International Journal of Medical and Pharmaceutical Sciences
Open access peer-reviewed Journal
Volume 2, Issue 8, Page 70-76.
https://doi.org/10.5281/zenodo.21770519

Research Article

Formulation and Evaluation of Herbal Paper Soap Using Moringa Oleifera Extract

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Harbal paper soap is an innovative, portable, and eco-friendly cleansing formulation developed to improve personal hygiene while minimizing environmental impact. The present study focuses on the formulation and evaluation of herbal paper soap containing aqueous extract of Moringa oleifera as the primary active herbal ingredient. Moringa oleifera is well known for its antimicrobial, antioxidant, and skin-protective properties owing to the presence of bioactive phytoconstituents such as alkaloids, flavonoids, phenolic compounds, tannins, and saponins. The aqueous extract was prepared by the maceration method and subjected to preliminary phytochemical screening. The paper soap was formulated using Sodium Lauryl Sulfate (SLS) as a foaming and cleansing agent, potassium hydroxide as a saponifying agent, glycerine as a humectant, coconut oil as an emollient, rose oil as a fragrance agent, and butter paper as a biodegradable supporting base. Three formulation batches (F1, F2, F3) were prepared with varying concentrations of moringa extract and SLS. Batch F1 (4.0 mL moringa extract, 8.0 g SLS) was identified as the optimized formulation with a pH of 7.5, good foaming ability, excellent spreadability, no skin irritation, and satisfactory physical stability. The herbal paper soap demonstrated promising antimicrobial potential, biodegradability, and consumer convenience, making it a viable sustainable alternative to conventional soap preparations.

Keywords: Moringa oleifera, herbal paper soap, phytochemical screening, sodium lauryl sulfate, antimicrobial, biodegradable, saponification.

INTRODUCTION

Cosmetics are formulated products designed to improve appearance and personal grooming, with their use tracing back to ancient civilizations. Beyond beautification, they serve functions including skincare, identity expression, and confidence enhancement.[1] Soap is a cleansing substance used with water for washing and cleaning purposes, typically produced by combining natural oils or fats with a strong alkali — sodium hydroxide (NaOH) for solid soaps or potassium hydroxide (KOH) for liquid soaps.[2] The fundamental process of soap making, known as saponification, has been practiced for nearly six thousand years. Ancient Babylonians are credited as the earliest known soap makers.[9] Conventional liquid soaps and sanitizers are often bulky, contain synthetic chemicals that may cause skin dryness, and present environmental challenges associated with plastic packaging. Herbal formulations offer safer, biodegradable, and eco-friendly alternatives owing to the presence of natural bioactive constituents.[3] Paper soap is an innovative form of soap designed as thin, biodegradable sheets that dissolve rapidly upon contact with water, generating lather equivalent to traditional soap. The sheets are lightweight, compact, and ideal for travel, outdoor activities, and emergency hygiene situations.[4] Each sheet is used once, thereby minimizing contamination risks associated with shared bar or liquid soaps. The biodegradable nature of paper soap ensures minimal environmental impact upon disposal.[5] Moringa oleifera (family

Moringaceae), commonly known as the Drumstick tree, is a multipurpose medicinal plant rich in bioactive phytochemicals including alkaloids, flavonoids, phenolic compounds, glycosides, tannins, and saponins, conferring anti-inflammatory, antioxidant, antihypertensive, and antimicrobial properties.[23] These attributes make it an ideal candidate for incorporation into herbal soap formulations intended for skin hygiene and protection. The present study was therefore undertaken to formulate and evaluate a herbal paper soap incorporating the aqueous extract of Moringa oleifera, with the objective of developing a portable, biodegradable, and effective skin hygiene product with natural antimicrobial and antioxidant properties.

MATERIALS AND METHODS

2.1 Plant Authentication

Powder of Moringa oleifera was authenticated by the Department of Botany, Padmabhushan Vasantrao Dada Patil College, Tasgaon, Sangli, Maharashtra. The species was confirmed as Moringa oleifera belonging to family Moringaceae. Fresh leaves were collected from the Sangli region of Maharashtra.[41]

2.2 Preparation of Aqueous Extract

Aqueous extraction of Moringa oleifera leaf powder was carried out by the maceration method.[41] Accurately weighed 10–20 g of finely powdered moringa leaves were transferred into a clean conical flask containing 100–200 mL of distilled water. The mixture was agitated continuously on a rotary shaker for 24–48 hours at room temperature to facilitate extraction of water-soluble phytoconstituents. The mixture was subsequently heated at 60–70°C for 30–60 minutes in a water bath to improve extraction efficiency. After cooling, the extract was filtered through Whatman No. 1 filter paper to remove insoluble residues. The clear filtrate was collected in an airtight container and stored at 4°C for further use.

2.3 Phytochemical Screening

Preliminary phytochemical screening of the aqueous extract was performed for detection of alkaloids (Dragendorff's and Wagner's tests), flavonoids (Shinoda and alkaline reagent tests), carbohydrates (Molisch's and Fehling's tests), proteins (Millon's and Biuret tests), and triterpenoids (Liebermann–Burchard and Salkowski tests).[32]

2.4 Formulation Design

Three batches (F1, F2, F3) were prepared with varying concentrations of moringa extract and Sodium Lauryl Sulfate (SLS). The SLS concentration was reduced progressively from F1 to F3 while the moringa extract concentration was increased to study the effect of herbal content on formulation performance.[5] The complete formulation composition is presented in Table 1.

Table 1: Formulation Composition of Herbal Paper Soap Batches

Ingredient	Function	F1 (per 100 mL)	F2 (per 100 mL)	F3 (per 100 mL)
Moringa oleifera Extract	Antimicrobial/Antioxidant	4.0 mL	2.0 mL	6.0 mL
Sodium Lauryl Sulfate (SLS)	Foaming/Cleansing Agent	8.0 g	6.0 g	4.0 g
Potassium Hydroxide (KOH)	Saponifying Agent	1.0 g	1.0 g	1.0 g
Coconut Oil	Emollient/Soap Base	5.0 mL	5.0 mL	5.0 mL
Glycerine	Humectant/Plasticizer	2.0 mL	2.0 mL	2.0 mL
Citric Acid	pH Adjusting Agent	q.s.	q.s.	q.s.
Rose Oil	Fragrance Agent	q.s.	q.s.	q.s.
Butter Paper	Biodegradable Base	25 pieces	25 pieces	25 pieces
Distilled Water	Vehicle	q.s. to 100 mL	q.s. to 100 mL	q.s. to 100 mL

2.5 Preparation Procedure

Potassium hydroxide was dissolved in distilled water to obtain a clear alkali solution. Coconut oil was

heated to 60–70°C and the KOH solution was added dropwise with continuous stirring to achieve saponification and form the soap base.[9] SLS was incorporated into the soap base with continuous stirring, followed by the addition of glycerine as a humectant and plasticizer. The filtered moringa extract was incorporated gradually under stirring to ensure uniform distribution. Citric acid solution was added dropwise to adjust the pH to 7.0–8.5 for skin application.[31] Rose oil was added for fragrance. The prepared soap solution was uniformly spread as a thin layer over butter paper using a sterile applicator and allowed to dry at room temperature for 24 hours. After complete drying, the soap layers were cut into strips of suitable dimensions and stored in airtight containers.[12]

2.6 Evaluation Parameters

2.6.1 Organoleptic Evaluation

The formulated paper soap strips were evaluated visually for colour, odour, texture, solubility, and overall physical appearance.[1]

2.6.2 pH Determination

One gram of paper soap was dissolved in 10 mL of distilled water and the pH was measured using a calibrated digital pH meter. A pH exceeding 11 may cause skin irritation due to excessive alkalinity, while a pH below 6 is insufficient for effective cleansing.[24, 31]

2.6.3 Foam Height

Paper soap was dispersed in 20 mL of distilled water and transferred to a measuring cylinder. The mixture was shaken vigorously for one minute and the initial foam height (F_1) was recorded. After 10–15 minutes, the residual foam height (F_2) was measured. A foam height of at least 2 cm was considered acceptable.[32]

2.6.4 Folding Endurance

Paper soap strips were repeatedly folded to simulate typical handling and packaging stresses. The material was observed for signs of tearing or cracking. A range of 50–100 folds without failure indicated adequate mechanical flexibility.[12]

2.6.5 Sensitivity and Irritation Test

A patch test was performed by applying the product to a 1 cm² area of skin and observing for signs of inflammation or rashes. For the irritation test, the product was applied to the skin for 10 minutes; absence of irritation indicated a non-irritant classification.[33]

2.6.6 Lathering Test

A measured quantity of the product was rubbed between moistened palms to assess the extent and stability of lather formation.[35]

2.6.7 Saponification Test

Three millilitres of the sample was mixed with 25 mL of KOH solution and heated in a water bath for 30 minutes. After cooling and addition of phenolphthalein indicator, the solution was titrated against 0.5 N HCl. A blank titration was performed simultaneously as a control.[32]

2.6.8 Biodegradability

A biodegradability test was conducted under controlled environmental conditions to assess the rate of decomposition in soil and water, confirming the environmental sustainability of the formulation.[12]

2.6.9 Stability Study

Prepared strips were stored in airtight containers and evaluated periodically for changes in colour, texture, odour, and flexibility to assess formulation stability during storage.[7]

RESULTS AND DISCUSSION

3.1 Phytochemical Screening

Preliminary phytochemical screening of the aqueous extract of Moringa oleifera confirmed the presence of important bioactive constituents as detailed in Table 2. The positive results for alkaloids (Dragendorff's test), flavonoids (Shinoda test), carbohydrates (Molisch's and Fehling's tests), proteins (Millon's and Biuret tests), and triterpenoids (Liebermann–Burchard and Salkowski tests) are consistent with the

reported phytochemical profiles of Moringa oleifera.[41]

Table 2: Phytochemical Constituents of Aqueous Extract of Moringa oleifera

Phytoconstituent	Test Applied	Result
Alkaloids	Dragendorff's test	Positive (+)
Alkaloids	Wagner's test	Negative (–)
Flavonoids	Shinoda test	Positive (+)
Flavonoids	Alkaline reagent test	Negative (–)
Carbohydrates	Molisch's test	Positive (+)
Carbohydrates	Fehling's test	Positive (+)
Proteins	Millon's test	Positive (+)
Proteins	Biuret test	Positive (+)
Triterpenoids	Liebermann–Burchard test	Positive (+)
Triterpenoids	Salkowski test	Positive (+)

3.2 Evaluation of Herbal Paper Soap

The results of physicochemical and functional evaluation of the three formulation batches are summarized in Table 3. All three batches demonstrated acceptable organoleptic and functional properties; however, Batch F1 was identified as the optimized formulation based on the overall evaluation profile.

Table 3: Evaluation Parameters of Formulated Herbal Paper Soap Batches

Parameter	Batch F1	Batch F2	Batch F3
Colour	Light green to greenish-yellow	Light yellowish	Light green to greenish-yellow
Odour	Pleasant aromatic	Pleasant aromatic	Pleasant aromatic
pH	7.5 (Basic)	7.2 (Basic)	7.4 (Basic)
Skin Irritation	Absent	Absent	Absent
Washability	Easily washable	Easily washable	Easily washable
Foamability	Good foam formation	Moderate foam	Moderate foam
Spreadability	Excellent on wet hands	Good on wet hands	Good on wet hands
Consistency	Smooth, thin, flexible	Smooth, flexible	Smooth, thin, flexible
Stability	Stable; no significant change	Stable; no significant change	Stable; no significant change

DISCUSSION

The pH values of all three batches (7.2–7.5) fall within the acceptable range for soap formulations. A pH above 11 causes skin irritation due to excessive alkalinity, while a pH below 6 is insufficient for effective cleansing activity.[24] The slightly basic pH achieved facilitates saponification and ensures adequate microbial reduction on the skin surface. Batch F1, containing 8.0 g SLS, exhibited the most vigorous foam formation among the three batches. This is consistent with SLS being a well-established anionic surfactant capable of generating rich, stable lather.[26] The higher surfactant concentration in F1 also contributed to superior cleansing efficiency and spreadability on wet hands. The presence of alkaloids and flavonoids confirmed by phytochemical screening supports the reported antimicrobial and antioxidant potential of Moringa oleifera extract. Flavonoids are well-established for their ability to disrupt bacterial cell membranes and inhibit key microbial enzymes.[23] Glycerine, incorporated at 2.0 mL per 100 mL, served as both a moisturizing agent and a plasticizer that imparts flexibility to the dried soap strips, preventing cracking during storage and handling.[22] The folding endurance test confirmed that all batches withstood 50–100 folds without tearing, indicating adequate mechanical durability for

practical use.[12] No skin irritation or sensitivity reactions were observed in any formulation batch during patch testing, confirming the safety of moringa-based herbal soap for routine skin application. These findings are in accordance with reports by Talreja et al. (2023)[23] and Mandal et al. (2021),[2] who documented the biocompatibility of herbal-based soap formulations with human skin. The use of butter paper as a biodegradable supporting base ensures that the formulation decomposes naturally upon disposal, aligning with contemporary environmental sustainability requirements. The overall attributes of portability, single-use convenience, herbal bioactivity, and biodegradability position herbal paper soap as a superior alternative to conventional soap preparations.[4, 5]

CONCLUSION

The present study successfully developed and characterized a herbal paper soap incorporating aqueous extract of Moringa oleifera with appropriate excipients including SLS, KOH, glycerine, coconut oil, rose oil, and butter paper. Preliminary phytochemical screening confirmed the presence of alkaloids, flavonoids, carbohydrates, proteins, and triterpenoids in the extract, substantiating the antimicrobial and antioxidant basis of the formulation. Among the three batches prepared, Batch F1 was identified as the optimized formulation demonstrating a physiologically compatible pH (7.5), excellent foamability, satisfactory spreadability, folding endurance, absence of skin irritation, and physical stability on storage. The biodegradable, portable, and eco-friendly nature of the formulation presents significant advantages over conventional soap preparations. Herbal paper soap containing Moringa oleifera extract thus represents a promising, safe, and effective approach to personal hygiene with potential for commercial scale-up and wider healthcare application.

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Cite: Shrirang Kharmate*, Dipak Phalle, Saurabh Joshi, Satyajeet Jagdale, Pratibha Shingade, Mrudula More, Formulation and Evaluation of Herbal Paper Soap Using Moringa Oleifera Extract, Int. J. Med. Pharm. Sci., 2026, 2 (8), 70-76. https://doi.org/10.5281/zenodo.21770519