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Formulation and Antimicrobial Evaluation of Bar Herbal Soap with Cinnamon Bark Powder

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Abstract: Soap is an essential personal care product that not only cleanses the skin but can also provide additional health benefits, such as antibacterial protection. Cinnamon (Cinnamomum sp.) contains bioactive compounds, including flavonoids, phenolics, and cinnamaldehyde, which have demonstrated antibacterial activity. This study aims to formulate and evaluate a solid herbal soap containing cinnamon bark powder at different concentrations, and to assess its physicochemical properties and antibacterial activity against *Staphylococcus aureus*. The methods used include soap production via saponification of oil and an alkali base, followed by the addition of cinnamon bark powder as the active ingredient. The evaluation included organoleptic, homogeneity, pH, and foam stability tests to assess the formulation's physical and chemical quality. The antibacterial activity of the cinnamon herbal soap was tested against *Staphylococcus aureus* using the agar diffusion method with three replicates. The results showed that the herbal solid soap was stable and homogeneous, meeting the physical and chemical requirements for soap. The antibacterial test showed the formation of inhibition zones with diameters of 9.33 ± 0.58 mm, 10.08 ± 1.13 mm, and 11.67 ± 1.44 mm at test concentrations of 10%, 20%, and 30% w/v, respectively. These findings indicate that the cinnamon bark- based herbal soap has potential as a natural antibacterial cleansing product. Further optimization is required to enhance product quality, long-term stability, and safety.

Keywords: Antibacterial; Bar Soap; Cinnamon; Formulation; Herbal Soap.

Introduction

Bar soap is one of the most widely used hygiene products in everyday life. The high rate of soap usage indicates that this product has become a basic necessity for the public. Soap is formed from the saponification reaction between fatty acids and strong bases, which act as cleansing agents to remove dirt and oil from the skin [1]. Soap is formulated with various additives to enhance its functions, such as moisturizers, preservatives, and antioxidants [2]. However, as times have changed, the function of soap has expanded beyond mere cleansing to prioritize other functions, such as acting as an antibacterial agent.

Despite their high usage rate, conventional bar soaps still have several drawbacks. One of their disadvantages is their tendency to dry out the skin due to their relatively high alkalinity. Certain groups of preservatives are also not easily biodegradable, posing a potential risk of contaminating water resources. Additionally, preservatives that release formaldehyde raise safety concerns, such as the risk of skin allergies [3]. Another common issue is the absence of active ingredients that provide additional skin benefits, so the soap functions solely as a cleanser without pharmacological effects. This underscores the need for innovative soap formulations that are safer, gentler, and offer functional added value.

Various studies have been conducted to enhance the quality and benefits of bar soap by adding natural ingredients. One natural ingredient with potential as an antibacterial agent is cinnamon (*Cinnamomum burmanni*). Cinnamon contains bioactive compounds such as flavonoids, phenolics, and cinnamaldehyde, which are known to possess antioxidant, antibacterial, and anti-inflammatory properties [4]. Jin *et al.* reported that bark oil extract from *Cinnamomum burmanni* exhibits antibacterial activity against *Staphylococcus aureus* [5]. Another study also demonstrated that bark extract from *C. burmanni* inhibits the growth of *S. aureus* and *Streptococcus mutans* with an inhibition zone of 13.83 mm [6]. This potential makes Cinnamomum a promising candidate for an active ingredient in cosmetic formulations, including solid soap. Compared with other natural ingredients, cinnamon offers a distinctive aroma and strong biological activity, thereby providing additional therapeutic functions while enhancing the product's appeal.

The majority of research on cinnamon (*Cinnamomum sp.*) as a natural antibacterial agent in cosmetic and personal care products uses extracts or essential oils as the active ingredient. Nafisah et al. (2022) reported that a liquid shop containing essential oil exhibited favorable physicochemical characteristics and antibacterial activity [7]. However, the production of cinnamon essential oil generally relies on steam distillation processes that require specialized equipment and additional processing steps, potentially increasing production costs and affecting the stability of certain bioactive constituents [8]. Despite the growing interest in cinnamon-based formulations, studies investigating the direct incorporation of cinnamon bark powder into soap products remain limited. Furthermore, previous studies have often focused on either antibacterial efficacy or physicochemical quality, while comprehensive assessments that integrate both remain scarce. Therefore, this

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study explored the use of cinnamon bark powder as a direct active ingredient in soap formulations and evaluated both its physicochemical characteristics and antibacterial activity to provide a more comprehensive understanding of its potential application in cosmetic products.

Research Methods

Preparation of Samples

The materials used in this research were virgin coconut oil, stearic acid (Dwilab Mandiri Scientific®), sodium hydroxide (Merck®), glycerin (Brataco®), propylene glycol (Brataco®), sugar liquid, aqua, cinnamon bark powder, Nutrient Agar (Merck®), sterile distilled water, and *Staphylococcus aureus.*

Meanwhile the tool used in this research was beaker glass (Pyrex), measuring cup (Pyrex), analytical balance (Faithful), mixer (Miyako), soap bottle, pH meter (HANNA), test tube, tube rack, incubator (Memmert), petri dish, erlenmeyer (Pyrex), measuring flask (Pyrex), Bunsen, autoclave (KK Gauges), dropper pipette, and laminar airflow (Biobase).

Research Design

This study employed a laboratory experimental design to formulate herbal bar soap containing cinnamon (*Cinnamomum* sp.) bark powder and to evaluate its physicochemical characteristics and antibacterial activity against *Staphylococcus aureus*. The study consisted of three treatment groups based on cinnamon bark powder concentration (10%, 20%, and 30% w/v), with each treatment conducted in triplicate.

Sampling technique

Cinnamon bark samples were collected from Nagari Dalko, Tanjung Raya District, Agam Regency, West Sumatra 26471, Indonesia**,** using a purposive sampling technique. Samples were selected based on their maturity, good physical condition, and absence of visible contamination to ensure consistency of the raw material used in the study.

Procedure for Herbal Soap Preparation

An alkaline solution was prepared by dissolving sodium hydroxide (NaOH) in distilled water under continuous stirring until a clear solution was obtained. Glycerin was then added to enhance the saponification process and improve moisturizing properties. Separately, virgin coconut oil (VCO) was heated to approximately 90°C, then stearic acid was added until completely dissolved. The alkaline solution was gradually introduced into the oil phase under constant stirring until a thick soap mass formed, indicating saponification. Ethanol was added to improve transparency and accelerate the reaction, followed by propylene glycol and sugar solution to enhance clarity and foam softness. Cinnamon powder (1–2%) was incorporated as a natural antibacterial agent and fragrance. The mixture was stirred until homogeneous and visually transparent. The hot soap was poured into molds and allowed to solidify for 3–6 hours, followed by curing for 24 hours prior to use [9].

Evaluation Methods

Organoleptic Evaluation

Organoleptic properties, including color, odor, texture, and homogeneity, were evaluated through direct observation. These parameters are essential indicators of consumer acceptability and are routinely used in cosmetic product evaluation [10].

pH Measurement

The pH of the soap samples was measured using a calibrated pH meter (or pH indicator strips). Approximately 1 g of soap was diluted in 10 mL of distilled water and stirred until homogeneous. The electrode was immersed in the solution, and the pH value was recorded [11].

Foam Stability Test

Foam stability was evaluated by dispersing 1g of the soap sample in 10 mL of distilled water in a graduated cylinder. The mixture was shaken manually for 1 minute to generate foam. The initial foam height was recorded immediately, followed by measurement after 1 minute. Foam stability was expressed as the percentage of foam height retained after 5 minutes compared to the initial height [12].

Antibacterial Activity Test

The antibacterial activity of the herbal soap was evaluated using the agar diffusion method. A bacterial culture (e.g., *Staphylococcus aureus*) was evenly spread onto nutrient agar plates. Soap samples (at concentrations of 10, 20, and 30% b/v) were applied to sterile paper discs on the agar surface. The plates were incubated at 37°C for 24 hours. The test is done in triplicate. The antibacterial activity was determined by measuring the diameter of the inhibition zone (clear zone) around the sample in millimeters. This method is widely used in evaluating the antimicrobial efficacy of soap formulations [13].

Data analysis

The results of physicochemical characterization and antibacterial activity were expressed as mean ± standard deviation (SD) from three independent measurements. Descriptive statistical analysis was used to summarize the experimental data.

Results and Discussion

Formulation of Cinnamon Herbal Soap

The method used to make herbal soap is the Hot Process method, which involves heating the mixture directly until the saponification reaction is complete and no free fatty acids remain. Additionally, this method was chosen because it is efficient, safe, and easy to use. The final formula for the cinnamon herbal soap is shown in Table 1.

Table 1. Contents of Herbal Soap Bar Formulation

Ingredients	F1 (%)	Uses
Virgin Coconut Oil (VCO)	32	Natural fat
Stearic Acid	12	Hardener
Sodium Hydroxide 30%	7	Iye
Glycerin	14	Humectant
Propylene Glycol	12	Humectant
Alcohol 96%	13	Solvent
Sugar Liquid (35 g in 25 g water)	5	Transparent agent
Aqua	5	Vehicle
Cinnamon powder	± 1 - 2	Antibacterial

Cinnamon was chosen because it contains cinnamaldehyde, a compound found in the bark and leaves that has antibacterial properties and helps reduce the risk of stroke and atherosclerosis. Additionally, cinnamon essential oil also has antibacterial properties that can combat bacteria such as *Staphylococcus aureus*, which is commonly found on the skin [14].

Organoleptic Evaluation Of Herbal Solid Soap

The organoleptic evaluation of the herbal solid soap (F1) demonstrated favorable physical characteristics, including a solid form, absence of cracks, a transparent appearance, and a stable cinnamon aroma. No observable changes in color, odor, or structure were detected after storage, indicating good physical stability. Figure 1 shows cinnamon herbal soap.

Figure 1. Cinnamon herbal soap

The absence of cracking suggests that the soap matrix was well-formed. This can be attributed to the balanced formulation, particularly the use of coconut oil as a fatty acid source and the presence of glycerin and propylene glycol, which function as humectants and plasticizers, enhancing the flexibility of the soap matrix [15]. The organoleptic examination of the herbal solid soap is displayed in Table 2.

Table 2. Organoleptic Evaluation Of Herbal Solid Soap

	Organoleptic		
	Form	Odor	Color
Formulation F1[a]	solid, not cracked	cinnamon aroma	transparent

a = transparent bar soap formulation

Furthermore, an adequate curing process allows completion of the saponification reaction and gradual water evaporation, resulting in a more compact and stable structure [16]. The persistence of the cinnamon aroma indicates that the herbal active compound remained stable during processing. Overall, the herbal soap exhibited good physical stability and desirable sensory properties, which are essential for consumer acceptance.

pH Measurement

The pH of the herbal solid soap (F1) ranged from 8 to 9, which is typical for soap produced via saponification with a strong alkali such as sodium hydroxide. This alkaline pH is effective for cleansing as it promotes emulsification of oils and removal of dirt [17]. This pH range is effective for cleansing, as it facilitates the emulsification and removal of oils and dirt from the skin surface [18]. Although this pH is higher than the physiological skin pH (approximately 4.5–6), soap is a rinse-off product that is only applied temporarily and subsequently washed away with water. Therefore, any increase in skin pH is generally transient and tends to return to normal after rinsing. Furthermore, the presence of glycerin in the formulation acts as a humectant that helps maintain skin moisture and improves user comfort [19]. Thus, the herbal solid soap can still be considered suitable for cleansing purposes despite its higher pH compared to natural skin conditions.

Foam Stability Test

Foam stability was expressed as the percentage of foam retention. This method is commonly used to assess surfactant performance in soap formulations. The resulting foam height was then measured. The results of the foam test are shown in Table 3.

Table 3. Results of the foam height test for herbal bar soap

Replication	Foam height (cm)
1	9
2	8.7
3	7.5

The table above shows that each replication produced different foam heights rather than a consistent increase. This variation is likely due to the manual shaking method, in which speed and duration cannot be precisely controlled, leading to fluctuations in foam height measurements [20]. The foam height test results for herbal bar soap comply with the SNI standard of 13–220 mm (1.3–22 cm). The foam formed lasted for 5 minutes. This indicates that the soap's foaming ability is quite good. Foam formation is a key parameter in assessing the quality of bath soaps. One of the components responsible for foam production is the type of triglyceride used in the formulation. Triglycerides with higher saponification values require a greater amount of base to achieve complete saponification. Among common lipid sources, coconut oil has a higher saponification value than palm oil and other fats [21]. Foam stability is influenced by the composition of fatty acids in the formulation. Coconut oil contains lauric and myristic acids, which contribute to the formation of soft foam, whereas palmitic and stearic acids enhance foam stability. In addition, oleic and ricinoleic acids are associated with the production of foam that is both stable and soft. In addition, the use of stearic acid as a foam stabilizer is also highly effective in producing stable foam [22].

Antibacterial Activity Test

After conducting pH, organoleptic [23] and foam tests [24], antibacterial activity [25] testing was carried out against *Staphylococcus aureus* bacteria using the agar diffusion method using paper disks [26]. Different concentration of the formulation was tested to determine their inhibitory effect on the formation of a clear zone around the discs. The diameters of the inhibition zones were measured, and the mean ± standard deviation was calculated from three experiments. The results are shown in Table 4.

Table 4. Antibacterial Activity Test of Bar Soap Using the Disk Diffusion Method

Sample	Inhibition zone (mm)			
	S. aureus			Mean ± SD
	I	II	III	
Bar Soap 10%	9	9	10	9.33 ± 0.58 mm
Bar Soap 20%	10	9	11.25	10.08 ± 1.13 mm
Bar Soap 30%	12.5	12.5	10	11.67 ± 1.44 mm
Positive control (chlorampenicol 1 mg/mL)	22	22.5	17	20.50 ± 3.04 mm
Negative control (DMSO 1%)	0	0	0	0 ± 0 mm

Based on the antibacterial activity test data against *S. aureus*, all bar soap concentrations showed an inhibition zone, indicating antibacterial activity (Figure 2). The average inhibition zone value increased with increasing concentration, namely 9.33 ± 0.58 mm (10%), 10.08 ± 1.13 mm (20%), and 11.67 ± 1.44 mm (30%).

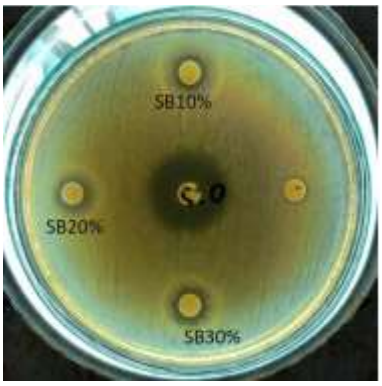

Figure 2. Antibacterial activity of bark powder herbal soap formulations against *Staphylococcus aureus* as determined by the agar diffusion method.

This suggests a relationship between the concentration of the active ingredient and its ability to inhibit bacterial growth. However, the increase was not very significant because it was close to the diffusion optimum in the agar medium. The antibacterial activity of this bar soap formulation does not only come from increasing the concentration, but is also influenced by the characteristics of the soap system, which has an alkaline pH (8-9) [27] and is further supported by the presence of cinnamon extract as a natural active ingredient [28]. Soap or a tropical formulation containing cinnamon extract can exhibit antibacterial activity against Staphylococcus aureus, although the degree of effectiveness is strongly influenced by the formulation type, extract concentration, and carrier system. These compounds act through several mechanisms, including the disruption of the bacterial cell membranes, increasing cell wall permeability, protein denaturation, and inhibiting essential enzymes [29].

In addition, the pH condition of soap, which is in the alkaline range (8-9), is thought to contribute to increasing antibacterial activity [30]. When compared with the positive control (chloramphenicol 1 mg/mL), the resulting inhibition zone was much larger, namely 20.50 ± 3.04 mm, indicating that the standard antibiotic still had higher effectiveness than the tested bar soap [31]. Meanwhile, the negative control (DMSO 1%) showed no inhibition zone (0 ± 0 mm), confirming that the solvent did not exhibit antibacterial activity and that the test results were valid. Overall, bar soap has potential as an antibacterial agent against S. aureus, especially at a concentration of 30%, but its effectiveness is still below that of the positive control, so further formulation optimization is needed to increase its activity [32].

The physicochemical evaluation demonstrated that all cinnamon bark powder soap formulations exhibited acceptable characteristics in appearance, homogeneity, pH, foam stability, viscosity, and specific gravity, indicating that incorporating cinnamon bark powder did not adversely affect product quality. These findings are in agreement with previous studies reporting that cinnamon-containing soap formulations possess favorable physicochemical properties and remain stable during storage and use [7]. The homogeneous distribution of cinnamon bark powder within the soap matrix suggests successful incorporation of the active ingredient, while the acceptable pH values indicate suitability for topical application. Unlike formulations based on cinnamon essential oil, which often require extraction, distillation, and additional stabilizing agents, the direct use of cinnamon bark powder offers a simpler formulation approach while preserving the natural characteristics of the raw material. Moreover, retaining the plant material in its original form may help maintain a broader spectrum of bioactive compounds that could be partially altered or lost during extraction processes [33]. These results suggest that cinnamon bark powder can be incorporated into soap formulations without compromising physicochemical quality, thereby supporting its potential as a practical and cost-effective natural cosmetic ingredient.

This study contributes to the development of antibacterial bar soap by demonstrating the feasibility of incorporating cinnamon bark powder into a conventional soap formulation (pH 8–9) while maintaining acceptable physicochemical properties and antibacterial activity, an approach that has received limited attention in previous studies.

Conclusion

The herbal soap formulation containing *Cinnamomum* bark powder exhibited acceptable physicochemical characteristics, good stability, and antibacterial activity against *Staphylococcus aureus*. These findings suggest that cinnamon bark powder has potential as a natural antibacterial ingredient in herbal soap products,

offering an alternative to synthetic additives while enhancing product appeal through its natural origin. However, this study was limited to physicochemical evaluation and in vitro antibacterial testing against a single bacterial species. In addition, long-term stability, skin compatibility, and consumer acceptance were not assessed. Therefore, further studies are recommended to optimize the formulation, evaluate product stability during storage, investigate its safety and efficacy through dermatological testing, and assess its performance against a broader range of microorganisms to support its potential application in cosmetic and personal care products.

Author's Contribution

All authors contributed significantly to this study. N. Sandrawati: conceptualized and designed the research and critical revision of the article. D.R. Stiadi and A.M. Tasman: formulation of the herbal solid soap and conducted laboratory experiments, including physical and chemical evaluations. Y. Mala Sari and F. Andriani: antibacterial activity testing, analyzed the data, and manuscript drafting. All authors have read and approved the final version of the manuscript.

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