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Bioactive Ritha Herbal Soap Using the Decoction Method with Selected Medicinal Plants

Atla Srinivasa Rao [1], Goriparthi Nangalya Swathi [1*], Rama Manohari Barri [1], Aswini Devi Botta [1], Dendukuri Bala Naga Suresh Varma [2], Juluri Leela Sri Satya Phani Kumar [3], Dachuru Rama Sekhara Reddy [4], Golisingi Urvasi Devi [1], Isukapudi Revathi [1], Myla C. Rao [5], Potula Sree Brahmanandam [6] and Gudla Sri Satya [7]

[1]Department of Pharmaceutical Analysis, Shri Vishnu College of Pharmacy, Bhimavaram-534202, India
[2]Department of Chemistry, Shri Vishnu Engineering College for Women (A), Bhimavaram-534202, India
[3]Department of Chemistry, B V Raju College, Bhimavaram-534202, India
[4]Department of Chemistry, Krishna University, Machilipatnam-521004, India
[5]Department of Physics, Andhra Loyola College, Vijayawada-520008, India
[6]Department of Physics, Shri Vishnu Engineering College for Women (A), Bhimavaram-534202, India
[7]Department of Civil Engineering, SRKR Engineering Collage (A), Bhimavaram-534202, India

*(e-mail: swathi.g@svcp.edu.in)

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ABSTRACT

This study aimed to develop and evaluate *Ritha (or, Reetha)* herbal soap formulated with bioactive herbal extracts recognized for their ethno-pharmacological and dermatological properties in Ayurveda. The formulation incorporated extracts from *Acacia nilotica, Aloe barbadensis, Azadirachta indica, Citrus lemon, Cocus nucifera, Curcuma longa, Ocimum sanctum, and Sapindus mukorossi.* These plant materials were processed using appropriate extraction techniques tailored to their specific constituents. The soap was prepared by combining the extracts with fatty oils and sodium hydroxide (lye) using the hot decoction method. The prepared herbal soap was compared to commercially available soaps in terms of its physical and chemical properties, including appearance, color, and odor. Key parameters of the soap were measured, yielding the following results: pH (8.38), % free alkali content (0.34), foamability (17 cm), foam stability (15 cm), moisture content (6.4%), and alcohol-insoluble matter (2.25%). Additionally, antioxidant and antibacterial activities were assessed, demonstrating that the soap exhibited potent antioxidant and antibacterial properties. This study demonstrates that high-quality herbal soap can be effectively formulated using the hot decoction method, incorporating parameters such as skin compatibility and the bioactive potential of the selected herbs.

Keywords: ritha herbal soap; bioactive herbal extracts; ayurveda; hot decoction method; skin compatibility

INTRODUCTION

The global demand for herbal cosmetics has seen a remarkable surge in recent years, driven by an increasing consumer preference for natural and skin-friendly products (Dongare et al., 2021; Jain et al., 2022). Traditional knowledge systems like Ayurveda, renowned for their ethno-pharmacological insights, have provided a foundation for developing herbal formulations that promise therapeutic and dermatological benefits. Among these, herbal soaps occupy a significant niche, given their dual role in personal hygiene and skincare. Added to the above, organic soaps, crafted from natural ingredients, herbs, and Ayurvedic compounds, offer a gentler alternative to conventional soaps. They ensure safer and more skin-friendly cleansing with minimal side effects, making them a superior choice for daily use (Debnath and Arpita Das, 2024).

However, many commercial herbal soaps fail to meet consumer expectations due to limited bioactive efficacy, low-quality formulations, or the incorporation of synthetic additives. This gap highlights the need for scientifically validated, high-quality herbal soap formulations.

The present study addresses these challenges by formulating and evaluating a Ritha-based herbal soap enriched with bioactive herbal extracts known for their dermatological and pharmacological properties. The key ingredients, such as *Sapindus mukorossi* (Ritha or Reetha), *Acacia nilotica*, *Aloe barbadensis* (Aloe vera), *Curcuma longa* (turmeric), *Cocus nucifera* (coconut oil), *Azadirachta indica* (neem), *Ocimum sanctum* (tulsi), and *Citrus lemon* (lemon), are well-documented in Ayurvedic literature for their anti-microbial, antioxidant, and skin-healing properties (Sharma et al., 2002; Jain et al., 2022). These ingredients were processed using tailored extraction techniques to maximize the yield and stability of active constituents.

Most importantly, researchers have demonstrated the potent antibacterial and anti-fungal properties of herbal soap ingredients, with neem standing out for its broad-spectrum medicinal efficacy against various bacterial strains and dermatophytes (Karnavat et al., 2022).

The formulation employs the hot decoction method, which allows for the integration of plant extracts with fatty oils and lye, ensuring the stability and homogeneity of the final product. Notably, this preparation method aligns with traditional soap-making practices while incorporating modern quality control measures. The physicochemical evaluation of the prepared herbal soap revealed favourable attributes, such as a pH of 8.38, low free alkali content (0.34%), and substantial foam stability (15 cm), which are critical for consumer acceptance and skin compatibility. The pH level of the present soap was found to be 8.33, which is near to 9, it can be classified as significantly more alkaline in nature. This inherent alkalinity plays a crucial role in skin health, offering a gentle and soothing effect that makes these products particularly beneficial for individuals with sensitive or reactive skin. Unlike acidic or harsh chemical-based alternatives, which can disrupt the skin's natural barrier and lead to irritation, organic products with a higher pH work harmoniously with the skin's ecosystem.

Furthermore, its potent antioxidant and antibacterial activities underscore its therapeutic potential, distinguishing it from many commercially available alternatives. Organic soaps are gaining popularity for their natural antibacterial agents (lavender, peppermint, tea tree, and lemongrass essential oils). These oils cleanse, soothe, and refresh while providing anti-microbial benefits. Unlike chemical-laden commercial soaps, organic alternatives nourish the skin and maintain its natural balance. Their eco-friendly and gentle nature makes them a preferred choice for conscious consumers (Indirani et al., 2022).

The study's findings are particularly significant in light of growing concerns about the safety and efficacy of synthetic and chemical-based soaps, which are often associated with skin irritation and environmental harm (Fernandes et al., 2023).

According to a report by the World Health Organization (WHO), approximately 34% of all workplace-related health issues involve skin diseases (Occupational Injuries and Illnesses, 2004). Data from 2020 indicates that fatalities due to skin diseases in India totaled 17,857, accounting for 0.21% of overall deaths, as per the World Health Rankings, according to https://www.worldlifeexpectancy.com/country-health-profile/india.

The optimal approach to addressing this situation is to incorporate herbal potentials into the formulation, ensuring enhanced therapeutic benefits with minimal side effects and greater safety.

The objective of this study is to develop a medicated herbal soap enriched with bioactive herbal extracts, which possess potent antioxidant and antibacterial properties, enhancing its suitability as a safe and effective alternative for daily use. The research aims to harness the therapeutic potential of various herbs while addressing the growing consumer demand for natural, sustainable, and skin-friendly products.

This approach not only ensures the product's efficacy and safety but also provides an innovative pathway for the herbal cosmetics industry to deliver eco-friendly and dermatologically beneficial solutions that align with the modern emphasis on sustainable and holistic wellness.

The hot decoction method was selected over cold saponification and other traditional extraction techniques primarily due to its superior ability to extract and integrate thermally stable bioactive compounds into the soap matrix (Basilio-Cortes et al., 2023). Unlike cold saponification, which may preserve certain heat-sensitive compounds but often limits the solubility and integration of key phyto-constituents, the hot decoction method facilitates thorough extraction of active herbal components—such as saponins, tannins, flavonoids, and essential oils—by applying controlled heat.

This method ensures better dissolution of both hydrophilic and lipophilic compounds into the aqueous and oily phases of the soap, resulting in a more homogeneous and stable formulation. It also enhances emulsion formation between plant extracts and fatty oils, allowing for greater retention of therapeutic properties in the final product. Furthermore, hot decoction mimics traditional Ayurvedic preparation methods while aligning with modern quality control standards, making it scientifically sound and culturally resonant.

Given the aim of formulating a high-efficacy herbal soap with proven dermatological benefits, the hot decoction approach offers a standardized and scalable method that enhances the bioavailability, stability, and skin-compatibility of herbal actives, thereby address the limitations of commercial soaps and satisfying the increasing consumer demand for safe, natural, and therapeutic skincare solutions.

Finally, by employing the hot decoction method, the study focuses on achieving a standardized and scalable formulation process that integrates these bioactive-rich ingredients while adhering to stringent quality control parameters.

MATERIAL AND METHODS

Collection of Plant Materials

For this study, the seeds of *Sapindus mukorossi*, pods of Acacia nilotica, and leaves of Citrus lemon, *Aloe barbadensis*, and the powdered rhizome of *Curcuma longa* were meticulously harvested from mature plants. These botanicals were carefully shade-dried to preserve their bioactive components, finely pulverized, and stored in air-tight containers to maintain their integrity. Additionally, high-quality coconut oil and rose oil, essential for the formulation, were sourced from trusted local markets. This thoughtful selection and preparation of ingredients laid a strong foundation for crafting the herbal soap.

Processing of Plant Material

The herbal extraction process was meticulously conducted using the decoction method (Lee, 2012), with water serving as the solvent to extract the bioactive compounds from *Sapindus mukorossi*, Acacia nilotica, *Citrus lemon, Azadirachta indica*, *Ocimum sanctum*, and *Curcuma longa* powders. Precisely 10 g of each powdered herb were placed in a conical flask and subjected to extraction over 24 h, with intermittent stirring to ensure optimal yield. The resulting extract was carefully concentrated and purified using a rotary evaporator to preserve its active constituents.

For *Aloe barbadensis* (Aloe vera), the latex was delicately scraped using a spatula and ground into a fine consistency using a mixer grinder. The extracted juice was heated in a water bath until the formation of bubbles ceased, indicating the stabilization of the extract. The processed juice was stored under refrigeration to maintain its bioactivity for subsequent use in the soap formulation. This methodical extraction process ensures the retention of the therapeutic properties of the herbs, laying the foundation for a high-quality herbal soap enriched with potent bioactive ingredients. Table 1 provides materials used in the preparation of soap and their description.

Table 1. Materials and their description.

S No	Material	Description	Figures
1	Ritha (Soapnut)	Scientific Classification: Kingdom: Plantae Order: Sapindales Family: Sapindaceae Genus: Sapindus Species: *S. mukorossi* Part Utilized: Fruit pericarp Benefits and Applications: Ritha is valued for its natural cleansing and foaming properties, making it a popular ingredient in herbal shampoos, soaps, and detergents. It is gentle on the scalp, promotes hair growth, and helps treat dandruff and lice. Additionally, its anti-microbial nature makes it suitable for skin care and treating minor skin infections.	

2	Babul (Indian Gum Arabic Tree)	Scientific Classification: Kingdom: Plantae Order: Fabales Family: Fabaceae Genus: Vachellia Species: *V. nilotica* Part Utilized: Bark, gum, pods, and leaves Benefits and Applications: Babul is extensively used in traditional medicine for its astringent, antibacterial, and anti-inflammatory properties. Its bark is used to strengthen gums and treat oral issues, while the gum exudate (gum arabic) is used in pharmaceuticals and food products. Decoctions made from bark and pods are also used to manage diarrhea, dysentery, and skin disorders.	
3	*Aloe vera*	Scientific Classification: Kingdom: Plantae Order: Asparagales Family: Asphodelaceae Genus: Aloe Species: A. vera Part Utilized: Leaf latex Benefits and Applications: Aloe vera is widely recognized for its medicinal and skincare properties. It is highly effective in soothing sunburns, providing deep hydration as a natural moisturizer, and aiding in acne treatment. Additionally, its antiseptic and antibacterial properties help in wound healing and preventing infections.	
4	Turmeric	Scientific Name: *Curcuma longa* -Kingdom: Plantae -Order: Zingiberales -Family: Zingiberaceae -Genus: Curcuma -Species: C. longa -Utilized Part: Rhizomes Applications and Benefits: The rhizomes of Curcuma longa are widely recognized for their medicinal properties. Rich in antioxidants and anti-inflammatory compounds, turmeric aids in wound healing. Additionally, it enhances skin radiance, promotes a natural glow, and helps manage conditions like psoriasis.	

5	Tulsi (Holy basil)	Scientific Name: *Ocimum sanctum* (also known as *Ocimum tenuiflorum*) Kingdom: Plantae Order: Lamiales Family: Lamiaceae Genus: Ocimum Species: sanctum (or tenuiflorum) Utilized Plant Parts: Leaves Medicinal Properties and Benefits: The leaves of Ocimum sanctum are known for their diverse therapeutic properties. They exhibit anti-inflammatory effects, help combat oxidative stress as powerful antioxidants, and possess anti-microbial properties that support overall health.	
6	Neem	Botanical Name: *Azadirachta indica* Kingdom: Plantae Order: Sapindales Family: Meliaceae Genus: Azadirachta Species: A. indica Parts used: Leaves Uses: Acts as an antibacterial, antiviral, anti-fungal, anti-inflammatory, anti-aging	
7	Coconut oil	The scientific classification of *Cocos nucifera*, commonly known as the coconut tree, is as follows: -Kingdom: Plantae -Order: Arecales -Family: Arecaceae -Genus: Cocos -Species: nucifera Utilized Part: The primary part used is the oil extracted from the coconut. Benefits & Applications: Coconut oil is widely recognized for its moisturizing and antioxidant properties. It helps in removing dead skin cells and impurities from the body, contributing to healthier skin. Additionally, it is known for its ability to reduce the appearance of stretch marks over time.	
8	Lemon	Scientific Name: *Citrus limon* Kingdom: Plantae Order: Sapindales Family: Rutaceae Genus: *Citrus* Species: *C. limon* Parts Utilized: The leaves of *Citrus limon* are commonly used for their beneficial properties.	

		Benefits and Applications: The essential oil derived from lemon leaves is valued for its pleasant fragrance. Additionally, the presence of Vitamin C contributes to its antioxidant potential, aiding in skin health. With antibacterial properties, it is often used in acne treatment.	
9	Sodium Hydroxide	Scientific Classification: Chemical Formula: NaOH IUPAC Name: Sodium Hydroxide Molar Mass: 39.997 g/mol Appearance: White solid (pellets, flakes, or granules) Solubility: Highly soluble in water, forming a strongly alkaline solution Part Utilized: Entire compound (industrial and laboratory applications) Benefits and Applications: Sodium hydroxide is a highly versatile and widely used chemical in various industries. It plays a crucial role in the manufacture of soaps, detergents, paper, textiles, and petroleum products. In laboratories, it is used as a strong base for titrations and pH regulation. It is also employed in water treatment, food processing (as a pH adjuster), and in the production of biodiesel. Its corrosive nature also makes it effective in drain cleaning products and degreasing agents.	
10	Other Chemicals	Stearic acid, Ethanol	

Antibacterial Activity Assessment

Specifically, ampicillin (10 µg/disc) and ciprofloxacin (5 µg/disc) were used as positive controls against bacterial strains to benchmark the efficacy of the herbal soap extract. Sterile distilled water was used as the negative control to ensure no anti-microbial effect in the absence of active agents. Zones of inhibition produced by the herbal formulation were compared against those of the standard antibiotics to evaluate relative antibacterial potency. Table 2 shows the standard antibiotic controls used for comparative analysis during the antibacterial activity assessment.

Table 2. Standard antibiotic controls used for antibacterial activity assessment.

S. No	Control Type	Agent	Concentration	Purpose
1.	Positive Control	Ampicillin	10 µg/disc	Benchmark for Gram-positive bacterial strains
2.	Positive Control	Ciprofloxacin	05 µg/disc	Benchmark for Gram-positive bacterial strains
3.	Negative Control	Distilled Water	---	Ensures no anti-microbial effect

Formulation of Herbal Soap

The decoction method was employed to prepare the soap formulation, extracting active plant constituents. Coconut oil, a natural fat, was used as a source of fatty acid salts (sodium or potassium), essential for soap formation.

10 g of coconut oil was placed in a beaker, while 7 g of NaOH was dissolved in 25 mL of ethanol and distilled water with continuous stirring in another beaker. The alkali solution was then added to the oil and heated on a hot plate at low

heat with constant stirring until the oil's odor disappeared, forming a homogeneous mixture. The mixture underwent filtration through Whatman No. 1 filter paper, carefully placed in a funnel, ensuring efficient separation of solid residues from the liquid phase. The filtered solution was then combined with 2 mL of extracts from *Sapindus mukorossi*, *Acacia nilotica*, *Aloe barbadensis*, *Curcuma longa*, *Ocimum sanctum*, *Azadirachta indica*, and *Citrus limon*, along with 1 g of stearic acid and 5 mL of ethanol. The mixture was stirred in a water bath until the extracts dissolved and became homogeneous. Finally, a few drops of rose oil were added and thoroughly mixed.
The resultant homogeneous semisolid mixture was poured into molds, left to solidify at room temperature, and evaluation parameters were done for characteristic changes. Table 3 provides the contents of formulation.

Table 3. Contents of formulation.

Ingredient	Quantity	Uses
Coconut oil	10 gm	Natural fat (Selvaraj, 2020)
NaOH	7 gm	Lye (Floros et al., 1987)
Ethanol	30 mL	Solvent (Saxena et al., 2011)
Ritha seed extract	2 mL	Detergent/surfactant (Saito et al., 2000)
Babul seed extract	2 mL	Detergent/surfactant (Manzoor et al., 2021)
Aloe vera juice	2 mL	Moisturizer (Harianti et al., 2020)
Turmeric extract	2 mL	Anti-septic and provides glow (Gul and Bakht, 2015)
Tulsi leaves extract	2 mL	Anti-microbial, anti-oxidant (Saranya et al., 2019)
Stearic acid	1 gm	Hardener (Gravelle et al., 2017)
Neem leaves extract	2 mL	Anti-fungal, antibacterial and anti-inflammatory (Seethapathy et al., 2022 and Bindra et al., 2023)
Lemon leaves extract	2 mL	Anti-oxidant, antibacterial (Hojjati et al., 2017)
Rose oil	q.s	Fragrance (Noh et al., 2024)
Distilled water	q.s	Vehicle (Abdulmunem, 2016)

In our formulation, each herbal extract was incorporated at a fixed volume of 2 mL, ensuring consistency across batches. This quantity was based on preliminary trials that assessed solubility, stability, and the observable effects on key physicochemical parameters (such as pH, foam stability, and texture). All extracts were prepared using the hot decoction method under uniform conditions (same plant-to-solvent ratio, temperature, and time) to maintain consistency in the concentration of bioactive constituents. By maintaining a fixed volume for each extract and preparing them using standardized decoction parameters, we ensured reproducibility in the final soap formulation.

Evaluation of Soap: A Comparative Physicochemical Assessment

To compare the quality and efficacy of the prepared soap formulation with that of commercially available herbal soaps, several key physicochemical parameters were analyzed. These evaluations are crucial indicators of soap performance, stability, and suitability for consumer use. By systematically assessing attributes such as pH balance, foam stability, total fatty matter (TFM), moisture content, and cleansing efficiency, we aim to establish a scientific basis for comparing the formulated soap with its market counterparts. The findings from this study will provide insights into the formulation's compliance with industry standards and its potential advantages over existing herbal soap products. Figure 1 depicts soap available in the market (left) and prepared soap (right).

(**a**) (**b**)

Fig. 1. (**a**) Soap available in the market; (**b**) Prepared soap.

Physical Parameters

The soap's color and clarity were visually assessed against a white background, while its odor was evaluated through direct smelling.

pH

To measure the pH value, the soap formulation was blended into 100 mL of distilled water and left undisturbed for two hours, facilitating thorough dispersion and homogeneity. Afterward, the solution's pH was measured using a pre-calibrated digital pH meter, ensuring accuracy and reliability in the assessment. This step was critical in evaluating the soap's compatibility with skin and its overall quality.

Measurement of % Free Alkali Content

A beaker holding 10 g of dried soap was filled with 150 milliliters of distilled water. To ensure complete dissolution, the mixture was subjected to reflux heating in a water bath for approximately 30 to 40 min. Afterward, the solution was allowed to cool and carefully transferred, along with its washings, into a 250-milliliter conical flask. The volume was then adjusted to the mark using distilled water. For the titration process, 10 milliliters of the prepared soap solution were taken in a titration flask, to which two drops of phenolphthalein indicator were introduced. The solution was then titrated against 0.1 M HCl until it turned colorless.

Measurement of Foam Height

A 2 g soap sample was dissolved in 50 mL distilled water with stirring and transferred to a 250 mL measuring cylinder. After thorough washing, the volume was adjusted to 200 mL. The mixture was given 25 uniform strokes and left undisturbed until the water level stabilized at 200 mL. Foam height was then measured above the water surface.

Assessment of Foam Stability

Foam stability was assessed using the same soap sample and distilled water quantity as in the foamability test. The mixture was left undisturbed for 30 min, after which the foam height was measured above the water level.

Determination of Moisture Content

A 10 g soap sample was first weighed as its "wet weight" before being dried at a controlled temperature (≤115 °C) until a stable mass was achieved. After cooling, the final "dry weight" was noted. The moisture content (%) was determined using:

$$\text{Moisture content (\%)} = [(A - B)/B] \times 100$$

where, A = Weight of wet sample (gm), B = Weight of dry sample (gm).

Alcohol-Insoluble Matter

50 mL of warm ethanol was added to a conical flask with a 5 g soap sample to facilitate dissolution. Using tarred filter paper and 20 mL of warm ethanol, the liquid was filtered and then dried at 1050 °C for an hour. As a result, the weighted filter paper had dried out.

Biological Parameters

Anti-oxidant Activity Assessment

The reducing power method was employed to evaluate anti-oxidant activity, where an increase in absorbance indicates enhanced reducing potential. The test involved mixing 1 mL of the diluted sample with 2.5 mL of 0.2 M phosphate buffer (pH 6.6) and 1% *w/v* potassium ferricyanide. The mixture was incubated at 50 °C for 20 min. Following incubation, 2.5 mL of 10% trichloroacetic acid was added, and the solution was centrifuged at 250 rpm for 15 min. The supernatant (2.5 mL) was then combined with an equal volume of distilled water and 0.5 mL of 0.1% ferric chloride. Absorbance was measured at 700 nm against a control.

RESULT

The summarized physico-chemical and biological assessments are presented in Tables 4 and 5, respectively.

Table 4. Physico-chemical parameters of formulation.

Parameters	Prepared Herbal Soap	Marketed Soap
Physical parameters		
Color	Color: cream	Color: Yellow
Odor	Odor: pleasant	Odor: Pleasant
Clarity	Clarity: Turbid	Clarity: Crystal clear
pH	8.38	7.98
% free alkali content	0.34	0.25
Foamability	17 cm	10.2 cm
Foam stability	15 cm	9.5
Moisture content (%)	6.4	3.56
Alcohol insoluble matter (% *v*/*v*)	2.25	5.60

Table 4 compares a prepared herbal soap to a marketed soap across various physico-chemical parameters. The prepared soap boasts higher foamability and stability, suggesting better cleaning efficacy. However, it also exhibits a higher pH and free alkali content, which could potentially be harsher on the skin. The marketed soap, on the other hand, is transparent and has a lower pH and free alkali content, making it potentially gentler. Ultimately, the choice between the two would depend on individual preferences for cleaning power versus skin sensitivity.

Table 5. Anti-oxidant activity of the formulations.

Concentration (µg/mL)	Prepared Herbal Soap Absorbance (AU)	Standard Herbal Soap Absorbance (AU)
0.1	0.325	0.334
0.2	0.364	0.308
0.3	0.452	0.256
0.4	0.518	0.224
0.5	0.672	0.143

Table 5 presents the antioxidant activity of both a prepared herbal soap and a standard herbal soap at varying concentrations. The prepared herbal soap consistently demonstrates higher absorbance values across all concentrations, suggesting a greater capacity to neutralize free radicals. This indicates that the prepared herbal soap possesses superior anti-oxidant properties compared to the standard herbal soap.

The results of the anti-oxidant activity analysis, as shown in Figure 2, reveal a clear trend where the prepared herbal soap consistently demonstrates superior anti-oxidant potential compared to the standard herbal soap, particularly as the concentration increases. The bar graph compares the anti-oxidant activity (absorbance) of prepared herbal and standard herbal soaps across different concentrations (0.1 to 0.5 µg/mL). At the lowest concentration (0.1 µg/mL), both soaps show nearly equal anti-oxidant activity, with the standard one slightly higher. However, as the concentration increases, the prepared herbal soap consistently exhibits higher anti-oxidant activity, with a steady rise in absorbance values from approximately 0.33 to 0.67 AU. In contrast, the standard herbal soap shows a declining trend in anti-oxidant activity, with absorbance decreasing from around 0.34 to 0.15 AU. This indicates that the prepared herbal soap is more effective and its anti-oxidant potential improves with increasing concentration, suggesting a superior formulation compared to the standard.

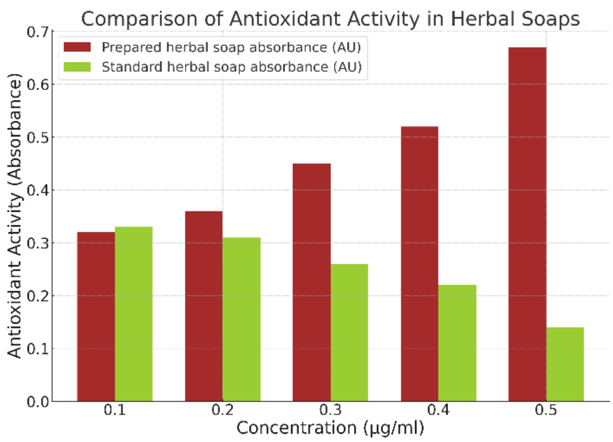

Fig. 2. Anti-oxidant activity analysis.

The antibacterial activity of prepared and marketed herbal soaps was assessed in our institute's central instrument lab (https://www.svcp.edu.in/infrastructure/#centralinstrumentationlab, accessed on 15 April 2025) by virtue of the agar-well diffusion method or standard cup plate technique using Sabouraud's dextrose agar (Hi-media) against *Salmonella typhi* (Gram-negative) and *Bacillus subtilis* (Gram-positive). Nutrient agar plates were inoculated with bacterial cultures, and wells were loaded with 400 µg/mL of each soap sample. Plates were incubated at 37 °C for 24 h. Activity was measured by the diameter of the clear zone (zone of inhibition) in millimetres (mm). Each test was performed in triplicate, and the results are presented as mean ± standard deviation. Table 6 shows the zone of inhibition of the formulations, which follows a graphical representation (Figure 3) that depicts the zone of inhibition for S. typhi and B. subtilis against both prepared and marketed soaps.

Table 6. Zone of inhibition of the formulations.

Samples	Dose (µg/mL)	Zone of Inhibition (mm)-S. Typhi (Mean ± SD)	Zone of Inhibition (mm)-B. Subtilis (Mean ± SD)
Prepared soap	400	0.90 ± 0.01	0.92 ± 0.01
Marketed soap	400	0.85 ± 0.01	1.72 ± 0.01

The scatter plot, as depicted in Figure 3, shows that both prepared and marketed soaps have minimal effect on *S. typhi*, with inhibition zones of 0.90 mm and 0.85 mm, respectively. However, for *B. subtilis*, the marketed soap is significantly more effective (1.72 mm) than the prepared soap (0.92 mm). This indicates that the marketed soap has stronger antibacterial action, especially against *B. subtilis*.

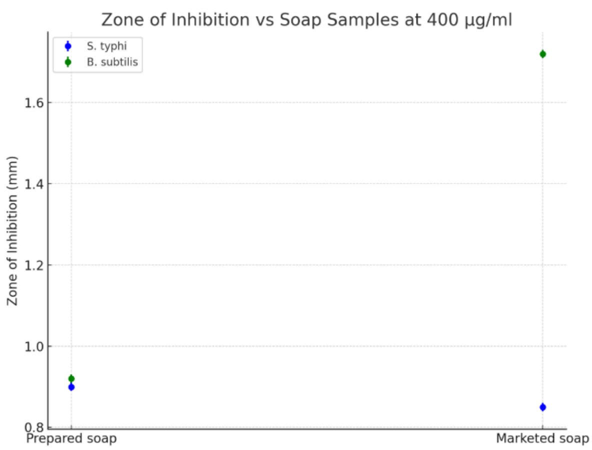

Fig. 3. Scatter plot with error bars, illustrating the zone of inhibition for S. typhi and B. subtilis against both prepared and marketed soap samples at a dose of 400 µg/mL.

DISCUSSION

The physicochemical and biological parameters of the prepared herbal soap were thoroughly analyzed, demonstrating promising results. The soap exhibited a visually appealing appearance with a pleasant odor and color, and its pH was within the recommended range of 7–10, ensuring skin compatibility. Key parameters, including alcohol-insoluble matter, foamability, foam stability, free alkali content, moisture content, and, adhered to standard values, reflect the quality and usability of the formulation. Biological assessments further reinforced the soap's efficacy, with anti-oxidant and antibacterial studies confirming its potency as a source of these beneficial activities. These findings highlight the soap's potential not only as a personal hygiene product but also as a dermatological aid.

Added to the above, herbal soaps are natural alternatives, because they are crafted using plant-based ingredients and botanical extracts providing skin-friendly and environmentally conscious options (Majumdar et al., 2023 and Das et al., 2024). Infused with nature's purity, herbal soaps embrace our skin with gentle care, free from harsh chemicals and synthetic fragrances. Crafted for even the most sensitive skin, they offer a soothing cleanse, letting botanicals work their magic (Majumdar et al., 2023). They contain natural ingredients with antibacterial, anti-fungal, and anti-inflammatory properties, effectively addressing various skin conditions (Manjula et al., 2024).

Common herbs used in these soaps include neem, tulsi, and turmeric, which offer specific benefits such as anti-dermatophytic, anti-inflammatory, and antiviral properties (Manjula et al., 2024). Herbal soaps are rich in vitamins, anti-oxidants, and minerals that nourish and heal the skin (Sharma and Verma, 2023). Additionally, they are biodegradable, cruelty-free, and eco-friendly, appealing to environmentally conscious consumers (Majumdar et al., 2023).

The pH of the formulated herbal soap was found to be 8.33, which, while slightly alkaline compared to the ideal skin pH range of 5.5–7.0, remains within the acceptable range for cosmetic soap formulations (typically up to pH 10). Alkaline pH helps enhance cleansing by removing excess oils and dirt from the skin. However, excessive alkalinity can disrupt the skin's natural acid mantle, potentially leading to dryness or irritation in sensitive individuals. In this formulation, the mild alkalinity was carefully balanced by the addition of emollient-rich ingredients like *Aloe vera*, coconut oil, and neem, known for their skin-soothing, moisturizing, and anti-inflammatory properties. These components mitigate potential irritation and promote skin hydration, making the soap suitable for regular use without compromising dermal health.

Additionally, the low free alkali content (0.34%) supports the soap's safety and minimizes the risk of caustic effects often associated with higher pH soaps. Despite the slightly alkaline nature, the combination of herbal actives and controlled formulation parameters, therefore, ensures skin compatibility and therapeutic benefits.

The following global statistics highlight the rise of herbal soap usage, possibly due to the rising consumer awareness about the adverse effects of synthetic chemicals, and a growing trend towards sustainable and eco-friendly products.

The global herbal soap market was valued at USD 181.31 million in 2023 (Lahare et al., 2024), while the market was valued at approximately USD 3.55 billion in 2024 and is projected to reach USD 5.5 billion by 2032, exhibiting a Compound Annual Growth Rate (CAGR) of 5.63% (https://www.wiseguyreports.com/reports/, accessed on 15 April 2025).

Further, increased disposable incomes leading to higher spending on premium personal care products also might have influenced the usage of herbal soaps.

Figure 4 visually compares the market dominance of usage of herbal soap in different regions, highlighting Asia Pacific as the leader.

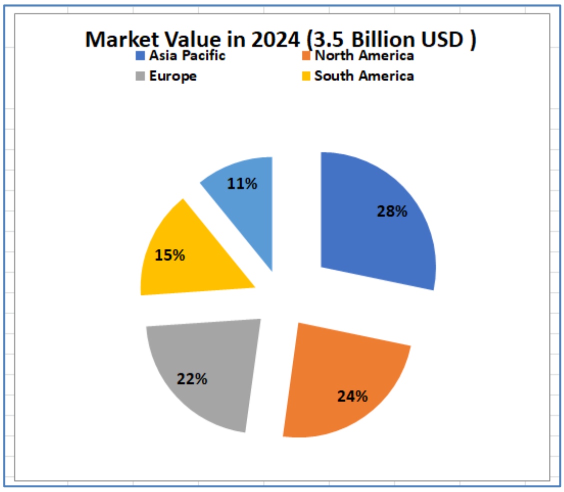

Fig. 4. The regional distribution of the herbal soap market in 2024 (Source: Google Trends).

CONCLUSION

The study concludes that high-quality herbal soap can be effectively formulated using the hot decoction process by carefully considering parameters like skin compatibility and the bioactive potential of herbs. This type of formulation addresses the shortcomings of many existing polyherbal or chemical-based soaps (Sharma et al., 2022; Harkhal and Deshmukh, 2024) offering a safer and more effective alternative. Such advancements in herbal formulations have the potential to revolutionize the herbal cosmetics industry, bridging gaps and correcting flaws in current products to meet consumer demand for sustainable, skin-friendly solutions.

Regarding future research, this study not only underscores the therapeutic and dermatological potential of herbal soaps but also provides a robust methodological framework for their development. Future research should focus on expanding the scope of bioactive compounds incorporated into such formulations and assessing their clinical efficacy through in vivo studies.

AUTHORS CONTRIBUTIONS

All the authors have contributed equally. All authors have read and agreed to the published version of the manuscript.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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