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Production and Antimicrobial Properties of Neem Based Herbal Soap against Selected Skin Pathogens

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ABSTRACT

The antibacterial and phytochemical qualities of neem-based soaps made with transparent glycerin bases and goat milk were examined in this study. Aloe vera gel, rose water, vitamin E, and natural aroma were added to soap compositions after fresh Azadirachta indica (neem) leaves were gathered and processed into oil and aqueous extracts. Following manufacture, the weight, pH, and foaming capacity were examined right away. Using the agar well diffusion method, the antibacterial properties of the soaps were evaluated against Staphylococcus aureus, Sporobolomyces spp., Malassezia furfur, Tinea capitis, Pseudomonas, Propionibacterium acne, and Candida albicans on Mueller Hinton Agar and Potato Dextrose Agar. According to the findings, the goat milk basis soap had larger zones of inhibition than the transparent base, and it was most active against Sporobolomyces spp. (25 mm). Both soaps demonstrated equal antifungal effects (15 mm) against Candida albicans. Phytochemical screening revealed that methanolic extracts of neem and aloe vera contained tannins, flavonoids, alkaloids, glycosides, and saponins, whereas aqueous extracts showed fewer bioactive compounds. The soaps had skin-compatible pH and adequate foaming capacity. This study concludes that neem-based soaps, particularly those made with goat milk, are effective natural alternatives for managing microbial skin infections. It was also recommended that neem-based soap should be considered for distribution in rural health campaigns, especially in areas prone to skin infections and where access to conventional medicated soaps is limited.

Keywords: *Antimicrobial, Neem, Herbal, Soap, Skin, Pathogens.*

Introduction

Since ancient times, people have utilised the seeds, bark, and leaves of the *Azadirachta indica* (neem) tree as a source of medicine [1]. Because each portion of neem has distinct chemical characteristics, its efficacy in treating different ailments may vary. Nimbidin, cyclic trisulphide, cyclic tetrasulphide, and polyphenolic flavonoids make up neem leaf extract. Antibacterial, antifungal, and anticancer properties are supported by these bioactive substances. Additionally, it has a lot of antioxidants, which aid in the growth of new skin cell tissues. Neem leaf has been used in Ayurvedic medicine to cure intestinal worms, anorexia, biliousness, leprosy, gum disease, blood disorders, epistaxis, and skin ulcers. In the meanwhile, certain kinds of neem limonoids found in neem leaves can stop the mutagenic effect [2].

Neem has been incorporated to enhance the properties of various products due to its proven antimicrobial properties. Apart from drugs, they have been added to soaps, creams and oils to meet up with the increase in the production of the soaps with water soluble sodium or potassium salts of fatty acids. Soaps are made from fats and oils by treating them chemically with a strong alkali and may be different in the way in which people use the word [3]. Soaps are exempted from the provisions of the Food Drug and Cosmetics Act because even though a section of the Act includes "Article for cleansing" in the definition of cosmetics, most commercial soaps available in market are incorporated with chemical agents having antimicrobial activity with potential depilatory properties on skin pathogens. Soaps are regarded as disinfectants required in daily practice hygiene [4]. Herbal soap is a substance made of a compound of herbal oils or fats with sodium hydroxide or any other strong alkali, and normally having fragrance and coloring introduced. Cleanliness and personal hygiene has become an essential global issue due to the growing diversity of diseases. As a fact, skin is the largest sensory organ of the body which serves as a barrier to protect the body organs and gathers sensory data from the surroundings. The hypodermis, and epidermis are the three primary layers [5] and every layer contributes in a completely unique manner to how the skin works as a whole. As skin imparts a specialized feature to body wellbeing, it is essential for to protect it from skin illnesses and ailments. Skin conditions are a generic infection. It harms human beings of all ages, inclusive of newborns and the elderly, and does so in numerous distinct ways. Infections, allergies, sun exposure, accidents, and different factors can all result in pores and skin problems [2]. Herbal soaps basically consist of plant parts such as seeds, rhizomes and roots which have potent antibacterial, anti-aging, antioxidant, and antiseptic effects. Herbal soaps contain none of the synthetic dyes, flavors, fluorides, or other additives typically found in commercial soaps. With the production of effective antiseptic soaps, germs will be controlled and humans will have an opportunity to live a safe life. Neem soap is rich, nourishing and helps to restore skin elasticity while protecting it from infection. Neem is recommended with skin problems such as eczema, acne, and dry skin because it contains citronella [6]. The soap can naturally help to repel insects and bacteria. Some neem soaps are prepared with pure neem leaves and seed extract. This formulation gently assertively detoxifies the skin while its antibacterial nature kills germs and bacteria. It is gentle yet effective for oily and acne prone skin. It also has anti-inflammatory and anti-fungal properties, flushes toxins, clears light scars and pigmentation [7]. Chemicals used in many commercial antimicrobial soaps may cause adverse reactions or increase antibiotic resistance. The neem plant, which is widespread in Nigeria and other developing nations but underutilised, has the potential to have an economic impact. Although neem leaf has long been recognised for its therapeutic and antibacterial qualities, its efficacy in transparent soap matrices has not received much scientific support [8]. The neem-based soap may be less effective when used in low quantities since certain strains of the chosen skin pathogens may already have a significant degree of resistance. Due to the increased prevalence of skin infections and pathogens, particularly dandruff and acne, many individuals are still looking for solutions through a variety of soaps and creams that either work or result in different skin reactions. Because neem leaf has been shown to have antibacterial qualities, it is necessary to make soap strengthened with it. This will significantly improve skin conditions, particularly for those who choose organic and plant-based products over chemical ones and have dandruff and acne on their faces [9]. Even though neem oil is natural, some people may still experience allergic reactions or irritation from it, particularly at high quantities. This restricts its use in the absence of appropriate dermatological testing and safety evaluations. It can be time-consuming and expensive to conduct in-vitro antimicrobial tests, maintain sterile lab conditions, and guarantee access to all required lab equipment and reagents, particularly for student or small-scale research settings [10]. This is in line with sustainable development objectives, which place a strong emphasis on using locally accessible, natural resources in health and wellness goods. This study aims to create and assess the antibacterial qualities of transparent beauty soap improved with neem leaf and goat milk.

Materials and Methods

Materials

Neem leaf transparent glycerin base soap, goat milk glycerin base soap, aloe vera gel, rose water, Vitamin E, scent, preservation, spatula, mortal and pistol, sieve, soap molds, digital scale, autoclave and incubator, distilled water, petri dishes, swab sticks and Nutrient Agar.

Methods

Source and Collection of Plant Samples

Samples of fresh, healthy *Azadirachta indica* leaves were collected from Auchi's native habitat. After properly cleaning the leaves with clean water to get rid of any dust or pollution, they were allowed to air dry for six (6) days at room temperature. Removing moisture without scorching the leaves is the aim. Goat milk soap was purchased together with other production-related products.

Source of Test Isolates

Test isolates includes; *Staphylococcus aureus, Klebsiella pneumonia*, *Propionibacterium*, *Malessazia furfur*, *Sporobolomyces* spp, *Tinea capitis, Pseudomonas aeruginosa* and *Candida albicans*. The isolates *Staphylococcus aureus*, *Pseudomonas* and *Candida albicans* were obtained from Auchi Polytechnic Cottage Hospital while *Propionibacterium*, *Sporobolomyces* spp, *Tinea capitis* and *Malessazia furfur* were isolated from volunteers. All isolates were confirmed through standard microbiological procedures.

Sterilization of Materials

All glass wares were first washed with detergent and distilled water before use.

Disinfection of Working Areas

The work bench was disinfected thoroughly before and after use with cotton wool soaked in methylated spirit and ethanol to clean the surfaces.

Preparation of Neem Oil

A blender was used to grind the clean, dry leaves into a powder. Dried leaves were put to the basin along with olive oil. The active components in the leaves were extracted using a double boiling process, which involved stirring the liquid for 20 to 30 minutes. The neem oil's tint instantly turned dark green, and it smelt like neem. The neem leaf residue was separated from the oil by filtering the mixture through a clean sieve. After that, a clean, air-dried bottle was used to keep the neem-infused oil.

Preparation of Aqueous Neem Extract

To get rid of filth and debris, fresh neem leaves (Azadirachta indica) were thoroughly rinsed with clean water. The natural juice was then extracted by physically pounding the leaves with a mortar and pestle. The crushed leaves were pressed and filtered to gather the resultant extract. Soap was made immediately from this fresh aqueous extract. But you can also boil or soak fresh dried neem leaves in distilled water, let them cool, then filter and concentrate.

Preparation of Soap

The preparation was carried out using the melt-and-pour method with a double-boiler technique due to its simplicity and suitability for incorporating heat-sensitive bioactive ingredients. The soap base was cut into small cubes and transferred into a stainless-steel bowl. A large pot moderately filled with water was placed on a stove to heat up and the bowl containing pieces of the soap base was lowered into the pot to form a double-boiling setup so that the water in the pot serves as a gentle heat. The soap base was stirred occasionally to ensure even melting. Once fully melted, the measured neem oil and neem leaf extract were incorporated into the mixture, followed by the addition of aloe vera gel and a few drops of rose water for skin nourishment and fragrance. A preservative (Germall Plus) was then added to ensure product stability and fragrance oil was introduced to enhance the scent. The mixture was poured into molds and allowed to solidify. After solidification, the soap was carefully removed from the molds and was ready for use.

pH Determination of the Neem Based Herbal Soap

In a clean beaker, precisely 1.0g of the soap was weighed and dissolved in 10mL of purified water. After giving the mixture a good stir, it was let to stand for five minutes. Next, a pH meter was used to measure the pH, and a universal pH indicator paper was used to confirm the results.

Test for Foaming Capacity: Ten millilitres of distilled water were used to dissolve precisely 0.2 grammes of the neem-based herbal soap. To create foam, the mixture was poured into a 100 mL measuring cylinder and forcefully shaken for two minutes. In order to assess foam stability, the foam height was measured both right away and ten minutes later [11]. According to the foamability test, the transparent neem-based soap produced a greater foam height of 15 cm, while the goat milk neem-based soap produced a foam height of 10 cm. After 10 minutes, the foam in both formulations showed stability, indicating strong foaming capability.

Antimicrobial Assessment

By streaking samples onto agar plates using a sterile wire loop, bacteria test organisms such as *Propionibacterium acnes* and fungi *Sporoblomycess* spp., *Malassezia furfur* (dandruff), and Tinea capitis were cultivated in order to evaluate the antimicrobial activity of the neem-based soap. After obtaining bacterial isolates from a volunteer's face using a swab stick streaked over nutrient agar, the samples were incubated for 24 hours at 27°C. Using a swap stick, fungus samples were taken from the volunteers' feet and scalps. After being smeared on PDA, it was allowed to sit at room temperature for three to five days.

Antimicrobial Activity Test

Sterile Petri dishes were prepared by pouring and solidifying appropriate media under aseptic conditions Mueller Hinton Agar for bacterial isolates and Potato Dextrose Agar for fungal isolates. Selected bacterial strains *Staphylococcus aureus, Pseudomonas aeruginosa,* and *Propionibacterium acnes* while fungal strains *Sporobolomyces spp., Malassezia furfur, Tinea pedis,* and *Candida albicans* were inoculated onto the surface of the solidified media by streaking. Using a sterile cork borer, wells about 6 mm in diameter were aseptically drilled into the agar. One millilitre of melted neem-enhanced soap solution was added to each well. Fungal plates were stored at ambient temperature for a whole day, whereas bacterial plates were incubated at 37 °C. After that, zones of inhibition were noted and observed. The degree of microbial growth suppression was shown by these zones.

Phytochemical Screening of Extract

The extract was subjected to phytochemical screening following the procedure outlined by Oke *et al.* [12]. Flavonoids, saponins, glycosides, tannins, alkaloids, and phlobatannin were all screened for in the extract.

Identification of Bacteria Isolate

Gram Staining: The bacterial culture was prepared as a thin smear on a glass slide, air-dried, and heat-fixed. After a minute of crystal violet staining, the smear was cleansed and given a minute of Gram's iodine treatment. After 30 seconds of decolorisation with 95% ethanol, it was immediately rinsed and counterstained for one minute with safranin. Gram-positive organisms appeared purple and Gram-negative organisms appeared pink when the slide was examined under oil immersion after drying.

Biochemical Test: The organisms were subjected to biochemical tests in order to properly identify them using the technique outlined by Iyevhobu *et al*. [13]. Catalase, oxidase, indole, nitrate reduction, lipase activity, urease, carbohydrate fermentation, and gelatin hydrolysis are among the biochemical assays.

Results

The different outcomes from the manufacturing and antibacterial activity of neem-based herbal soap are displayed in the tables below. Table 1 displays the weight, pH, and foaming capacity of neem soap; Table 2 displays the antibacterial properties of soap produced against specific pathogens measured in zones of inhibition (mm); Table 3 displays the antifungal properties of soap produced against specific pathogens measured in zones of inhibition (mm); and Table 4 presents the qualitative phytochemical analysis of plant extract.

Table 1: pH, Foaming Capacity and Weight of Neem Soap

Samples	pH	Foaming Capacity (mm)	Weight (g)
Goat Milk Soap Base	7.09	10	93
Transparent Soap Base	7.77	15	93

Table 2: Antibacterial Properties of Soap Produced against Selected Pathogens (Zone of inhibition)

Samples	Goat Milk Soap Base (mm)	Transparent Soap Base (mm)
Staphylococcus aureus	22	16
Pseudomonas aeruginosa	15	10
Propionibacterium acnes	14	10

Table 3: Antifungal Properties of Soap Produced against Selected Pathogens (Zone of inhibition)

Samples	Goat Milk Soap Base (mm)	Transparent Soap Base (mm)
Sporobolomyces spp	25	23
Malassezia furfur	23	21
Tinea capitis	16	14
Candida albican	15	15

Table 4: Qualitative Phytochemical Analysis of Plant Extract

Phytochemicals	Neem	Aloe Vera
Tannins	+ +	-
Flavonoids	+ +	+
Phenolic compound	+ +	-
Cardiac Glycosides	+ +	+

Terpenoid	+	-
Steroid	+	+
Alkaloid	+	+ + +
Saponins	+ +	+ +

Key words: + = Present; + + = Moderately Present; + + + = Highly Present

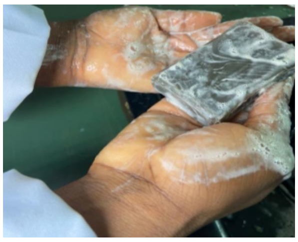

Figure 1: Soap with No Goat Milk

Figure 2: Goat Milk Neem Soap

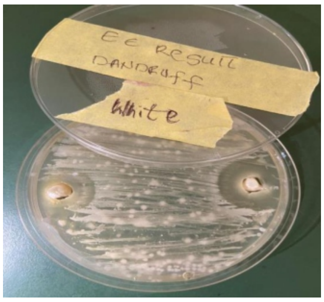

Figure 3: Malassezia Furfur (Milk Colored Dandruff)

Figure 4: Staphylococcus aureus

Figure 5: Sporobolomyces spp (The Orange Dandruff)

Figure 1 shows the produced soap with No Goat Milk, figure 2 shows the Goat Milk Neem Soap, Figures 3, 4 & 5 shows the antimicrobial activity of the produced and their zones of inhibition against different organisms.

Discussion

The manufactured soaps' pH values were within the permitted range of 7–10, as advised by Nigerian regulatory bodies [14]. The transparent neem soap had a pH of 7.77, whereas the goat-milk neem soap was 7.09. Given that overly alkaline soaps (pH > 10) are typically harsh and corrosive, these values show that both soaps are moderate, safe for skin application, and less likely to cause irritation. This outcome is consistent with the study conducted by Salako et al. [15], who found that herbal soaps made from natural oils using cold saponification had pH values ranging from 7.1 to 9.8. Similarly, Uduma *et al.*, [16] observed soap pH values ranging from 7.0 to 8.5, measured using a digital pH meter on a 1% soap solution, which is comparable to the method employed in the present study. Hence, the close agreement suggests that the formulation of neem-based herbal soaps in this study conforms with established ranges for mild, skin-friendly products.

In terms of foaming capacity, the transparent neem soap produced a foam height of 15 cm, while the goat-milk neem soap produced 10 cm. Foam height is an important quality parameter, as it reflects lathering ability, which is strongly associated with consumer preference. Akinneye *et al.*, [17] reported that acceptable foam heights for bar soaps generally range from 1.5 to 25 cm, while Raja & Banu [18] found foam values of 1.3–22 cm in various herbal soap formulations. Thus, the foam produced in this study falls well within acceptable ranges. The relatively lower foaming observed in the goat-milk formulation may be due to its higher fat and free fatty acid content, which is known to suppress foam formation and stability [19, 20].

Additionally, both soap formulations had a uniform weight of 93 g, reflecting good consistency and accuracy in production. The isolate showed rod-shaped morphology with small, white to cream, smooth colonies, consistent with Propionibacterium acnes (now reclassified as *Cutibacterium acnes*) [21]. Biochemical tests further supported this identification, as the organism was Gram-positive, catalase-positive, oxidase-negative, and also positive for indole, nitrate reduction, urease, carbohydrate fermentation, gelatin hydrolysis, and lipase activity. According to Bergey's Manual of Systematic Bacteriology [22], these biochemical and cultural characteristics are typical of C. acnes. *Propionibacterium acnes* is a common commensal skin bacterium that has been linked to acne pathogenesis because of its capacity to generate lipases, hydrolyse sebum triglycerides, and induce inflammatory reactions [23].

The fungal isolates showed distinct morphological features that aided their identification. *Malassezia furfur* appeared oval to round with smooth, moist, cream to yellowish colonies that were opaque to slightly translucent, consistent with its known characteristics as a lipophilic yeast associated with skin infections [24]. *Sporobolomyces* spp. formed round to oval, smooth, glistening, orange colonies that were opaque and moist, which agrees with its typical description as a pigmented yeast [25]. The sample isolates, suspected to be *Tinea pedis* (a dermatophyte), produced spherical structures with downy to fluffy colonies that were white to cream, opaque, and velvety, features typical of dermatophytic fungi such as Trichophyton species. These findings indicate a diversity of fungal organisms with distinct colony morphologies, supporting their accurate identification.

The antibacterial activity of the neem-based soaps showed varying zones of inhibition against the test pathogens. Against *Staphylococcus aureus*, the goat milk soap base produced a larger inhibition zone (22 mm) compared to the transparent base (16 mm), indicating stronger effectiveness. Similarly, for *Pseudomonas aeruginosa* (15 mm vs. 10 mm) and *Propionibacterium acnes* (14 mm vs. 10 mm), the goat milk soap base consistently showed greater antibacterial activity. These results suggest that the incorporation of goat milk enhanced the antimicrobial properties of the soap, possibly due to bioactive compounds that synergize with neem extracts, making the goat milk formulation more effective overall. This finding is consistent with research demonstrating that goat milk contains antimicrobial peptides (such as α-s2-casein-derived peptides) that are effective against Gram-positive bacteria such as *S. aureus* and *P. acnes* [26]. Goat milk's known antibacterial and immunomodulatory qualities are also highlighted in broader assessments of its rich composition, which includes immunoglobulins, lactoferrin, lysozyme, and other bioactive proteins [27].

The antifungal activity of the formulated soaps demonstrated effective inhibition against the tested organisms. The goat milk soap base consistently demonstrated slightly higher activity than the transparent base, with inhibition zones of 25 mm vs. 23 mm for *Sporobolomyces* spp., 23 mm vs. 21 mm for *Malassezia furfur*, and 16 mm vs. 14 mm for *Tinea pedis*.

For *Candida albicans*, both soap bases exhibited equal inhibition zones of 15 mm, suggesting similar efficacy. Overall, the results indicate that both formulations possess broad antifungal properties, with the goat milk soap base showing a marginal advantage, possibly due to synergistic effects between goat milk components and neem extract. This finding is consistent with studies demonstrating that neem leaf extracts exhibit significant antifungal activity against dermatophytes and Candida species [28, 29], and that combinations of neem extracts with other agents can enhance antifungal efficacy through synergistic mechanisms [30].

Important bioactive substances such as flavonoids, phenolic compounds, terpenoids, steroids, alkaloids, and saponins were found in the qualitative phytochemical screening of neem and aloe vera extracts. Depending on the plant source, differences were noted in tannins and cardiac glycosides. Neem's antibacterial and therapeutic qualities are attributed to its abundance of alkaloids, flavonoids, tannins (moderately present), saponins, terpenoids, steroids, glycosides (moderate), and phenols [31, 32]. Conversely, depending on the extraction technique, aloe vera revealed the presence of flavonoids, tannins, saponins, steroids, terpenoids, and cardiac glycosides, which are linked to its calming, moisturising, and antioxidant properties [33]. The combined presence of these phytochemicals in both extracts supports their synergistic role in enhancing the antimicrobial and therapeutic properties of the formulated herbal soaps.

This study explored the antimicrobial properties and phytochemical composition of neem (*Azadirachta indica*)-based soaps using both goat milk and transparent glycerin bases. The formulations incorporated neem oil, neem aqueous extract, aloe vera gel, and other natural additives to assess their effectiveness against a range of microbial pathogens including *Staphylococcus aureus*, *Sporobolomyces spp.*, *Malassezia furfur*, *Tinea capitis*, and *Candida albicans*. The antimicrobial sensitivity tests revealed that both soap formulations possessed significant inhibitory effects on the test organisms. Notably, with inhibition zones as large as 25 mm and 23 mm, respectively, the goat milk soap base shown somewhat better antimicrobial activity than the clear basis, particularly against *Sporobolomyces* spp. and *Malassezia furfur*. The promise of both soaps in treating common fungal skin infections was highlighted by their similar antifungal efficacy against *Candida albicans*.

Conclusion

In conclusion, neem-based soaps, particularly those formulated with goat milk, present a natural, affordable, and effective alternative to synthetic antimicrobial skincare products. Their use may be especially beneficial in managing skin conditions caused by bacteria and fungi, while also nourishing the skin through bioactive plant-based ingredients.

The following suggestions are offered in light of the study's findings: Neem-based soaps, particularly those prepared with goat milk, should be commercialised because of their potential antibacterial and skin-friendly qualities. To guarantee the long-term effectiveness and safety of the soap products under various storage settings, stability and shelf-life testing should be carried out. Small and medium-scale entrepreneurs should be encouraged to explore the production of neem-based herbal soaps, especially using goat milk glycerin base, due to its higher antimicrobial efficacy and skin-friendly properties. Public awareness campaigns should be encouraged to promote the benefits of natural soaps as safer alternatives to synthetic chemical-based products. Government and health organizations should promote the benefits of herbal-based personal care products like neem soap, highlighting their natural ingredients, low toxicity, and effectiveness in managing skin-related infections. Neem-based soap should be considered for distribution in rural health campaigns, especially in areas prone to skin infections and where access to conventional medicated soaps is limited.

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Dispute of Interest

No conflicts of interest are disclosed by the writers. The paper's writing and content are solely the authors' responsibility.

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Data and Materials Availability

The consent for all relevant data used in this study is declared by the authors.

Contributions of the Authors

All authors participated in the entire study process.

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