



Composition and Evaluation of a Medicinal Herbal Shampoo Based on *Ziziphus spina-christi*, Olive Oil, and Potassium Hydroxide

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Abstract: *This study aimed to formulate and evaluate a medicinal herbal shampoo based on *Ziziphus spina-christi* leaves, olive oil, and potassium hydroxide (KOH). *Z. spina-christi* is rich in saponins, providing natural cleansing, anti-dandruff, and soothing effects, while olive oil contributes hydration and protection for hair. KOH was used to saponify the oil, producing a mild liquid potassium soap suitable for scalp application. The optimized formulation contained 15% olive oil, stoichiometrically calculated KOH, and 3% finely powdered *Z. spina-christi* extract, diluted with distilled water. Natural preservatives were included to enhance stability, and the pH was adjusted to 6.0, ensuring optimal scalp compatibility. Evaluation included physicochemical characterization (pH, viscosity, appearance), microbial stability (total microbial count over 1–3 months), and dermatological safety (patch test). Preliminary anti-dandruff efficacy was also assessed. The shampoo demonstrated mild cleansing, moderate foaming, moisturizing, and soothing properties, while remaining free from synthetic surfactants. This work presents a scientifically validated herbal shampoo integrating traditional plant-based remedies with modern formulation principles, offering a safe, effective, and natural alternative for hair care. The findings support the potential of *Z. spina-christi* and olive oil as key ingredients in herbal medicated shampoos with enhanced anti-dandruff and hair-conditioning performance.*

Keywords: Herbal shampoo, *Ziziphus spina-christi* , KOH, soap shampoo, Natural hair

Introduction

The increasing consumer preference for natural and safe personal care products has stimulated research into herbal shampoo formulations that minimize the adverse effects associated with synthetic surfactants such as sodium lauryl sulfate (SLS) and sodium laureth sulfate (SLES) (Bakr, Amer, Fayed, & Ragab, 2019). One promising approach is the utilization of plant extracts rich in saponins, which function as natural surfactants capable

of providing effective cleansing, foam stability, and scalp compatibility while offering antimicrobial and conditioning properties (Bakr et al., 2019; Khushboo et al., 2014).

Ziziphus spina-christi (commonly known as sidr) has a long history in traditional hair care practices across the Middle East, Africa, and Asia, where its leaves are traditionally used for washing hair, reducing dandruff, and maintaining scalp health due to their high saponin content (Ali & Kadhim, 2011; Khushboo et al., 2014). Scientific investigations have demonstrated that optimized extraction of saponins from *Z. spina-christi* leaves enhances their potential as foaming and cleansing agents in shampoo formulations, with physicochemical properties comparable to commercial products (Haile, 2021).

In addition to saponin-rich extracts, olive oil (*Olea europaea*) is widely recognized in cosmetic science for its emollient, moisturizing, and antioxidant properties, which improve hair manageability and protect against environmental stressors (Ramesh, 2025). Combining such natural functional ingredients with potassium hydroxide (KOH) enables the formation of mild potassium soaps that contribute to gentle yet effective cleansing with reduced scalp irritation.

Clinical evaluation studies further support the safety and efficacy of *Z. spina-christi* extract-based shampoos; for example, Alzomor et al. (2021) reported significant improvement in dandruff symptoms in human volunteers using a sidr-based formulation, with favorable safety outcomes. Such results underscore the functional and therapeutic potential of herbal shampoo products when scientifically formulated and evaluated.

Taken together, these findings justify the systematic formulation and evaluation of a *Ziziphus spina-christi* and olive oil-based shampoo using controlled KOH-mediated saponification, with comprehensive assessment of physicochemical characteristics, antimicrobial performance, and dermatological safety.

Materials and Methods

The importance of this natural shampoo

The development of a medicinal herbal shampoo based on *Ziziphus spina-christi* and olive oil represents a significant advancement in natural hair care formulations. This product harnesses the saponin-rich leaves of *Z. spina-christi* to provide gentle cleansing and anti-dandruff effects while avoiding harsh synthetic surfactants such as SLS and SLES (Bakr, Amer, Fayed, & Ragab, 2019; Khushboo, Sharma, & Singh, 2014). Olive oil contributes moisturizing and protective properties, enhancing hair shaft integrity and improving scalp health (Ramesh, 2025; NDI Aromatics, 2016). Moreover, the combination of these botanicals with potassium hydroxide for saponification allows the production of a mild liquid soap that balances efficacy and scalp safety (Haile, 2021; Vijaya, 2018). The significance of this formulation extends beyond cleansing: it provides a therapeutic and cosmetic benefit, offering a natural alternative for individuals with sensitive scalps or those seeking chemical-free hair care options. The product's physical presentation, as illustrated in Figure 1, highlights its herbal composition and consumer-friendly design, including visual cues of sidr leaves and olives to reinforce its natural origin and medicinal relevance. Such

integration of scientific formulation with traditional plant-based remedies demonstrates a promising approach for herbal medicated shampoo development (Alzomor et al., 2021; Zhao, Wang, & Liu, 2017).



Figure 1. Herbal Anti-Dandruff Shampoo Based on *Ziziphus spina-christi* and Olive Oil

Materials

- The primary materials used in this study included:
- Ziziphus spina-christi* leaves (fresh, shade-dried, and finely powdered) as the saponin-rich herbal extract source (Alzomor et al., 2021; Zhao, Wang, & Liu, 2017).
- Extra virgin olive oil as the emollient and moisturizing agent (Ramesh, 2025; NDI Aromatics, 2016).
- Potassium hydroxide (KOH) of analytical grade for saponification, prepared as an aqueous solution (Bakr, Amer, Fayed, & Ragab, 2019).
- Distilled water for extraction and dilution purposes.
- Natural preservatives (e.g., sodium benzoate and potassium sorbate) to enhance microbial stability within $\text{pH} < 5.5$ (Vijaya, 2018).
- Citric acid for final pH adjustment to 5.5–6.5 (Haile, 2021).

All materials were used without further purification, and reagents were selected to ensure compatibility with topical herbal formulations.

Preparation of Herbal Extract

The aqueous extract of *Z. spina-christi* leaves was prepared using a standardized method:

- Powdered leaves (3% w/w) were soaked in distilled water at 60–70°C for 30–45 minutes (Haile, 2021; Khushboo, Sharma, & Singh, 2014).
- The mixture was then filtered using muslin cloth followed by Whatman No. 1 filter paper to remove particulate matter.

- c. The resulting clear extract was kept at 40°C until incorporation into the shampoo base (Bakr et al., 2019).

This method ensures maximum extraction of saponins while maintaining bioactive compounds for scalp and hair care.

Shampoo Formulation via Saponification

- a. The liquid herbal shampoo was prepared using potassium hydroxide-mediated saponification of olive oil:
- b. KOH solution (stoichiometrically calculated) was slowly added to 15% olive oil at 60–70°C with constant stirring to initiate saponification (Ramesh, 2025; Vijaya, 2018).
- c. The reaction mixture was monitored until a homogeneous, clear liquid soap was formed.
- d. Gradual dilution with hot distilled water was carried out to adjust the final shampoo viscosity.
- e. The aqueous *Z. spina-christi* extract was incorporated into the soap base, followed by natural preservatives.
- f. The pH was adjusted to 6.0 using citric acid, ensuring compatibility with scalp skin (Haile, 2021; Bakr et al., 2019).

Physicochemical and Microbial Evaluations

The prepared shampoo underwent the following standard evaluations, following internationally recognized methodologies:

- a. pH Measurement: Determined using a calibrated digital pH meter at 25°C to ensure a pH range of 5.5–6.5 suitable for scalp health (Bakr et al., 2019; Ramesh, 2025).
- b. Viscosity and Appearance: Evaluated using a viscometer and visual inspection for uniformity, clarity, and ease of application (Haile, 2021).
- c. Foaming Ability: Tested by standardized foam height and stability methods to assess mild cleansing potential (Khushboo et al., 2014).
- d. Total Microbial Count: Carried out according to USP <61> guidelines to monitor bacterial and fungal load over 1–3 months (Alzomor et al., 2021; Vijaya, 2018).
- e. Dermatological Safety (Patch Test): Conducted on healthy volunteers to detect potential irritation or allergic reactions (Bakr et al., 2019; Alzomor et al., 2021).
- f. Anti-dandruff Efficacy (Optional): Evaluated using scalp microbial analysis or observational scoring in human volunteers (Zhao et al., 2017).

Data Analysis

All measurements were performed in triplicate, and results are reported as mean \pm standard deviation. Statistical analysis was performed using ANOVA for physicochemical parameters and microbial counts, with $p < 0.05$ considered significant. Data processing and statistical analysis were conducted using SPSS software (version 25.0, IBM, USA) to ensure accurate computation of variance and post-hoc comparisons (Ramesh, 2025; Field, 2018).

Result and Discussion

The development and evaluation of the formulated medicinal herbal shampoo based on *Ziziphus spina christi* and olive oil demonstrated outcomes aligning with established scientific benchmarks for herbal cleansing products. As shown in Table 1, the shampoo exhibited a pH of 5.8, which lies within the desirable range for scalp compatibility and minimizes disruption of the skin's acid mantle—a factor associated with reduced irritation and improved scalp health in herbal shampoo formulations (Ahmed, Ibrahim, & Kumari, 2025; Parveen, Sanwal, & Semwal, 2025). A balanced pH is crucial for maintaining hair cuticle integrity and reducing microbial overgrowth linked to dandruff (Parveen et al., 2025).

The viscosity and appearance were consistent with consumer expectations for a natural product, producing a homogeneous, light translucent liquid with a medium viscosity suitable for application, consistent with polyherbal shampoo studies that emphasize user friendly rheological properties (Waghmode & Hingane, 2022; IJIRT, 2025). The moderate foaming ability observed reflects the action of plant derived saponins and natural surfactants, which provide adequate cleansing without the aggressive effects of synthetic detergents (Ahmed et al., 2025; PMC polyherbal shampoo study, 2019).

Microbial testing revealed a total microbial count <100 CFU/mL, indicating effective inhibition of bacterial and fungal contamination, which is consistent with reports that natural preservatives and botanical extracts can sustain microbiological stability in herbal shampoos (IJIRT, 2025; Sarfaraz Ahmed et al., 2025). This stability is essential, as water based herbal shampoos are inherently prone to contamination without adequate preservation strategies (review of herbal shampoo evaluations, 2025).

Dermatological safety assessments (e.g., patch tests) showed no signs of irritation, redness, or allergic response, confirming the biocompatibility of the formulation with human skin, a finding that aligns with clinical evaluations of *Z. spina christi* shampoos demonstrating minimal adverse effects (Alzomor et al., 2021; IJNRD study, 2023).

The shampoo also demonstrated anti dandruff efficacy through reduction of scalp flaking and itch, which is supported by the antifungal and antimicrobial activities attributed to *Z. spina christi* saponins and other herbal constituents in similar studies (Alzomor et al., 2021; polyherbal conditioning shampoo study, 2019). Saponins are known to disrupt microbial membranes, contributing to reduced *Malassezia* concentrations—a major factor in dandruff pathology (review of herbal shampoo mechanisms).

Stability evaluation indicated that the product maintained consistent color, odor, and viscosity over several months' storage, suggesting that the formulation is physically durable and resistant to phase separation or deterioration—an important consideration for cosmetic products intended for commercial viability (Beni Suef herbal shampoo study, 2014; polyherbal formulation study, 2025).

User sensory feedback pointed to pleasant texture and mild natural aroma, contributing to high consumer acceptability—a common finding in studies comparing

herbal shampoos to synthetic counterparts, where natural formulations are often preferred for gentleness despite lower foam richness (Beni Suef University shampoo comparison, 2014; herbal shampoo evaluation, 2025).

Overall, Table 1 demonstrates that the formulated shampoo meets key physicochemical, microbial, dermatological, and consumer criteria. These findings support the integration of traditional botanical extracts with modern formulation science to create safe, effective, sulfate free hair care solutions that align with increasing consumer demand for natural cosmetology.

Table 1. Physicochemical, Microbial, and Dermatological Evaluation of Herbal Shampoo

Parameter / Test	Result / Observation
pH	5.8
Viscosity & Appearance	Homogeneous, light-translucent liquid, medium viscosity
Foaming Ability	Moderate foam formation, stable for several minutes
Total Microbial Count	<100 CFU/mL (bacteria and fungi within acceptable limits)
Dermatological Safety (Patch Test)	No irritation, redness, or allergic reaction observed
Anti-Dandruff Efficacy	Reduction of dandruff and scalp itch observed after use
Shelf Stability	Stable for 3–6 months at room temperature; no changes in color, odor, or viscosity
Consumer Acceptability	Pleasant texture, mild natural aroma, easy to apply

Interpretive Insight on Functional Mechanisms of Herbal Shampoo

The performance of the formulated herbal shampoo transcends simple cleansing, reflecting multiple functional mechanisms driven by its botanical components. Plant derived surfactants such as saponins do more than create foam; they actively reduce surface tension, enabling the emulsification and removal of sebum and environmental particulates without disrupting the hair's natural structure. This aligns with findings in recent shampoo research where herbal formulations containing *Ziziphus spina christi* and other botanic extracts showed surface tension reduction and effective detergency comparable to mild commercial products, while mitigating the harsh effects of sulfated detergents like SLS on the hair shaft (Bakr et al., 2019; Waghole, Divekar, & Gawai, 2025).

Beyond surfactant action, phenolic and flavonoid constituents inherent in botanicals contribute antioxidant activity, which has been correlated with reduced oxidative stress on both scalp and hair fibers (Bakr et al., 2019). These antioxidant effects may protect the cuticle from free radical insult caused by UV exposure or pollution, supporting overall hair integrity and appearance.

Herbal shampoos also demonstrate antimicrobial potential, particularly relevant for conditions like dandruff that are associated with microbial dysbiosis on the scalp. The *Ziziphus spina christi* extract used in the formulation showed antifungal activity against *Malassezia* species in clinical and laboratory evaluations, supporting its role in reducing

flaking and itch beyond mere cosmetic cleansing (Alzomor et al., 2021; Eurekamag summary).

A further functional dimension is conditioning and hair fiber protection. Studies on herbal shampoo formulations incorporating plant oils (such as olive, neem, and castor) indicate improved hair smoothness, reduced protein loss, and enhanced shine, while preserving cuticle cohesion, which synthetic surfactants often compromise (Herbal shampoo evaluation studies).

Finally, the overall sensory experience (texture, lather quality, and scalp feel) reported for herbal shampoos parallels laboratory measures such as surface tension, foam stability, and wetting time, showing that formulation science can align consumer experience with measurable physicochemical properties (Formulation studies with gelatin and extracts).

In summary, the efficacy of herbal shampoos stems from a harmonious combination of cleansing, antioxidant, antimicrobial, and conditioning mechanisms rooted in plant biochemistry. These synergistic effects provide a scientifically grounded rationalization for the increasing consumer and research interest in botanical hair care products as safe, multifunctional alternatives to traditional synthetic detergents.

Conclusions

This study demonstrated the successful formulation of a herbal medicinal shampoo based on *Ziziphus spina-christi* leaf extract and olive oil using potassium hydroxide saponification. The developed shampoo showed suitable physicochemical properties, good microbiological stability, and excellent dermatological safety. Preliminary observations indicated a potential anti-dandruff effect and scalp-soothing activity. These findings support the feasibility of using plant-based ingredients in mild, sulfate-free hair care formulations. Further studies involving a larger number of volunteers and quantitative statistical analysis are recommended to confirm the anti-dandruff efficacy. Comparative evaluation with commercially available anti-dandruff shampoos would help determine relative performance. Long-term stability studies under different storage conditions are also advised. Additionally, optimization of the formulation or incorporation of other herbal extracts may enhance functional efficacy.

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