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Formulation and Evaluation of Goat Milk Soap Incorporated by Calamine and Lemongrass Oil

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ABSTRACT

The study focuses on the formulation and evaluation of goat milk soap incorporated with calamine and lemongrass oil to develop a mild, functional cleansing bar with enhanced dermatological benefits. Goat milk was selected as the base due to its rich composition of fatty acids, vitamins, and minerals known to support skin hydration and barrier function. Calamine was incorporated for its soothing, anti-inflammatory, and antipruritic properties, while lemongrass oil was added for its antimicrobial action and pleasant natural fragrance. The soap formulations were prepared using the cold-process method, and varying concentrations of calamine and lemongrass oil were assessed to determine their effects on physicochemical characteristics and user acceptability. Evaluation parameters included pH, foamability, hardness, moisture content, cleansing efficiency, microbial stability, and sensory attributes. The optimized formulation demonstrated a skin-friendly pH, stable texture, good lathering ability, and effective cleansing performance, with added soothing and antimicrobial properties. Overall, the results indicate that goat milk soap enriched with calamine and lemongrass oil can serve as a beneficial natural skincare product with potential value for sensitive and irritated skin.

Keywords: Goat milk soap; Calamine; Lemongrass oil; Natural skincare; Soap formulation; Physicochemical evaluation.

1. INTRODUCTION

The term **"cosmetic"** is derived from the Greek word ***kosmetikos***, signifying the "power, order, or skill in decorating." Within the regulatory framework of the **Drugs and Cosmetics Act (1940) and Rules (1945)**, cosmetics are formally defined as:

"Articles intended to be rubbed, poured, sprinkled, or sprayed on, introduced into, or otherwise applied to the human body or any part thereof for cleansing, beautifying, promoting attractiveness, or altering the appearance."

Soap represents one of the most fundamental cosmetic delivery systems. Chemically, soap is defined as a **salt of fatty acids** produced via the saponification of triglycerides. Beyond its widespread utility in domestic cleaning and industrial lubrication, soap serves as a primary vehicle for topical hygiene and the delivery of therapeutic agents to the skin.

Among various formulations, **Goat Milk soap base** has gained significant pharmacological interest due to its nutrient-dense profile. Unlike synthetic surfactants, goat milk-based soaps are rich in both **saturated and unsaturated fats**, which produce a creamy, low-irritant lather that preserves the skin's lipid barrier. Furthermore, goat milk is a complex biological matrix containing essential **proteins, vitamins, and minerals**.

The protein fraction, particularly casein and whey, is considered the most vital component, as it provides amino acids that assist in skin repair and hydration. The presence of **lactic acid** (an alpha-hydroxy acid) in goat milk further enhances its value by promoting gentle exfoliation and maintaining the skin's acidic pH. Consequently, goat milk soap serves as an ideal, nourishing base for the incorporation of medicated ingredients like calamine and essential oils.

Benefits of goat milk soap:

- To improve dry skin.
- Prevent acne.

- To cure skin infection like, irritated, tight skin, redness, wounds.
- To maintain your skin natural moisture.
- Fight signs of skin aging.

2. Materials and Methods

2.1 Materials

- Goat milk melt-and-pour soap base (commercial grade)
- Calamine powder (pharmaceutical grade)
- Lemongrass essential oil
- Glycerine
- Vitamin E capsules (tocopherol acetate)
- Distilled water
- Chemicals for evaluation: phenolphthalein, HCl, NaOH, media for microbial studies

2.2 Equipment

- Water bath
- Digital weighing balance
- pH meter
- Molds
- Hardness tester
- Hot plate
- Glassware
- Incubator
- Petri dishes

3. Material & Methodology

3.1 Optimized Melt-and-Pour Formulation

The preparation of the medicated goat milk soap was performed using a controlled melt-and-pour technique, integrated with stabilized dispersion methods to ensure ingredient homogeneity.

1. Size Reduction and Controlled Melting

The goat milk soap base was cut into uniform cubes (approximately 1–2 cm^3) to increase surface area and ensure even heat distribution. Melting was conducted using a **double boiler (water bath)** system maintained strictly between **60°C and 70°C**.

2. Humectant Integration

Once the base reached a fully fluid state, **glycerine** was added. Stirring was maintained at a constant, slow speed to prevent the incorporation of air bubbles, which can cause structural instabilities (pitting) in the final bar.

3. Progressive Dispersion of Calamine

To ensure a smooth texture and even distribution of the active ingredient, **calamine powder** was incorporated using the **geometric dilution method**:

- A small portion of the molten base was mixed with the total amount of calamine to create a concentrated "mother paste."
- This paste was then gradually diluted with the remaining soap base.
- *Quality Control:* This step eliminates clumping and ensures the 3D matrix of the soap has a uniform concentration of calamine.

4. Antioxidant Fortification

Vitamin E (Alpha-tocopherol) was extracted from capsules and folded into the mixture. Beyond its skin benefits, Vitamin E acts as a secondary antioxidant to prevent the rancidity of the fats within the goat milk base.

5. Thermosensitive Phase (Fragrance Fixation)

The mixture was monitored using a digital thermometer. **Lemongrass essential oil** was added only when the temperature dropped below **40°C**.

6. Molding and De-aeration

The homogenous mixture was poured into silicone molds. To remove surface bubbles, a light mist of **99% Isopropyl Alcohol** was sprayed immediately after pouring. The molds were left undisturbed at a controlled temperature (25 ± 2°C) for 24 hours.

7. Curing and Saponification Completion

Although melt-and-pour bases are technically pre-saponified, a **7-day curing period** was implemented in a cool, dry environment. This allows for moisture evaporation, resulting in a harder, longer-lasting bar with a more stable pH.

3.2 Scientific Justification of Ingredients

1. The selection of ingredients was based on their synergistic ability to provide gentle cleansing, anti-inflammatory relief, and antioxidant protection.

Ingredient	Role in Formulation	Scientific Justification
Goat Milk Soap Base	Primary Matrix / Cleansing Agent	Contains **Lactic Acid** (Alpha Hydroxy Acid) which promotes gentle cell turnover and maintains a pH (~5.5) compatible with the human skin's acid mantle. It is rich in vitamins A, B, and D.
Glycerine	Humectant	Acts as a powerful humectant that draws moisture from the atmosphere into the skin. In melt-and-pour soap, it counteracts the potential drying effects of surfactants.
Calamine Powder	Anti-pruritic & Astringent	Composed of **Zinc Oxide** and **Ferric Oxide**. Zinc oxide provides a cooling effect to relieve itching (pruritus) and serves as a mild antiseptic and anti-inflammatory agent.
Vitamin E	Antioxidant & Skin Conditioner	Specifically **Alpha-tocopherol**. It protects the skin's lipid barrier from oxidative stress caused by free radicals and prevents the rancidity (oxidation) of fats within the goat milk base.
Lemongrass Oil	Antimicrobial & Fragrance	Rich in **Citral** and **Limonene**, which exhibit potent antibacterial and antifungal properties. It acts as a natural astringent to tone the skin and provides aromatherapeutic stress relief.

Table 1: Composition of Soap Formulations

Sr.No	Ingredient	Quantity
1	Goat milk soap base	70gm
2	Calamine powder	2gm
3	Lemongrass oil	1ml
4	Olive oil	1ml
5	Vitamine E Capsule	2capsule
6	Alovera gel	1ml
7	Glycerin	1ml

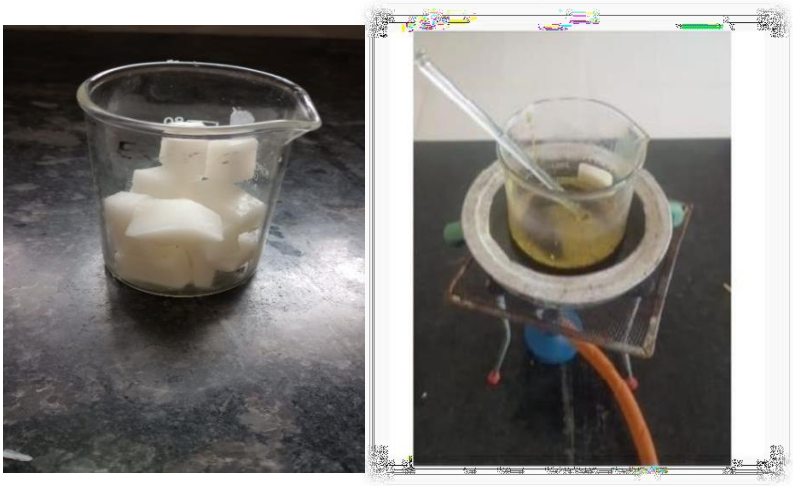

Fig No 1:Pour and melt of goat milk base

4. Evaluation Parameters

The formulated goat milk soap was evaluated for its physicochemical and sensory attributes to ensure safety, efficacy, and consumer compliance.

4.1 Organoleptic Evaluation

The sensory characteristics were assessed through visual and olfactory inspection.

- **Color:** Pinkish (attributed to the uniform dispersion of Calamine).
- **Odor:** Pleasant (characteristic of Cymbopogon essential oil).
- **Appearance:** Homogeneous with a smooth surface finish.

4.2 Physical Evaluation

4.2.1 pH Determination

The pH was measured using a standardized pH indicator paper and confirmed via a digital pH meter. The readings consistently fell between **5.2 and 6.5**.

4.2.2 Foam Retention

To evaluate foam stability, 20 ml of a 1% (w/v) soap solution was transferred to a 100 ml graduated cylinder. The cylinder was stoppered and agitated vigorously for 4 minutes. The foam volume was recorded at 1-minute intervals. The results indicated high stability, with foam remaining visible and structurally intact for **5 minutes**.

4.2.3 Foam Height (Foaming Capacity)

To determine the total foaming capacity, 2.0 g of the formulated soap was dissolved in 50 ml of distilled water. The solution was agitated for 3 minutes to induce maximum aeration and allowed to reach equilibrium for 10 minutes. The resultant foam height was recorded to quantify the surfactant activity of the goat milk base.

4.2.4 Moisture Content (Loss on Drying)

The moisture content was determined using the Oven Drying Method. A 5.0 g sample was weighed into a tared petri dish and heated at 105°C in a hot air oven until a constant weight was achieved. The sample was cooled in a desiccator before final weighing. The moisture content ($MC\%$) was calculated using the formula.

4.2.5 Cleaning Efficiency (In-Vivo Wash Test)

The cleansing efficacy was evaluated using a controlled panel test. A standardized volume of mineral oil was applied to the palms of participants. Following a uniform washing protocol with the formulated soap, participants assessed the presence of residual oil. The formulation met the efficacy criteria, as **over 70%** of participants reported a complete absence of greasy residue, confirming satisfactory emulsification properties.

Result & Discussion:

4.1 Organoleptic Evaluation

The organoleptic properties of the formulated soap are summarized in **Table 2**. The **pinkish** is attributed to the presence of calamine powder (ferric oxide), while the **smooth texture** indicates the successful implementation of the geometric dilution method, ensuring no grit or agglomeration of the powder was present. The **pleasant odour** confirms that the lemongrass essential oil remained stable during the cooling phase (<40°C).

Table 2: Organoleptic Evaluation

Colour	**Pinkish**
Odour	**Pleasant**
Texture	**Smooth**

4.2 Physical Evaluation and Critical Discussion

The physical parameters of the soap (Table 3) provide insight into its safety, efficacy, and consumer acceptability.

Table No 3: Physical Evaluation

Sr. NO	PARAMETERS	OBSERVATION
1	pH	5.2–6.5
2	Foam retention	The foam was observed to last for 5 minutes
3	Foam height	240 ml
4	Moisture content	1.84%
5	Cleaning efficiency	The cleaning efficiency was considered satisfactory.

4.2.1 Analysis of pH Stability

The observed pH range of **5.2 to 6.5** is highly significant as it closely mimics the **acid mantle** of human skin (average pH 5.5). Most commercial soaps have an alkaline pH (9.0–11.0), which can disrupt the skin's lipid barrier and cause irritation. The slightly acidic to neutral pH of this formulation, influenced by the lactic acid in the goat milk base, ensures that the soap is non-irritating and suitable for sensitive skin.

4.2.2 Foaming Properties (Height and Retention)

Foam height (**240 ml**) and retention (**5 minutes**) are critical indicators of surfactant efficiency. While high foam does not always correlate to better cleaning, it is a primary factor in consumer preference. The 5-minute retention suggests that the glycerine and goat milk fats act as foam stabilizers, maintaining a dense, creamy lather that allows the calamine to remain in contact with the skin long enough to exert its anti-pruritic effects.

4.2.3 Moisture Content and Shelf Life

The moisture content was found to be **1.84%**. In soap formulation, low moisture content is often preferred to prevent the bar from becoming too soft (mushy) during use. However, because this is a "Melt and Pour" base containing goat milk, a minimal amount of moisture is essential to keep the bar from becoming brittle. A value under 2% indicates a well-cured, firm soap bar with a potentially long shelf life.

4.2.4 Cleaning Efficiency

The cleaning efficiency was rated as **satisfactory**, confirming that the saponified fats in the goat milk base effectively emulsified surface oils and dirt. The presence of lemongrass oil may have further enhanced this through its natural solvent and antimicrobial properties.

Fig No 2: Goat milk soap

5. CONCLUSION

The present study successfully formulated and evaluated a medicated soap utilizing a **goat milk base** enriched with **calamine powder** and **lemongrass essential oil**. The physicochemical evaluation confirmed that the formulation maintains a skin-compatible pH (5.2–6.5), high foaming capacity, and optimal moisture content, ensuring both safety and consumer acceptability.

The therapeutic efficacy of the soap is derived from the synergistic action of its components:

- **Goat Milk:** Provides deep hydration and nourishment through its rich profile of essential fatty acids and proteins, maintaining the skin's lipid barrier.

- **Calamine Powder:** Effectively manages cutaneous irritation by soothing rashes, relieving pruritus (itching), and reducing erythema (redness). Its mild astringent properties further assist in the treatment of acneform lesions.

- **Lemongrass Oil:** Contributes potent antioxidant and antimicrobial properties, protecting the skin from oxidative stress while balancing sebum production to improve overall skin texture.

In conclusion, this formulation represents a gentle yet effective multifunctional cleansing agent. It is particularly suitable for sensitive and acne-prone skin types, offering a natural alternative to synthetic detergents. The combination of these ingredients effectively purifies the skin while maintaining its physiological balance, leading to a refreshed and healthy dermatological profile.

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