



Research Article

Formulation and Evaluation of Herbal Hand Soap Using Aloe Vera, Potato, and Turmeric

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Herbal formulations have gained significant attention in the cosmetic and personal care industry due to their natural origin, minimal side effects, and enhanced skin compatibility. This research article presents the formulation and comprehensive evaluation of herbal hand soap incorporating three potent botanical ingredients: Aloe vera (*Aloe barbadensis*), potato starch (*Solanum tuberosum*), and turmeric (*Curcuma longa*). The developed soap formulations were evaluated for various physicochemical parameters including pH, foam stability, detergency, skin irritation potential, and antimicrobial efficacy. Results demonstrated that the herbal hand soap exhibited optimal pH values between 8.5-9.5, excellent foam stability persisting for over 5 minutes, superior detergency properties, and significant antimicrobial activity against *Staphylococcus aureus* and *Escherichia coli*. Additionally, the formulation demonstrated minimal skin irritation potential in Draize test with potential dermatological applications. This study validates the efficacy and safety profile of the proposed herbal hand soap formulation, making it a promising alternative to conventional synthetic soaps.

Keywords: Herbal soap, Aloe vera, Potato starch, Turmeric, Antimicrobial activity, Physicochemical evaluation.

INTRODUCTION

Hand hygiene represents one of the most critical aspects of personal care and disease prevention in contemporary society. The escalating emergence of antimicrobial resistant pathogens and the heightened awareness of skin health have catalyzed a paradigm shift toward natural and herbal personal care products, particularly hand soaps [1]. Conventional synthetic soaps, while effective in cleansing, often contain harsh chemicals such as sodium lauryl sulfate (SLS) and synthetic fragrances that can cause skin irritation, dryness, and allergic reactions, especially in individuals with sensitive skin [2]. Herbal ingredients have been utilized in traditional medicine systems for centuries, with documented antimicrobial, antioxidant, and skin nourishing properties [3]. Among the most promising botanical candidates for soap formulation includes Aloe vera, potato starch, and turmeric, each possessing distinct dermatological and antimicrobial benefits. Aloe vera (*Aloe*

barbadensis Miller), belonging to the family Liliaceae, contains over 75 active compounds including polysaccharides, amino acids, and anthraquinones, which exhibit emollient, wound healing, and antimicrobial properties [4]. Potato starch (*Solanum tuberosum*) has been traditionally used as a skin soothing and moisture retaining agent, while turmeric (*Curcuma longa*) is renowned for its potent curcuminoid compounds with strong antimicrobial and anti-inflammatory attributes [5]. The primary objective of this research was to develop an optimal herbal hand soap formulation incorporating Aloe vera, potato starch, and turmeric, and to comprehensively evaluate its physicochemical properties, antimicrobial efficacy, and dermatological safety profile. The hypothesis underlying this study posits that a synergistic combination of these three herbal ingredients would yield a soap formulation with superior antimicrobial activity, enhanced skin compatibility, and improved sensory attributes compared to conventional soaps.

MATERIALS AND METHODS

MATERIALS

The following materials were procured for soap formulation: Aloe vera gel (fresh extract), potato starch (pharmaceutical grade), turmeric powder (curcumin content: 95%), coconut oil (virgin, cold pressed), palm oil (refined), sodium hydroxide (NaOH, analytical grade), distilled water, glycerin (pharmaceutical grade), essential oils (lavender and rose), sodium chloride (NaCl), and sodium silicate. All materials were sourced from certified suppliers and authenticated prior to use. Microbial reference strains including *Staphylococcus aureus* (ATCC

6538) and *Escherichia coli* (ATCC 8739) were obtained from the microbiology laboratory repository.

Formulation Development

Four distinct soap formulations (F1, F2, F3, and F4) were prepared utilizing the cold saponification method. The formulations were systematically designed with varying concentrations of herbal ingredients to optimize the final product. The detailed composition of each formulation is presented in Table 1. The basic principle involved the reaction of fatty acids (coconut oil and palm oil) with sodium hydroxide in the presence of herbal extracts and additives.

Table 1: Soap Formulation Composition

Ingredients (g)	F1 (Control)	F2	F3	F4 (Optimal)
Coconut Oil	120	120	120	120
Palm Oil	80	80	80	80
Sodium Hydroxide (NaOH)	50	50	50	50
Distilled Water	50	50	50	50
Aloe vera Gel	0	10	10	15
Potato Starch	0	5	8	10
Turmeric Powder	0	3	5	8
Glycerin	10	10	12	15
Essential Oil Mix	5	5	6	8

F1 = Control formulation without herbal ingredients; F2, F3, F4 = Formulations with increasing herbal concentrations

Soap Preparation Procedure

The saponification process was conducted under controlled laboratory conditions. Coconut oil and palm oil were combined and heated to 45-50°C. Sodium hydroxide solution (prepared by dissolving NaOH in distilled water) was simultaneously heated to the same temperature. The herbal ingredients (Aloe vera gel, potato starch, and turmeric powder) were dissolved in distilled water to form a homogeneous mixture. The heated alkali solution was slowly added to the oil mixture with continuous stirring at 100 rpm using a mechanical stirrer. The resulting mixture was stirred for approximately 45 minutes until trace formation (light ribbon pattern on the surface when solution is drizzled). At this point, glycerin and essential oil mixture were added, followed by

continuous stirring for an additional 10 minutes. The mixture was then poured into molds lined with parchment paper and allowed to cure at room temperature (25±2°C) for 24 hours. Following initial solidification, the soap was removed from molds and allowed to further cure for 28 days in a temperature-controlled environment (20-25°C, relative humidity 45-55%) before evaluation. The cured soap bars were then cut into uniform samples (approximately 10g each) for testing.

Physicochemical Evaluation

pH Determination: The pH of soap solutions (1% w/v in distilled water) was determined using a calibrated digital pH meter at 25°C. Measurements were performed in triplicate, and mean values were recorded [6].

Foam Stability: Foam stability was assessed using a modified Ross-Miles method. A 1% soap solution (50

mL) was poured from a height of 90 cm into a 100 mL graduated cylinder containing 50 mL of the same solution. Foam height was measured at 0, 1, 3, and 5 minutes. Results were expressed as percentage of initial foam height retained after 5 minutes [6].

Detergency Test: Detergent properties were evaluated using the soil removal assay. Cotton cloth (5×5 cm) stained with standard soil mixture (carbon black and mineral oil) was washed in 1% soap solution at 40°C for 10 minutes. Soil removal was quantified colorimetrically using a spectrophotometer at 500 nm, with results expressed as percentage soil removal [6].

Hardness: Soap hardness was determined using a hardness tester (Shore A durometer), with measurements performed at five different points on each soap bar sample [7].

Antimicrobial Evaluation

Antimicrobial activity was assessed using the disk diffusion method (Kirby Bauer method) against *Staphylococcus aureus* and *Escherichia coli*. Sterile Mueller Hinton agar plates were seeded with 0.1 mL of overnight bacterial culture. Soap extracts (10 mg/mL in dimethyl sulfoxide, DMSO) were impregnated onto sterile paper disks (6 mm diameter) and placed on inoculated plates. After incubation at 37°C for 24 hours, zones of inhibition were measured in millimeters. Gentamicin (10 µg) and DMSO served as positive and negative controls, respectively [8].

Dermatological Safety Evaluation

Skin irritation potential was evaluated using the Draize test as per guidelines. New Zealand white rabbits (n=6) were used with ethical approval from the Institutional Animal Ethics Committee. A 1% soap solution (0.5 mL) was applied to intact skin on the dorsal region and covered with a 2.5 cm × 2.5 cm gauze patch. Observations were recorded at 24, 48, and 72 hours for erythema and edema formation. Scoring was performed using the Draize scale (0-8), with lower scores indicating minimal irritation [9].

Statistical Analysis

All experiments were performed in triplicate (n=3), and results were expressed as mean±standard deviation. One-way analysis of variance (ANOVA) followed by Tukey's post hoc test was used for statistical comparison between formulations. A p-value <0.05 was considered statistically significant [10].

RESULTS

Physicochemical Properties

- **pH measurements** of all formulations ranged from 8.5 to 9.5, which falls within the acceptable range for skin care products. Formulation F4 (optimal herbal formulation) demonstrated a pH of 9.2 ± 0.3 , indicating appropriate alkalinity while minimizing potential skin irritation. The control formulation (F1) exhibited a slightly higher pH of 9.5 ± 0.2 . Herbal ingredient incorporation resulted in a slight decrease in pH values, which could be attributed to the acidic nature of plant extracts [11].
- **Foam stability** assessment revealed significant differences among formulations. The control formulation (F1) retained 72% of its initial foam height after 5 minutes. However, formulations F2, F3, and F4 demonstrated progressively improved foam stability with retention values of 78%, 85%, and 89%, respectively. The enhanced foam stability in formulations containing herbal ingredients can be attributed to the saponin content and emulsifying properties of the botanical extracts [12].
- **Detergency testing** demonstrated superior soil removal efficiency in formulations containing herbal ingredients. F1 (control) achieved 68% soil removal, while F2, F3, and F4 achieved 74%, 81%, and 87% soil removal, respectively. The enhanced detergent properties of the herbal formulations suggest synergistic interactions between the botanical components and the soap matrix [13].
- **Hardness measurements** indicated that all formulations exhibited appropriate hardness values (75-85 Shore A units), which ensures

structural integrity during storage and use without excessive brittleness [14].

Antimicrobial Activity

Antimicrobial evaluation using the disk diffusion method revealed significant activity against both test organisms. Against *Staphylococcus aureus*, the control formulation (F1) demonstrated an inhibition zone of 12 ± 1 mm, while formulations F2, F3, and F4 showed progressively larger zones of 15 ± 1 mm, 18 ± 2 mm, and 22 ± 2 mm, respectively. Similarly, against *Escherichia coli*, inhibition zones increased from 10 ± 1 mm (F1) to 13 ± 1 mm (F2), 16 ± 2 mm (F3), and 20 ± 2 mm (F4). The positive control (Gentamicin) displayed zones of 28 ± 1 mm and 26 ± 1 mm against *S. aureus* and *E. coli*, respectively. The antimicrobial efficacy was directly proportional to the concentration of herbal ingredients, particularly turmeric, which is known for its potent curcuminoid antimicrobial compounds [15].

Dermatological Safety

Draize test results demonstrated excellent dermatological safety profiles for all formulations. The control formulation (F1) exhibited minimal erythema and edema (Draize score: 1 ± 0.5). Formulations F2 and F3 showed similar safety profiles with scores of 1.5 ± 0.5 and 2 ± 0.5 , respectively. Notably, the optimal herbal formulation (F4) demonstrated exceptional safety with a Draize score of 1.5 ± 0.5 , suggesting that the herbal ingredients do not induce skin irritation even at higher concentrations. These results indicate that the formulation is suitable for sensitive skin applications [16].

DISCUSSION

This comprehensive research successfully developed and evaluated a novel herbal hand soap formulation incorporating three botanically significant ingredients: Aloe vera, potato starch, and turmeric. The systematic incorporation of these herbal components resulted in a soap product with significantly enhanced physicochemical, antimicrobial, and dermatological properties compared to the control formulation [17]. The pH values obtained (8.5-9.5) are consistent with earlier

reports on natural soap formulations and fall within the recommended range for gentle skin care products. The slight pH reduction observed with herbal ingredient incorporation could be beneficial in reducing potential irritation while maintaining adequate alkalinity for effective cleansing [18]. The enhanced foam stability observed in herbal formulations is particularly significant for consumer acceptance and product efficacy perception. Aloe vera polysaccharides and potato starch carbohydrates likely contribute to improved foam stabilization through their ability to form protective films around air bubbles [19]. The superior detergent properties demonstrated by the herbal formulations (87% soil removal for F4) suggest that the herbal ingredients do not compromise, but rather enhance, the cleansing efficacy of the soap. This is crucial for commercial viability and consumer satisfaction [20]. The most notable finding pertains to the antimicrobial activity. Turmeric's curcuminoid compounds (curcumin, demethoxycurcumin, and bisdemethoxycurcumin) have been extensively documented in the literature for their broad-spectrum antimicrobial activity. The concentration dependent increase in antimicrobial efficacy (from F1 to F4) corroborates previous studies on curcumin's bactericidal properties against both gram-positive and gram-negative organisms [21]. The excellent safety profile demonstrated in the Draize test is particularly encouraging for commercial development. The herbal ingredients appear to impart skin conditioning properties without introducing irritation potential, which is often a limitation of synthetic antimicrobial agents commonly used in conventional hand soaps [22-26].

CONCLUSION

This research successfully demonstrated the feasibility of developing an effective herbal hand soap formulation incorporating Aloe vera, potato starch, and turmeric. The optimal formulation (F4) exhibited superior physicochemical properties, excellent antimicrobial efficacy against clinically relevant pathogenic bacteria, and minimal dermatological safety concerns. The product represents a promising alternative to conventional synthetic soaps, offering enhanced therapeutic properties while maintaining safety and efficacy standards. Future studies should include long term stability testing, consumer sensory

evaluation, and clinical efficacy trials in real world settings to further establish the commercial viability of this formulation.

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