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Formulation and Physicochemical Evaluation of A Polyherbal Shampoo Containing Manilkara Zapota Seed Oil for Natural Hair Care Applications

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ABSTRACT

Background: Herbal cosmetics have gained considerable attention owing to increasing consumer preference for safe, eco-friendly, and plant-based personal care products. Conventional shampoos formulated with synthetic surfactants may cause scalp irritation, dryness, and hair damage following prolonged use. *Manilkara zapota* (Sapodilla) seed oil, an underutilized by-product of the fruit industry, is a rich source of fixed oils and phytoconstituents with potential antioxidant, conditioning, and moisturizing properties. Incorporation of sapodilla seed oil with traditional medicinal plants may provide a natural alternative for the development of effective herbal hair care formulations.

Objective: The present study aimed to extract and characterize *Manilkara zapota* seed oil, formulate a polyherbal shampoo containing selected herbal ingredients, and evaluate the formulation using standard physicochemical quality control parameters.

Materials and Methods: Sapodilla seed oil was extracted by Soxhlet extraction and incorporated into a polyherbal shampoo containing Aloe vera, Hibiscus petals, Shikakai, fenugreek, rose petals, lemon juice, vinegar, gelatin, and essential oils. The prepared formulation was evaluated for organoleptic characteristics, pH, foamability, foam stability, percentage solid content, surface tension, wetting time, dirt dispersion, solubility, and preliminary skin irritation using standard cosmetic evaluation procedures. The formulation and evaluation methods were based on the experimental protocol described in the study.

Results: The formulated shampoo exhibited a homogeneous reddish-brown appearance with a pleasant aromatic odour and viscous consistency. The pH of the 10% shampoo solution was 6.0, while the percentage solid content ranged from 20–25%. The formulation produced a foam volume of 25 mL with dense and stable foam, reduced surface tension to 34.70 dynes/cm, and demonstrated a wetting time of 45 s. Furthermore, the shampoo showed good solubility, satisfactory dirt dispersion, and no observable skin irritation during preliminary evaluation, indicating acceptable physicochemical quality and compatibility for topical application.

Conclusion: The developed polyherbal shampoo demonstrated satisfactory physicochemical characteristics and preliminary safety, supporting the potential use of *Manilkara zapota* seed oil as a functional natural ingredient in herbal hair care products. The formulation combines effective cleansing with conditioning properties while utilizing an underexploited agricultural resource. Further investigations involving phytochemical standardization, microbiological quality assessment, accelerated stability studies, and controlled clinical evaluation are recommended to establish long-term safety, efficacy, and commercial applicability.

Introduction

Hair is an important biological appendage that protects the scalp from environmental damage while contributing to thermoregulation, sensory perception, and personal appearance. Healthy hair is often regarded as an indicator of overall well-being, and maintaining its integrity requires effective cleansing without disrupting the natural scalp environment. Increasing exposure to environmental pollutants, ultraviolet radiation, harsh chemical treatments, and lifestyle related stress has contributed to various hair disorders, including dandruff, dryness, hair breakage, and excessive hair fall. Consequently, there is growing interest in developing herbal hair care products that combine cleansing efficiency with therapeutic benefits and improved safety profiles (1,2).

Shampoo is one of the most frequently used cosmetic preparations for cleansing the hair and scalp. An ideal shampoo should effectively remove sebum, dirt, sweat, and environmental contaminants while maintaining the natural moisture balance and structural integrity of the hair shaft. Conventional shampoos mainly contain synthetic surfactants such as sodium lauryl sulfate and sodium laureth sulfate because of their excellent foaming and detergency properties. However, prolonged use of these surfactants has been associated with scalp irritation, excessive dryness, cuticular damage, and allergic reactions in susceptible individuals. These concerns have encouraged the development of herbal shampoos formulated with naturally derived ingredients that are considered milder and more environmentally friendly (2,3).

Herbal shampoos utilize medicinal plant extracts rich in saponins, flavonoids, phenolic compounds, tannins, alkaloids, and essential oils, which possess cleansing, antioxidant, antimicrobial, anti-inflammatory, and conditioning activities. Plant-derived saponins function as natural surfactants capable of reducing surface tension and producing stable foam while minimizing scalp irritation. Consequently, herbal shampoos have gained considerable attention as alternatives to synthetic formulations because they combine cosmetic performance with additional biological benefits (4,5).

Manilkara zapota (L.) P. Royen, commonly known as sapodilla or chikoo, is a tropical fruit-bearing tree belonging to the family Sapotaceae. Although the fruit is widely consumed for its nutritional value, the seeds

remain an underutilized agricultural by-product despite containing numerous biologically active constituents. Previous phytochemical investigations have demonstrated that sapodilla seeds contain fixed oils, saponins, flavonoids, tannins, phenolic compounds, and other secondary metabolites exhibiting antioxidant, antimicrobial, and anti-inflammatory properties. The presence of natural saponins and fixed oils suggests that sapodilla seed oil may function as a mild cleansing and conditioning agent in herbal shampoo formulations (6–8).

Several medicinal plants have traditionally been incorporated into herbal shampoos because of their complementary therapeutic properties. *Acacia concinna* (Shikakai) serves as a natural cleanser owing to its high saponin content, whereas *Aloe barbadensis* (Aloe vera) provides moisturizing and soothing effects that improve scalp hydration. *Hibiscus rosa-sinensis* has been reported to strengthen hair fibers, improve shine, and reduce hair breakage, while fenugreek contributes proteins and mucilage that promote hair conditioning and reduce dandruff. The synergistic combination of these botanicals with sapodilla seed oil may enhance both cleansing performance and cosmetic acceptability (4,5,9).

Although numerous herbal shampoo formulations have been reported using medicinal plants such as neem, amla, reetha, and shikakai, relatively few investigations have explored the application of *Manilkara zapota* seed oil as a principal functional ingredient. Furthermore, utilization of sapodilla seeds supports sustainable use of agricultural by-products by converting a discarded natural resource into a value-added cosmetic ingredient. Therefore, the present study was undertaken to extract and characterize sapodilla seed oil, formulate a polyherbal shampoo containing selected herbal ingredients, and evaluate the prepared formulation using standard physicochemical quality control parameters including pH, foamability, foam stability, surface tension, wetting time, solid content, and skin irritation.

2. Materials and Methods

2.1 Study Design

The present investigation was designed as an experimental laboratory study to formulate and evaluate a polyherbal shampoo containing *Manilkara zapota* seed oil as the primary active ingredient. The study comprised extraction of sapodilla seed oil, preparation of selected herbal ingredients, formulation of the polyherbal shampoo, and evaluation of the finished product using standard physicochemical quality control methods commonly employed for cosmetic formulations (11,12).

2.2 Collection and Authentication of Plant Materials

Fresh mature fruits of *Manilkara zapota* (L.) P. Royen were collected from Vijayapuri Colony, Ghatkesar, Medchal, Malkajgiri District, Telangana, India. Seeds were manually separated, washed thoroughly with distilled water to remove adhering pulp, shade dried, and stored in airtight containers until extraction. Botanical authentication was carried out in the Department of Pharmacognosy, Princeton College of Pharmacy, Telangana, and a voucher specimen was deposited in the departmental herbarium for future reference.

Fresh Aloe vera leaves, Hibiscus petals (*Hibiscus rosa-sinensis*), Shikakai (*Acacia concinna*), fenugreek (*Trigonella foenum-graecum*) seeds, rose petals, lemons, rose oil, menthol oil, gelatin, vinegar, methanol, sodium lauryl sulfate, guar gum, and distilled water were used for formulation and evaluation (13).

2.3 Equipment

The experimental work was performed using a Soxhlet extraction apparatus, electronic analytical balance (Dhona Instruments Ltd., Kolkata, India), calibrated micropipettes, digital pH meter, refrigerator, hot-air oven, graduated cylinders, magnetic stirrer, and standard laboratory glassware.

2.4 Extraction of *Manilkara zapota* Seed Oil

Sapodilla seeds were crushed into coarse particles and extracted by Soxhlet extraction using methanol as the extraction solvent. Approximately 12 g of crushed seed powder was placed in a cellulose extraction thimble, while 200 mL of methanol was transferred into the round-bottom flask. Continuous extraction was carried out until complete exhaustion of the plant material. The solvent was subsequently recovered by evaporation, and the extracted oil was collected and stored in amber-colored bottles under refrigerated conditions until further use. The extraction procedure was repeated to obtain sufficient oil for formulation studies (14,15).

2.5 Preparation of Herbal Ingredients

Fresh Aloe vera leaves were peeled manually and the inner gel was homogenized to obtain Aloe vera juice. Hibiscus flowers and rose petals were shade dried and powdered separately. Fenugreek seeds were soaked overnight and ground into a smooth paste. Fresh lemon juice was extracted immediately before formulation. Gelatin was dissolved in warm distilled water to prepare the thickening solution. Shikakai pods were dried and powdered to obtain a fine herbal powder. Vinegar was incorporated to adjust formulation acidity, while rose oil and menthol oil were used as fragrance and cooling agents (16).

2.6 Formulation of Polyherbal Shampoo

Initially, Hibiscus powder, Shikakai powder, and rose petal powder were blended thoroughly. In a separate container, Sapodilla seed oil, Aloe vera juice, lemon juice, and vinegar were mixed uniformly. The liquid phase was gradually incorporated into the powdered ingredients under continuous stirring until a homogeneous mixture was obtained. Gelatin solution was then added to improve viscosity, followed by incorporation of rose oil and menthol oil. The prepared shampoo was allowed to stand for complete deaeration before being transferred into airtight containers for evaluation (11,17).

Table 1. Composition of Polyherbal Shampoo

Ingredient	Quantity	Functional role
Manilkara zapota seed oil	10 mL	Conditioning agent
Aloe vera juice	30 mL	Moisturizer
Gelatin	15 g	Thickening agent
Shikakai powder	20 g	Natural cleanser
Fenugreek paste	10 g	Hair conditioning agent
Hibiscus petal powder	20 mL	Hair strengthening agent
Rose petal infusion	20 mL	Fragrance
Rose oil	10 drops	Perfuming agent
Menthol oil	8–9 drops	Cooling agent
Lemon juice	5–8 mL	Shine enhancer
Vinegar	7–8 mL	pH adjuster
Distilled water	80–90 mL	Vehicle

2.7 Evaluation of the Formulated Shampoo

The prepared shampoo was evaluated using established physicochemical quality control methods reported for herbal shampoo formulations (11–13,18).

2.7.1 Organoleptic Evaluation

The shampoo was examined visually for colour, odour, appearance, consistency, homogeneity, foam formation, and phase separation.

2.7.2 pH Determination

A 10% (w/v) shampoo solution was prepared using distilled water, and the pH was measured using a calibrated digital pH meter at room temperature (18).

2.7.3 Foamability and Foam Stability

Foaming characteristics were evaluated by the cylinder shake method. Fifty millilitres of 1% shampoo solution was transferred into a graduated cylinder and shaken uniformly ten times. Foam height was recorded immediately after shaking, and foam stability was determined after 5 min (11,18).

2.7.4 Determination of Percentage Solid Content

Approximately 4 g of shampoo was accurately weighed into a previously dried evaporating dish and dried at 105°C until constant weight. Percentage solid content was calculated gravimetrically (12).

2.7.5 Surface Tension Measurement

Surface tension of the shampoo solution was determined using the stalagmometric method. Reduction in surface tension was considered an indicator of detergent efficiency (11,18).

2.7.6 Wetting Time

The wetting ability of the shampoo was evaluated using the canvas disc method by recording the time required for complete immersion of the canvas disc in shampoo solution (18).

2.7.7 Dirt Dispersion Test

Dirt dispersion was evaluated by adding India ink to diluted shampoo solution. Distribution of ink between the foam and aqueous phase was visually assessed, with lower ink retention in the foam indicating better cleansing performance (12).

2.7.8 Skin Irritation Test

A preliminary skin compatibility test was performed by topical application of the shampoo to intact skin. The treated area was examined for erythema, itching, edema, burning sensation, or other visible signs of irritation after the observation period (13).

3. Results

3.1 Organoleptic Evaluation

The formulated polyherbal shampoo containing *Manilkara zapota* seed oil was successfully prepared and evaluated for its physical characteristics. The formulation exhibited a reddish-brown colour with a pleasant aromatic odour and a homogeneous appearance. The shampoo was turbid in nature and possessed a viscous consistency, which facilitated easy application and uniform distribution on hair. No visible phase separation or precipitation was observed during the initial evaluation, indicating satisfactory physical stability of the formulation. The presence of Aloe vera gel, gelatin, and herbal extracts contributed to the desirable texture and consistency of the shampoo. These observations suggest that the selected herbal ingredients were compatible and produced a cosmetically acceptable formulation.

Table 2. Organoleptic characteristics of the formulated polyherbal shampoo

Parameter	Observation
Colour	Reddish brown
Appearance	Homogeneous
Transparency	Turbid
Odour	Pleasant aromatic
Consistency	Viscous
Texture	Smooth
Foam type	Dense
Phase separation	Not observed

3.2 Physicochemical Evaluation

The prepared shampoo was evaluated for physicochemical parameters including pH, foam volume, solid content, surface tension, wetting time, skin irritation, solubility, and dirt dispersion. The formulation demonstrated acceptable quality characteristics suitable for routine hair cleansing applications. The observed pH was compatible with the physiological pH of the scalp, while the percentage solid content indicated appropriate product consistency. Furthermore, the reduction in surface tension and satisfactory foam characteristics suggested effective cleansing performance. No signs of skin irritation were observed during the preliminary compatibility study.

Table 3. Physicochemical properties of the formulated polyherbal shampoo

Evaluation parameter	Result
Colour	Reddish brown
Transparency	Turbid
Odour	Pleasant
pH (10% solution)	6.0
Solid content (%)	20–25
Foam volume (mL)	25
Foam type	Dense
Surface tension (dynes/cm)	34.70
Wetting time (s)	45
Skin irritation	No irritation
Solubility	Good
Dirt dispersion	Good

3.3 pH Determination

The pH of the prepared shampoo was found to be 6.0, which falls within the desirable pH range for hair care formulations. A mildly acidic pH helps maintain the natural acid mantle of the scalp, minimizes cuticular

swelling, and improves hair smoothness and shine. The observed pH therefore indicates that the formulation is suitable for regular application without causing significant scalp irritation.

3.4 Percentage Solid Content

The percentage solid content of the shampoo was found to be 20–25%. This level of solids provides an appropriate balance between product viscosity and ease of rinsing. Excessively high solid content may make shampoo difficult to spread and remove, whereas lower solid content may reduce cleansing efficiency. The observed range indicates satisfactory formulation characteristics.

Figure 1: Percent of solid contents of Shampoo

3.5 Foamability and Foam Stability

The formulated shampoo produced a foam volume of 25 mL with dense and stable foam. Although foam generation is not directly proportional to cleansing efficiency, stable foam contributes to consumer acceptance and reflects the presence of naturally occurring saponins derived from Sapodilla seed oil and Shikakai. The formulation maintained satisfactory foam stability throughout the evaluation period.

Figure 2: Foamability and Foam stability of Shampoo

3.6 Surface Tension

Surface tension of the prepared shampoo was measured as 34.70 dynes/cm, indicating an effective reduction compared with pure water. Lower surface tension facilitates improved wetting of hair fibres and enhances removal of sebum and particulate contaminants during washing. This observation suggests satisfactory detergent performance of the formulated herbal shampoo.

3.7 Wetting Time

The wetting ability of the formulation, determined by the canvas disc method, showed a wetting time of 45 s. Wetting time is an indirect measure of detergent efficiency, and the observed value indicates that the shampoo possessed adequate surface activity for effective cleansing.

3.8 Dirt Dispersion Test

The dirt dispersion study demonstrated that the added particulate matter remained predominantly in the aqueous phase rather than accumulating within the foam. This finding indicates satisfactory cleansing efficiency and suggests that the shampoo would effectively remove dirt without promoting redeposition on the hair surface.

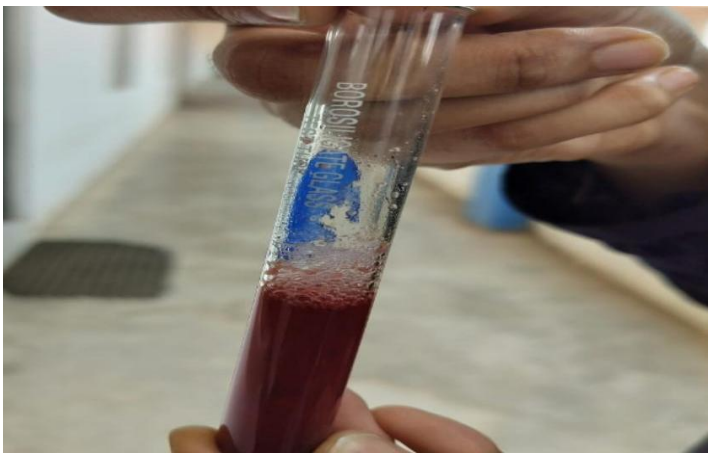

Figure 3: Dirt dispersion

3.9 Skin Irritation Test

The preliminary skin compatibility study showed no visible erythema, itching, edema, burning sensation, or irritation following topical application of the prepared shampoo. These observations indicate that the formulation was well tolerated under the experimental conditions and may be considered suitable for topical use.

a. **b.**

Figure 4: Skin irritation test (Before application after application of Shampoo)

4. Discussion

The present study demonstrated the successful formulation of a polyherbal shampoo incorporating *Manilkara zapota* seed oil together with Aloe vera, Hibiscus petals, Shikakai, fenugreek, rose petals, lemon juice, and other herbal ingredients. The selected ingredients were intended to provide complementary cleansing, conditioning, moisturizing, and scalp-protective effects while minimizing the reliance on synthetic surfactants. The prepared formulation exhibited satisfactory organoleptic and physicochemical characteristics, indicating that the selected herbal ingredients were compatible and produced a stable cosmetic preparation. These findings support previous reports that polyherbal formulations can effectively combine cleansing efficiency with improved scalp compatibility (19,20).

The organoleptic evaluation demonstrated that the shampoo possessed a homogeneous appearance, reddish-brown colour, pleasant herbal odour, and viscous consistency without visible phase separation. Such characteristics are important quality attributes because they influence consumer acceptance, product stability, and ease of application. Similar physical characteristics have been reported for herbal shampoos prepared using botanical ingredients rich in natural polysaccharides and saponins, where appropriate viscosity contributes to improved product handling and uniform distribution during application (20,21).

The pH of the formulated shampoo was found to be 6.0, which is within the range generally considered suitable for scalp and hair care. Mildly acidic formulations help maintain the natural acid mantle of the scalp, reduce swelling of the hair cuticle, improve cuticular alignment, and enhance hair smoothness and shine. Maintenance of an appropriate pH is also important for minimizing scalp irritation associated with alkaline cosmetic products. Similar pH values have been reported in previously published herbal shampoo formulations, supporting the suitability of the present formulation for routine use (19–22).

The percentage solid content of the shampoo ranged from 20–25%, indicating an acceptable balance between product consistency and ease of rinsing. Shampoo formulations with excessively high solid content may become difficult to spread and wash away, whereas formulations containing very low solid content often exhibit reduced cleansing efficiency. The observed solid content therefore suggests that the prepared formulation possesses appropriate rheological characteristics for practical application (19,21).

Foaming ability is frequently regarded as an important indicator of consumer satisfaction, although it does not directly correlate with cleansing performance. The formulated shampoo produced 25 mL of dense and stable foam, indicating satisfactory surface-active properties. This foaming behaviour is likely attributable to the presence of naturally occurring saponins present in Shikakai and the surface-active phytochemicals associated with *Manilkara zapota* seed constituents. Previous investigators have similarly reported that herbal shampoos containing saponin-rich plant materials generate stable foam while providing effective cleansing without excessive dependence on synthetic surfactants (18–21).

Surface tension is an important physicochemical parameter because reduction of water surface tension facilitates spreading of the shampoo solution over the hair fibers and enhances removal of accumulated sebum and particulate contaminants. The formulated shampoo reduced surface tension to 34.70 dynes/cm, indicating satisfactory detergent performance. This value is comparable to those reported for herbal shampoo formulations containing natural surfactants and supports the effectiveness of the selected herbal ingredients in promoting cleansing activity (19,20).

The wetting ability of the formulation, evaluated using the canvas disc method, demonstrated a wetting time of 45 s. Wetting time provides an indirect measure of detergent efficiency because rapid penetration of the shampoo solution into the test substrate reflects improved surface activity. The observed wetting characteristics indicate that the formulation possesses adequate cleansing potential and are consistent with previously reported herbal shampoos containing botanical surfactants (18,21).

The dirt dispersion test demonstrated that particulate matter remained predominantly within the aqueous phase rather than accumulating in the foam. This observation suggests effective removal of dirt without significant redeposition onto the hair surface during rinsing. Similarly, the preliminary skin irritation assessment revealed no visible erythema, itching, edema, or burning sensation following topical application, indicating satisfactory skin compatibility under the conditions evaluated. These observations support the use of plant-derived ingredients as milder alternatives to harsh synthetic cleansing agents (19,22).

One of the noteworthy aspects of the present investigation is the utilization of *Manilkara zapota* seed oil, which is generally considered an agricultural by-product. Previous phytochemical studies have demonstrated that sapodilla seeds contain fixed oils, flavonoids, phenolic compounds, tannins, and other bioactive

constituents possessing antioxidant and anti-inflammatory activities (6–8). Although the present investigation primarily evaluated physicochemical quality characteristics rather than biological efficacy, incorporation of sapodilla seed oil represents a promising approach for developing value-added herbal cosmetic products while promoting sustainable utilization of underexploited natural resources.

The present study has certain limitations. The evaluation focused primarily on physicochemical quality parameters and preliminary skin compatibility. Additional investigations, including microbiological quality assessment, accelerated stability testing, quantitative phytochemical standardization, rheological characterization, and controlled clinical evaluation involving a larger study population, would provide more comprehensive evidence regarding long-term safety, stability, and cosmetic performance. Furthermore, comparative evaluation with commercially available herbal and synthetic shampoos would strengthen the assessment of product efficacy.

Overall, the findings indicate that the developed polyherbal shampoo possesses acceptable physicochemical characteristics and cosmetic performance. The combination of *Manilkara zapota* seed oil with traditional herbal ingredients produced a formulation with suitable pH, satisfactory foaming behavior, adequate wetting ability, appropriate surface tension, acceptable solid content, effective dirt dispersion, and good preliminary skin compatibility. These observations support the potential application of sapodilla seed oil as a functional ingredient in herbal shampoo formulations and provide a foundation for future product optimization and clinical evaluation.

5. Conclusion

In the present study formulation of a polyherbal shampoo incorporating *Manilkara zapota* seed oil together with Aloe vera, Hibiscus petals, Shikakai, fenugreek, rose petals, lemon juice, and other herbal ingredients. The developed formulation exhibited acceptable physicochemical and organoleptic characteristics, indicating good compatibility among the selected natural ingredients. The shampoo possessed a homogeneous reddish-brown appearance, pleasant herbal odor, appropriate viscosity, and satisfactory cosmetic acceptability.

Evaluation of the formulation demonstrated a scalp-compatible pH of 6.0, percentage solid content of 20–25%, foam volume of 25 mL, surface tension of 34.70 dynes/cm, and a wetting time of 45 s. Furthermore, the shampoo exhibited good dirt dispersion, satisfactory solubility, and no observable skin irritation during preliminary evaluation, suggesting that the formulation is suitable for routine topical application under the conditions assessed. These findings indicate that the combination of naturally occurring surfactants and conditioning agents present in the selected herbal ingredients can produce a shampoo with desirable cleansing and cosmetic properties.

The incorporation of *Manilkara zapota* seed oil represents an innovative approach to utilizing an underexploited agricultural by-product in cosmetic formulations. In addition to its potential conditioning properties, the phytochemical composition of sapodilla seed oil may contribute antioxidant and scalp-protective benefits, supporting its application as a functional ingredient in herbal hair care products. The use of plant-derived ingredients also aligns with the increasing demand for environmentally sustainable and naturally derived cosmetic formulations.

Although the present study demonstrated encouraging physicochemical characteristics, additional investigations are required before commercial application. Future research should include detailed phytochemical standardization of the extracted oil, microbiological quality assessment, accelerated and long-term stability studies, rheological characterization, preservative efficacy testing, and controlled clinical evaluation involving a larger study population. Comparative studies with commercially available herbal and

synthetic shampoos would further establish the performance and consumer acceptability of the developed formulation.

Overall, our findings of this study suggest that a polyherbal shampoo formulated with *Manilkara zapota* seed oil is a promising natural hair care product with satisfactory physicochemical quality attributes and preliminary safety characteristics. The formulation provides a scientific basis for further product optimization and supports the potential use of sapodilla seed oil as a value-added ingredient in herbal cosmetic formulations.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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