap Production

The production of paper soap involves two main processes: (1) the extraction of cinnamon and (2) the formulation of the soap.The extraction of cinnamon was conducted using the boiling method. Initially, 300 g of cinnamon was cut into smaller pieces (2 cm) and ground into a fine powder with an 80-mesh size. A total of 5 g of cinnamon powder was then weighed and dissolved in 100 mL of water as a solvent. The mixture was subsequently boiled at varying temperatures (60°C, 70°C, and 80°C) for 15 and 20 minutes, with temperature monitoring performed using a thermometer. Finally, the extract was filtered using fine filter paper to obtain the filtrate.

The process of making paper soap involves several steps. First, 20 mL of palm oil is placed in a beaker glass and heated on a hot plate at 65°C. Then, 7 g of stearic acid and 20 mL of 30% NaOH solution are added while maintaining the temperature at 65°C and stirring for 2 minutes. Next, additional ingredients are incorporated, including 15 mL of 96% ethanol, 13 mL of glycerin, 3 mL of coco-DEA, 0.3 g of NaCl, 0.1 g of EDTA, 0.1 g of BHT, 7 g of texapon, and 3 g of sugar (pre-dissolved in distilled water). The mixture is stirred for another 2 minutes at 75°C.

Before adding the cinnamon extract, the mixture is allowed to cool to approximately 50°C. Then, 10 mL of cinnamon extract is added, and stirring continues for 2 minutes at 55°C. The soap mixture is then evenly spread onto wax paper using a brush to a thickness of 1 mm and left to dry at room temperature (25°C) for 24 hours. Once dried, the paper soap is cut into 3×3 cm sheets. The following diagram illustrates the paper soap production process.

2.4 Research Analysis

2.4.1 Foam Stability Test

Initially, 1 g of paper soap was weighed and placed into a 50 mL beaker glass. Then, 10 mL of distilled water was added, and the mixture was heated on a hot plate until the soap completely dissolved. After allowing the solution to cool, it was transferred into a test tube and shaken for 3 minutes to generate foam. The initial foam height was measured, followed by another measurement after letting the foam settle for 5 minutes. The percentage of foam loss was then calculated using the formula:

$$\text{Foam Loss (\%)} = \frac{\text{initial foam height} - \text{final foam height}}{\text{initial foam height}} \text{ x } 100\% \quad (1)$$

2.4.2 Free Alkali Test

The free alkali test was performed using the following procedure [13]: First, 5 g of paper soap sample was weighed and placed into a 250 mL Erlenmeyer flask, followed by the addition of 25 mL of 96% ethanol. The mixture was then heated on a hot plate until it reached boiling point and maintained in this state for 10 minutes before being cooled while ensuring the soap remained in liquid form. Subsequently, three drops of phenolphthalein (PP) indicator were added, and the solution was titrated with 0.1 N HCl solution until the color disappeared. The titration volume was then recorded. The percentage of free alkali was calculated using the formula:

$$\text{Free Alkali (\%)} = \frac{\text{HCl Volume x HCl Normality x } 0.04}{\text{Sample Weight}} \text{ x } 100\% \quad (2)$$

2.4.3 Moisture Content Analysis

The moisture content analysis was conducted using the following procedure [14]: First, the weighing dish was heated in an oven at approximately 105°C for 30 minutes, then cooled in a desiccator to remove moisture before weighing. Next, 4 g of the sample was weighed into the pre-dried dish. The sample was then placed in an oven at approximately 105°C for 2 hours, followed by cooling in a desiccator for 30 minutes before being weighed again. The container was sealed while in the oven and then transferred to the desiccator. The weighing process was repeated until a constant weight was obtained.

The moisture content was calculated using the following formula:

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$$\text{Moisture Content (\%)} = \frac{W_1 - W_2}{W} \text{ x } 100\% \quad (3)$$

where W_1 represents the weight of the container and sample before drying, W_2 is the weight after drying, and W is the weight of the sample.

2.4.4 Functional Group Analysis

The functional compounds of the paper soap were analyzed using Fourier Transform Infrared (FTIR) spectroscopy. The spectra were recorded using an FTIR-8400S spectrophotometer (Shimadzu Deutschland GmbH) with KBr and polyethylene pellets. A total of 0.001 g of the sample was weighed and homogenized with 0.01 g of anhydrous KBr using an agate mortar. The mixture was then pressed into a transparent pellet using a vacuum hydraulic press (Gaseby Specac) at a pressure of 1.2 psi. Afterward, the sample was scanned by passing infrared radiation through it, with the resulting wavelengths detected by a sensor connected to a computer, generating a set of spectral values for analysis. The sample was typically scanned within the absorption range of 500–4000 cm^{-1}. The analysis results depend on the chemical structure, molecular bonding, and functional groups present in the sample.

2.4.5 Antibacterial Activity Test

Before the testing process begins, all equipment is sterilized using an autoclave for 30 minutes at a pressure of 15 dyne/cm^3 (1 atm) and a temperature of 121°C. The equipment is first washed, dried, and wrapped in paper. A bacterial suspension of *Escherichia coli* is then prepared by using an inoculating loop to collect bacteria and suspending them in a test tube containing 5 mL of sterile 0.9% physiological NaCl solution. The preparation of Nutrient Agar (NA) for bacterial cultivation begins with weighing 2.8 g of NA into an Erlenmeyer flask, adding 100 mL of distilled water, and heating the solution on a hotplate while stirring until homogeneous. The mixture is then sterilized in an autoclave at 121°C for 15 minutes. Under aseptic conditions, the media is poured into sterile petri dishes and left at room temperature until solidified [16].

Next, 1 mL of the bacterial suspension is introduced into a petri dish, followed by the addition of 15 mL of NA medium. For each treatment (sample), a paper disc is immersed in a solution prepared by dissolving 1 g of paper soap in 9 mL of distilled water. The positive control contains the formulated paper soap, while the negative control is prepared by adding only distilled water to a paper disc. The treated paper discs are then placed onto the solidified NA medium. The petri dishes are incubated for 24 hours, after which the inhibition zones around the paper discs are observed and measured using a caliper [16].

2.4.6 Organoleptic Test

The organoleptic test was conducted with 25 panelists to evaluate the physical characteristics of the formulated paper soap using sensory perception and a scoring system. This test assessed the color, aroma, and overall thickness of the soap preparation using a five-point scale [15]. The Likert scale for each category is presented in Table 2.

Table 2. The Likert Scale for Each Category

Likert Scale	Color	Aroma	Thickness
1	Very white	Very weak cinnamon aroma	Very thick
2	White	Weak cinnamon aroma	Thick
3	Slightly brown	Slight cinnamon aroma	Slightly thick
4	Brown	Cinnamon aroma	Thin
5	Very brown	Strong cinnamon aroma	Very thin

2.4.7 Skin Irritation Test

The skin irritation test was conducted using the open patch test method with panelists. A small amount of the paper soap was applied to the skin and left for 5 minutes to observe any signs of irritation, such as redness or itching symptoms [17].

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3 Results and Discussion

3.1 Foam Stability, Free Alkali, and Moisture Content

The foam stability, pH, free alkali, and moisture content of the cinnamon extract paper soap varied among treatment combinations, as presented in Table 3. The foam height or foam stability test was conducted to determine the foam height produced by the cinnamon extract paper soap formulation. This was done by shaking the sample and allowing it to stand for 5 minutes. The highest average foam stability of cinnamon extract paper soap was observed at 80°C for 15 minutes, with a value of 11.3659%, while the lowest was recorded at 60°C for 15 minutes, at 2.7595%. A lower average foam stability value indicates better foam stability. The foam stability test in this study was conducted at a 5% significance level. The extraction temperature treatment showed a significant effect on foam stability, as indicated by F calculated > F table (6.5916 > 3.8852). However, the extraction time had no significant effect, with F calculated < F table (0.2246 < 4.7472). Meanwhile, the interaction between extraction temperature and time had a highly significant effect, as shown by F calculated > F table (7.3574 > 3.8852). Since the extraction temperature had a significant influence on foam stability, further analysis was performed using the Least Significant Difference (LSD) test. The LSD test results indicated that the 60°C 15-minute treatment differed significantly from the 60°C 20-minute treatment. However, the 60°C 20-minute treatment did not significantly differ from the 70°C 15-minute treatment. Similarly, the 70°C 15-minute treatment was not significantly different from the 70°C 20-minute treatment, and the 70°C 20-minute treatment did not significantly differ from the 80°C 15-minute treatment. Lastly, the 80°C 15-minute treatment was not significantly different from the 80°C 20-minute treatment.

Table 3. Foam Stability, Free Alkali Content, and Moisture Content of Cinnamon Extract Soap Based on Treatment Combinations

Treatment Combination	Foam Stability (%)	Free Alkali (%)	Moisture Content (%)
T_1W_1	2,7595±0,9468	1,7006±0,0141	1,6573±0,8223
T_1W_2	8,9010±1,8587	1,3262±0,0147	1,6891±0,6796
T_2W_1	10,3724±1,6356	2,0767±0,0187	1,6582±0,0407
T_2W_2	7,8260±1,5511	1,0806±0,0112	1,6781±0,0351
T_3W_1	11,3659±3,1139	2,2238±0,0187	1,7141±0,3354
T_3W_2	9,2524±3,1924	0,4322±0,0043	1,7698±0,8975

The foam stability of cinnamon extract soap ranged from 2% to 11%. This result is supported by the study of Nurani et al. [8], which reported foam formation ranging from 9% to 11%. The variation in foam height was influenced by manual shaking during testing, leading to inconsistencies in foam stability. Additionally, differences in treatments affected foam stability since cinnamon contains saponins, which contribute to foam formation. Saponins have foaming properties that, when mixed with water and agitated, produce stable foam. As a secondary metabolite with soap-like characteristics, saponins function as natural surfactants [18]. Cinnamon also contains essential oils that can influence soap foam quality. These oils impact the texture and stability of the foam. The extraction temperature and duration affect the quantity and concentration of essential oils in the extract. Excessively high temperatures or prolonged extraction times may degrade the essential oils or reduce their quality, ultimately affecting soap foam formation [8]. Foam stability refers to the ability of foam to maintain its structure over a specific period. A soap with good foam stability retains its foam without rapid collapse. A higher percentage of foam loss indicates lower residual foam after a set period, signifying unstable foam that dissipates quickly [19].

The free alkali test was conducted to determine the presence of excess free alkali, which can cause skin irritation in the formulated soap. Free alkali or free fatty acids refer to fatty acids present in soap but not bound as sodium compounds or triglycerides (neutral fats) [20]. According to the Indonesian National Standard (SNI) for solid soap [20], the maximum allowable free alkali content is 0.1%. Based on Table 3, the analysis of free alkali in cinnamon extract paper soap showed that the highest average free alkali content was 2.2238% at 80°C for 15 minutes, while the lowest was 0.4322% at 80°C for 20 minutes. The free alkali levels obtained in this study did not meet the SNI standards for solid soap.

In this study, the extraction temperature of cinnamon had an F-value higher than the F-table (481.6029 > 3.8852), indicating a significant difference. Similarly, the extraction time also showed a highly significant difference (F-value 23744.0343 > 4.7472). Moreover, the interaction between extraction temperature and time was also significantly different (F-value 3595.2350 > 3.8852). These results suggest that extraction temperature and time had a highly significant effect on the free alkali content of the paper soap. Further analysis using the Least Significant Difference (LSD) test revealed that the treatment at 60°C for 15 minutes was significantly different from 60°C for 20 minutes. The treatment at 60°C for 20 minutes was significantly different from 70°C for 15 minutes, which also differed from 70°C for 20 minutes. The treatment at 70°C for 20 minutes was

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significantly different from 80°C for 15 minutes, while 80°C for 15 minutes also showed a significant difference from 80°C for 20 minutes.

During the 15-minute extraction time, an increase in free alkali content was observed as the extraction temperature increased. In contrast, during the 20-minute extraction time, a decrease in free alkali content was noted as the temperature increased. Generally, the rise in free alkali content correlates with an increase in the soap's pH. However, at high extraction temperatures and prolonged extraction times, the free alkali content decreased. This is likely due to the degradation of certain cinnamon components, including the active compound cinnamaldehyde, which may affect the saponification process and lead to a reduction in free alkali content [21]. Cinnamaldehyde is the key active compound in cinnamon that contributes to free alkali formation in soap. During soap production, cinnamaldehyde can act as a catalyst that influences reaction rates by lowering activation energy, thereby affecting the formation of free alkali [22].

Significant differences in free alkali content in solid soap influenced by cinnamon extraction temperature and time may be attributed to variations in the rate and completeness of the saponification reaction, as well as the efficiency of extracting cinnamon components. This finding aligns with the study by Dinastuti et al. [21], which reported a free alkali content of 0.01% in solid soap with added cinnamon extract. The presence of free alkali in soap results from an incomplete saponification reaction. Increased free alkali content is influenced by excess NaOH, which fails to completely bind with oils, leaving residual alkali in the soap. This occurs due to the heating and stirring involved in the soap-making process, where sodium hydroxide, a key soap-forming agent, reacts with fatty acids or oils [23]. The high free alkali content in the cinnamon extract paper soap may also be attributed to the alkaline nature of cinnamon extract, which has a pH of 8.5.

The determination of moisture content is conducted to measure the amount of water present in the soap. According to the Indonesian National Standard [20], the maximum allowable moisture content in soap is 15%. In solid bath soap, moisture content indicates the amount of water retained within the formulation. Based on the data in Table 3, the analysis of moisture content in paper soap shows an increasing trend across different treatments. The highest average moisture content was recorded at 80°C for 20 minutes, reaching 1.7698%, while the lowest average was observed at 60°C for 15 minutes, with a value of 1.657%. The extraction temperature treatment for cinnamon showed an F-value (0.0297) lower than the F-table value (3.8852), indicating no significant difference. Similarly, the extraction time treatment had an F-value (0.0168), which was also lower than the F-table value (4.7472), meaning no significant difference. Additionally, the interaction between extraction temperature and time resulted in an F-value (0.0015) lower than the F-table value (3.8852), indicating no significant interaction effect.

The extraction temperature and duration of cinnamon in paper soap did not significantly affect its moisture content. This is because the soap-making process, including saponification and drying, along with the relatively low extract concentration, plays a more dominant role in determining the final moisture content. These findings align with the study by Dinastuti et al. [21], which reported that variations in cinnamon extraction temperature did not significantly impact the moisture content of solid soap, with moisture levels ranging from 1% to 3%. Although extraction temperature and duration can influence the components of cinnamon that dissolve in the solvent, they do not necessarily alter the soap's moisture content. If the extraction process does not significantly modify the structure or chemical composition of the soap, the moisture content remains unchanged. However, if higher extraction temperatures and longer durations lead to increased moisture content, this may be due to chemical reactions during extraction that enhance the soap's ability to absorb water [24].

3.2 Functional Group Analysis

Functional group analysis was conducted to identify the functional groups present in cinnamon extract. Fourier Transform Infrared (FTIR) spectroscopy was employed as an analytical tool to detect functional groups, identify compounds, and analyze sample mixtures without causing any structural damage. The wavenumbers obtained from the FTIR spectra were compared with reference data to determine the corresponding functional groups. In this study, the analysis was done by using paper soap treated at 70°C for 15 minutes (T_2W_1) and paper soap treated at 70°C for 20 minutes (T_2W_2). The FTIR spectra for T_2W_1 are presented in Figure 1 and 2, respectively.

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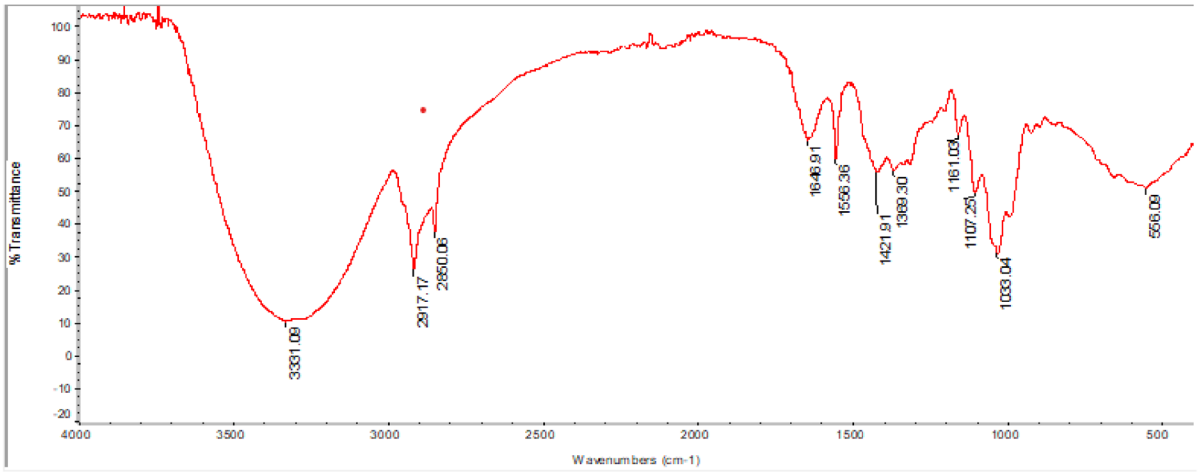

Figure 1. FTIR Spectra for Paper Soap Treated at 70°C for 15 Minutes (T_2W_1)

Based on Figure 1, a total of 11 functional groups were identified. These functional groups include aromatic groups, primary alcohol (R-OH, CH_2OH), secondary alcohol (R-OH, CHROH), alkyl halides (R-X), nitro ($-NO_2$), aldehyde, alkene, methylene alkane ($-CH_2-$), methyl alkane ($-CH_3-$), and hydroxyl (-OH) groups. The numerical values below the peaks in the chromatogram represent the peak frequencies corresponding to each functional group. The FTIR spectrum of functional groups in cinnamon extract paper soap at 70°C for 15 minutes shows a peak at 3331.09 cm^{-1}, indicating the presence of an -OH group. The peak at 2917.17 cm^{-1} corresponds to the methyl alkane ($-CH_3-$) group, while the peak at 2850.06 cm^{-1} indicates the presence of a methylene alkane ($-CH_2-$) group. The alkene group is observed at 1646.91 cm^{-1}, and the aromatic groups are detected at 1556.36 cm^{-1} and 556.09 cm^{-1}. Additionally, the aldehyde group appears at 1421.91 cm^{-1}, the nitro ($-NO_2$) group at 1369.30 cm^{-1}, the alkyl halide (R-X) group at 1161.03 cm^{-1}, the secondary alcohol (R-OH, CHROH) group at 1107.25 cm^{-1}, and the primary alcohol (R-OH, CH_2OH) group at 1033.04 cm^{-1}.

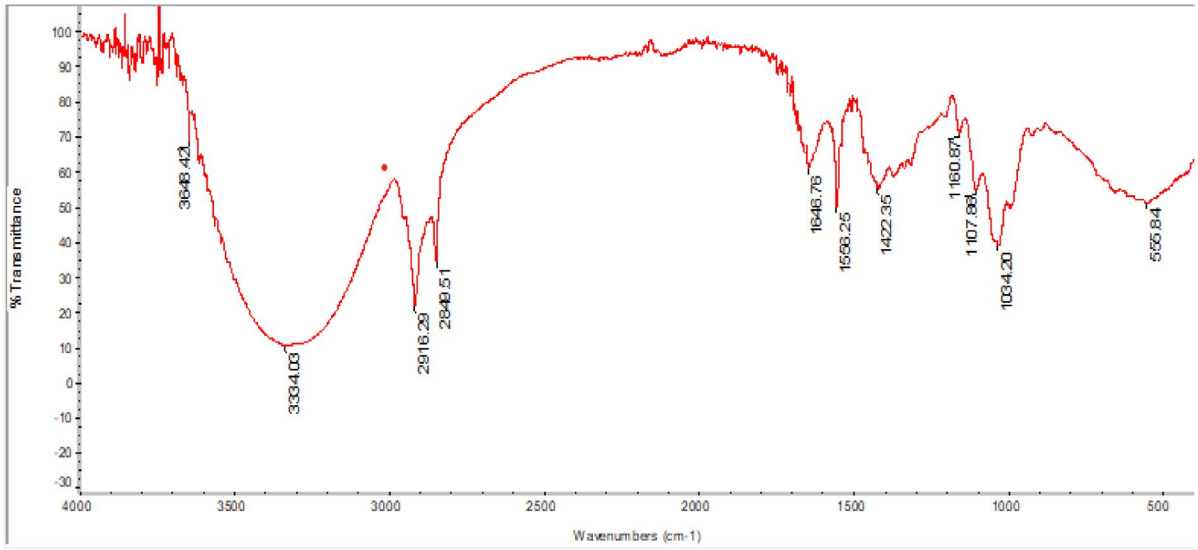

Figure 2. FTIR Spectra for Paper Soap Treated at 70°C for 20 Minutes (T_2W_2)

Based on Figure 2, 11 functional groups were identified, including aromatic groups, primary alcohol (R-OH, CH_2OH), secondary alcohol (R-OH, CHROH), alkyl halides (R-X), aldehyde, alkene, methylene alkane ($-CH_2-$), methyl alkane ($-CH_3-$), and hydroxyl (-OH) groups. The wavenumbers corresponding to these groups were obtained from the FTIR spectrum of cinnamon extract paper soap at 70°C for 20 minutes. A peak at 3648.42 cm^{-1} indicates the presence of a primary alcohol (R-OH, CH_2OH) group, while a peak at 3334.03 cm^{-1} corresponds to the hydroxyl (-OH) group. The methyl alkane ($-CH_3-$) group appears at 2916.29 cm^{-1}, and the methylene alkane ($-CH_2-$) group at 2849.51 cm^{-1}. The alkene group is detected at 1646.76 cm^{-1}, and the aromatic groups at 1556.25 cm^{-1} and 555.84 cm^{-1}. Additionally, the aldehyde group is found at 1422.35 cm^{-1}, the alkyl halide (R-X) group at 1160.87 cm^{-1}, the secondary alcohol (R-OH, CHROH) group at 1107.86 cm^{-1}, and the primary alcohol (R-OH, CH_2OH) group at 1034.20 cm^{-1}.

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These results align with those of Sembiring et al. [25], who identified functional groups in cinnamon extract within a wavenumber range of 4403.49 cm^{-1} to 393.48 cm^{-1}. Their study identified characteristic aromatic ring signals at 1689.64 cm^{-1}, supporting the presence of aromatic groups in this study at 1556.25 cm^{-1} and 555.84 cm^{-1}. Aromatic functional groups are known to have antioxidant properties. As described by Mulyani [26], the aroma of cinnamon is influenced by its aromatic compounds, such as cinnamaldehyde, eugenol, safrole, camphor, aceteugenol, and minor aldehydes. In this study, both of the samples had the same functional groups with variations in the wavenumber range.

3.3 Antibacterial Activity

Antibacterial activity testing can be conducted using diffusion and dilution methods. The disc diffusion test measures the diameter of the clear zone, which indicates bacterial growth inhibition due to the presence of antibacterial compounds in an extract. The antibacterial activity test on cinnamon extract-infused paper soap was performed using the disc diffusion method. This method is advantageous as it is simple, fast, and cost-effective, requiring no specialized equipment. The purpose of this antibacterial activity test is to evaluate the ability of cinnamon extract-infused paper soap to inhibit the growth of *Escherichia coli* [27]. Based on the research results presented in Figure 3, a clear zone was observed around the paper disc on the agar medium. This clear zone indicates an inhibition area where *Escherichia coli* growth was suppressed due to the effect of cinnamon extract in the paper soap. The formation of this inhibition zone confirms that cinnamon extract has antibacterial activity against *Escherichia coli*, which can be assessed by measuring the diameter of the inhibition zone. The measurement was conducted using a caliper, revealing the presence of a clear zone surrounding the paper disc.

The research results indicate that the diameter of the antibacterial inhibition zone varies depending on the combination of extraction temperature and time. The T_2W_1 (70, 15) treatment produced the largest inhibition zone (1.6±0.8505 mm), followed sequentially by T_1W_2 (60, 20) 1.4±0.5292 mm, T_1W_1 (60, 15) 1.3±0.1000 mm, T_3W_1 (80, 15) 1.2±0.0577 mm, T_3W_2 (80, 20) 1.1±0.0874 mm, and T_2W_2 (70, 20) 1.05±0.0700 mm.The highest average inhibition zone was observed in the treatment at 70°C for 15 minutes, with a diameter of 1.6 mm, while the smallest inhibition zone was found in the treatment at 70°C for 20 minutes, measuring 1.05 mm. Additionally, distilled water (aquadest) was used as a negative control in this study. Observations showed that no inhibition zone formed around the paper disc in the negative control treatment, with an average diameter of 0.00 mm, indicating no antibacterial activity against *Escherichia coli*. The analysis results indicated that the effect of extraction temperature on cinnamon extract had an F-value lower than the critical F-table value ($0.4548 < 3.8852$), meaning there was no significant difference. Similarly, the effect of extraction time also had an F-value lower than the F-table ($0.6716 < 4.7472$), confirming no significant difference. The interaction between temperature and extraction time also showed no significant difference, as the F-value was lower than the F-table ($0.8926 < 3.8852$). This indicates that variations in temperature and extraction time in the preparation of cinnamon extract paper soap did not significantly influence its antibacterial activity.

According to Fitryani [28], the extraction temperature of cinnamon affects its active compounds, as these compounds are heat-sensitive. When exposed to high temperatures, these active compounds may degrade, leading to reduced antibacterial efficacy. Cinnamon contains several antimicrobial compounds, including essential oils, flavonoids, saponins, tannins, and alkaloids. Although these compounds have different mechanisms of action, they share a common function in inhibiting bacterial growth. One of the key active compounds in cinnamon is cinnamaldehyde, which has been proven to exhibit antibacterial properties. A previous study by Aqmarina et al. [29] found that cinnamon contains 61.53% cinnamaldehyde at various tested concentrations. In this study, the optimal extraction temperature for antibacterial activity was determined to be 70°C. The diameter of the inhibition zone serves as an indicator of the strength of the active compounds in cinnamon extract in suppressing microbial growth. The larger the inhibition zone, the stronger the antibacterial properties of the active compounds [30]. The results of this study align with previous research by Noviano et al. [31], which also confirmed that cinnamon possesses antibacterial activity against *Escherichia coli*. This antibacterial effect is attributed to the flavonoid content in cinnamon, which acts by forming complexes with extracellular proteins and disrupting the integrity of bacterial cell membranes.

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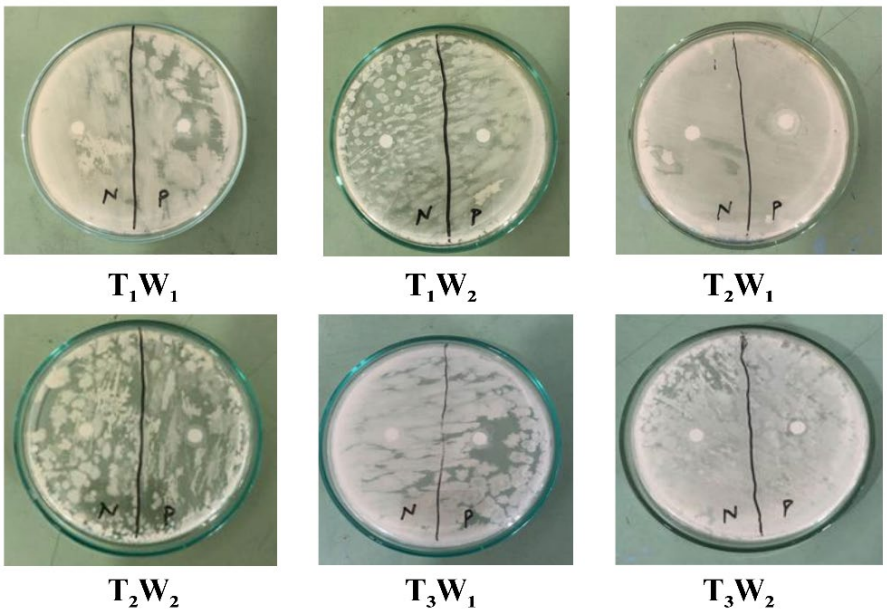

Figure 3. Inhibitory Effect of Cinnamon Extract Paper Soap on the Antibacterial Activity Against *Escherichia Coli*

3.4 Organoleptic Test Results

The organoleptic test results were obtained from various treatments involving different temperatures and extraction durations of cinnamon. Table 4 presents the organoleptic data for color, aroma, and thickness based on the average results of each treatment. Color is the wavelength of light reflected from the soap, which can be perceived by the panelists' vision. After aroma, color is the most significant factor influencing the appeal of both food and non-food products. According to Musfiroh [32], color is one of the key parameters used to assess product quality. A product with an appealing color can create a positive impression, even if it does not necessarily indicate better functionality.

Table 4. The Organoleptic Score (from Likert Scale) for Each Category in Each Combination

Treatment Combination	Color	Aroma	Thickness
T_1W_1	3,560±0,583	2,280±0,891	4,200±0,816
T_1W_2	4,160±0,624	1,880±0,781	3,000±0,816
T_2W_1	4,200±0,645	2,200±0,764	4,000±0,764
T_2W_2	3,600±0,645	2,200±0,816	3,160±1,068
T_3W_1	2,720±0,542	2,440±0,768	3,280±0,792
T_3W_2	2,600±0,645	2,920±1,038	2,600±0,500

Based on Table 4, the treatments involving cinnamon extract paper soap at 60°C for 15 minutes, 60°C for 20 minutes, 70°C for 15 minutes, and 70°C for 20 minutes resulted in white-colored soap. In contrast, treatments at 80°C for 15 minutes and 80°C for 20 minutes produced soap with a slightly brownish hue. These findings suggest that the temperature and duration of cinnamon extraction significantly influence the color of the paper soap formulation. The color scoring test for cinnamon extract paper soap yielded a 5% significance level, where the panelist evaluation showed an F-value (3.3510204) greater than the F-table value (1.608437096), indicating a highly significant difference. Similarly, the sample analysis showed an F-value (43.2244898) greater than the F-table value (2.289851283), confirming a highly significant difference. These results indicate that the temperature and duration of cinnamon extraction have a statistically significant impact on the color of the paper soap. Therefore, further analysis was conducted using the Least Significant Difference (LSD) test. The results of the LSD test revealed that the treatment at 60°C for 15 minutes was significantly different from 60°C for 20 minutes, while 60°C for 20 minutes was not significantly different from 70°C for 15 minutes. However, the treatment at 70°C for 15 minutes was significantly different from 70°C for 20 minutes, and 70°C for 20 minutes was significantly different from 80°C for 15 minutes. Additionally, the treatment at 80°C for 15 minutes was significantly different from 80°C for 20 minutes.

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The scoring test results indicate that higher extraction temperatures and longer durations lead to a more brownish color in the soap [26]. These findings are supported by previous research conducted by Nurani et al. [8], which found that solid soap turned brown as the concentration of cinnamon extract increased. Higher extraction temperatures accelerate the extraction process and increase the solubility of color compounds in cinnamon extract, leading to a more intense color in paper soap. However, excessively high temperatures may also cause the degradation of color compounds and other active substances, which could reduce both the color quality and the beneficial properties of the extract.

Aroma is considered an important evaluation parameter as it quickly provides an assessment of the product's acceptability by consumers [33]. The aroma of a product is perceived when volatile compounds enter the nasal passage and are detected by the olfactory system. Based on Table 4, the aroma of the cinnamon extract paper soap ranged from weak to slightly noticeable. This indicates that higher extraction temperatures influence the resulting aroma intensity. the aroma scoring test at a 5% significance level showed that the panelist evaluation had an F-value (4.0355566) greater than the F-table value (1.608437096), indicating a highly significant difference. Similarly, the sample analysis yielded an F-value (6.2579596) greater than the F-table value (2.289851283), confirming a highly significant difference. These results demonstrate that extraction temperature and duration significantly impact the aroma of the paper soap. Consequently, further analysis was conducted using the Least Significant Difference (LSD) test. The LSD test results indicated that the treatment at 60°C for 15 minutes was significantly different from 60°C for 20 minutes, 60°C for 20 minutes was significantly different from 70°C for 15 minutes, while 70°C for 15 minutes was not significantly different from 70°C for 20 minutes. However, 70°C for 20 minutes was significantly different from 80°C for 15 minutes, and 80°C for 15 minutes was significantly different from 80°C for 20 minutes.

The aroma scoring results show that higher extraction temperatures and longer durations lead to a stronger cinnamon scent. These findings align with a study by Dinastuti et al. [21], which found that higher cinnamon extraction temperatures resulted in a more intense cinnamon aroma in soap. Higher temperatures enhance the dissolution rate of aromatic compounds from cinnamon. Compounds such as cinnamaldehyde and eugenol, which provide the distinctive cinnamon scent, dissolve more effectively in solvents at elevated temperatures. Consequently, a greater number of aromatic compounds is extracted, leading to a stronger aroma in the soap. This confirms that extraction temperature and duration significantly influence the fragrance intensity of the produced soap. According to Othman et al. [34], cinnamon extraction temperature and duration affect the physical characteristics of the extract. The extraction process causes cell wall components to break down due to pressure differences inside and outside the cell. Since aromatic compounds in cinnamon, such as cinnamaldehyde, are highly volatile, optimizing extraction temperature and duration is crucial to achieving the best extraction process.

Furthermore, the thickness of a product is an essential factor as it can influence consumer preference. In general, paper soap is designed to be thin, resembling a sheet. According to Table 4, the thickness of cinnamon extract paper soap varied depending on the extraction conditions. The soap produced at 60°C for 15 minutes and 70°C for 15 minutes was categorized as thin, whereas the soap from treatments at 60°C for 20 minutes, 70°C for 20 minutes, 80°C for 15 minutes, and 80°C for 20 minutes was classified as slightly thin. The results indicate that higher extraction temperatures and longer durations reduce the thinness of the soap, while lower temperatures and shorter durations result in thinner paper soap.

The thickness scoring test at a 5% significance level showed that the panelist evaluation had an F-value (3.58598) greater than the F-table value (1.608437096), indicating a highly significant difference. Similarly, the sample analysis yielded an F-value (20.3852) greater than the F-table value (2.289851283), confirming a highly significant difference. This suggests that extraction temperature and duration significantly affect the thickness of the paper soap. Consequently, further analysis was conducted using the Least Significant Difference (LSD) test. The LSD test results showed that the treatment at 60°C for 15 minutes was significantly different from 60°C for 20 minutes, 60°C for 20 minutes was significantly different from 70°C for 15 minutes, 70°C for 15 minutes was significantly different from 70°C for 20 minutes, 70°C for 20 minutes was significantly different from 80°C for 15 minutes, and 80°C for 15 minutes was significantly different from 80°C for 20 minutes.

The scoring test for the thickness of cinnamon extract paper soap confirms that extraction temperature and duration significantly influence soap thinness. Higher extraction temperatures tend to reduce the thinness of the soap due to faster drying processes and changes in the viscosity of the soap mixture. Additionally, the soap processing method also affects its thinness. If the molding process is performed quickly, the soap mixture solidifies rapidly, resulting in uneven thinness. This is due to the heating and stirring process during soap production, which influences saponification. Sodium hydroxide, as a base-forming agent in soap, reacts with fatty acids or oils, leading to saponification and a faster soap solidification process [23].

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3.5 Skin Irritation Test Results

Skin irritation testing is one of the essential requirements for high-quality paper soap formulations. This test aims to determine whether the product causes any adverse effects on the skin. Irritation testing is a crucial part of product safety procedures [35]. In this study, the irritation test was conducted using paper soap formulations with the highest and lowest antibacterial activity. The soap was applied to the hands of panelists, left for five minutes, and observed for any reactions such as itching, burning sensation, dryness, or redness.

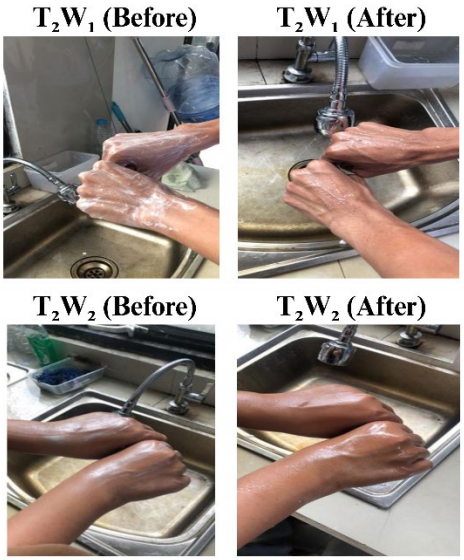

Figure 4. Observations on the Irritation Test of Cinnamon Extract Paper Soap

The results presented in Figure 4 showed that the cinnamon extract paper soap produced at 70°C for 15 minutes (T_2W_1), which exhibited the highest antibacterial activity, did not cause skin irritation. Similarly, the formulation at 70°C for 20 minutes (T_2W_2), which had the lowest antibacterial activity, also did not cause irritation. This is because the pH and free alkali content of the soap were not excessively high, preventing skin irritation. These findings align with a previous study by Mulyani et al. [26], which reported no irritation from soap made with cinnamon bark powder. High levels of free alkali can cause skin irritation and are typically indicated by an excessively high soap pH [19]. Based on the free alkali and pH test parameters—both of which influence skin irritation—the cinnamon extract paper soap in this study was found to be safe for use.

4 Conclusion

Based on the research findings, the extraction temperature and duration of cinnamon significantly influenced the chemical and physical properties of paper soap. The optimal conditions varied for different parameters. The best results for moisture content and foam stability were obtained at an extraction temperature of 60°C for 15 minutes, while free alkali content was best at 80°C for 20 minutes. The antibacterial properties showed the best results at 70°C for 15 minutes. In the organoleptic evaluation, the optimal conditions for color scoring were at 60°C for 20 minutes, aroma scoring at 80°C for 20 minutes, and thickness scoring at 60°C for 15 minutes. The analysis further indicated that extraction temperature and duration had a significant effect on free alkali content, foam stability, and skin irritation, as well as organoleptic properties such as color, aroma, and thickness. However, these factors did not significantly affect moisture content and antibacterial properties. The results also demonstrated that the physicochemical characteristics of the paper soap met the quality standards outlined in SNI 06-3532-2016, except for the free alkali content, which exceeded the permissible limit of 0.1%, rendering it non-compliant with soap quality requirements.

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