A Synergistic Study of Phyto Cosmetic Formulation and Physicochemical Profiling of a Cold Processed Natural Lavender Soap

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Abstract
Cold-process soap-making is a sustainable method that retains the therapeutic properties of botanical ingredients. This study aimed to formulate and evaluate a cold-processed soap using coconut, olive, and castor oils with lavender essential oil as a natural additive. The SOAPCALC formulation tool was employed to calculate the required lye and water quantities based on the saponification values of the selected oils. The soap was prepared at controlled temperatures (35–40°C), ensuring the retention of volatile and bioactive compounds. Physicochemical parameters were tested as per IS 286:1981 standards by a NABL-accredited laboratory. Results indicated a high Total Fatty Matter (TFM) content of 73.8%, moisture content of 3.98%, acceptable pH, low free alkali (0.13%), and the presence of glycerol and unsaponified oils, which contribute to the soap's moisturizing properties. The study confirms that cold-processed lavender soap made using plant-based oils is dermatologically safe and aligns with natural cosmetic product development goals.

Keywords: Cold Process Soap, Coconut Oil, Olive Oil, Castor Oil, Lavender Oil

1. Introduction

Soap-making has evolved from traditional methods using animal fats and ash to scientifically refined techniques aimed at enhancing product quality, skin safety, and environmental sustainability. The key chemical reaction involved is saponification, where triglycerides (fats/oils) react with an alkali, typically sodium hydroxide (NaOH), to form soap (fatty acid salts) and glycerol [1].

Synthetic soaps—commonly referred to as syndet bars—are often composed of petroleum-derived surfactants, artificial preservatives, and synthetic fragrances. These may include sodium lauryl sulfate (SLS), sodium laureth sulfate (SLES), parabens, and formaldehyde releasers, which are associated with skin irritation, allergic reactions, and potential endocrine disruption [2]. Prolonged exposure to such chemicals may increase the risk of skin cancer and hormonal imbalances, leading many consumers to seek natural alternatives [3]. While these soaps may deliver aggressive cleansing and rich foaming, they often disrupt the skin's natural lipid barrier, contributing to dryness and sensitivity.

In contrast, cold-processed soaps offer a gentler and more skin-compatible alternative. They are crafted from plant-derived oils and essential oils, providing mild cleansing, natural emollience, and skin-

conditioning benefits while avoiding synthetic additives. These soaps are biodegradable and align with the principles of green chemistry. The cold process method is widely preferred by natural product formulators because it retains the therapeutic properties of oils, butters, and essential oils. The saponification reaction in this method is performed at moderate temperatures (35–40°C), preserving natural glycerine and other heat-sensitive bioactive components [4].
Several plant-based formulations have gained popularity in recent years, incorporating herbal ingredients such as aloe vera, neem, turmeric, tulsi, lemon, and sandalwood. These botanicals have demonstrated antioxidants, antibacterial, anti-inflammatory, and moisturizing properties. Studies evaluating herbal soaps confirm compliance with key quality benchmarks like Total Fatty Matter (TFM), foam stability, acceptable pH, and extended shelf life [5–8]. Popular cold-processed soaps in the market include goat milk soap, neem-tulsi soap, charcoal detox soap, turmeric and sandalwood soap, and honey-oatmeal soap. These varieties are widely appreciated for their natural composition, gentle cleansing action, and skin-repairing properties. Most artisanal soap makers and small-scale formulators prefer the cold process method due to its ability to incorporate botanical actives and retain glycerol. Recent studies highlight the growing consumer shift toward handcrafted, herbal soaps as a safer, more sustainable alternative to synthetic commercial products [9–11].
Among essential oils used in cold-processed soaps, lavender (Lavandula angustifolia) is highly recognized for its calming fragrance and therapeutic value. Its key bioactive compounds—linalool and linalyl acetate—have been shown to possess antimicrobial, anti-inflammatory, and mood-soothing effects. The cold process technique helps retain these volatile compounds, enhancing the overall functionality and sensorial appeal of the final product [12, 13].
Cold-process soap-making, however, requires precision in formulation. Proper lye calculation, oil-to-water ratio, mixing temperatures, and curing durations are critical to ensure product consistency and safety. Extended curing for 4–6 weeks ensures complete saponification, improved hardness, and longer shelf life [14].
Additional quality determinants include the choice of cold-pressed oils, purity of water and alkali, and environmental conditions during the curing process. Emphasis on super fatting, pH optimization, and natural glycerol retention further contributes to the skin-conditioning properties of the soap [15–17].
The present work focuses on the formulation and physicochemical evaluation of a cold-processed lavender soap using cold-pressed coconut, olive, and castor oils in combination with lavender essential oil. The formulation was tested for quality parameters as per IS 286:1981 standards in a NABL-accredited laboratory. This work supports the ongoing development of herbal, sustainable, and dermatologically safe soap formulations. has evolved from traditional methods using animal fats and ash to scientifically refined techniques aimed at enhancing product quality, skin safety, and environmental sustainability. The key chemical reaction involved is saponification, where triglycerides (fats/oils) react with an alkali, typically sodium hydroxide (NaOH), to form soap (fatty acid salts).

2. Materials and Methods

2.1 Ingredients

The cold process soap formulation was developed using a balanced blend of plant-based oils and selected additives to achieve desirable cleansing, moisturizing, and natural skincare performance. All ingredients were accurately weighed using a digital scale and the oils were combined based on their individual saponification values to maintain product quality and safety. The overall INS (Iodine Number –

Saponification Number) value of the soap was calculated to be 139, ensuring optimal hardness and skin conditioning balance.

Table 1: Composition and Functional Role of Ingredients in the Formulated Cold Process Soap

Ingredient	Approximate Percentage (% w/w)	Function
Coconut Oil	30%	Cleansing, hardness, rich in lauric acid
Olive Oil	25%	Conditioning, moisturization, oleic acid
Castor Oil	10%	Lather enhancement, humectant (ricinoleic acid)
Distilled Water	30%	Solvent for lye, ensures purity
Sodium Hydroxide (Lye)	Calculated based on SAP values	Enables saponification
Lavender Essential Oil	2–3%	Fragrance, skin-soothing, antimicrobial

Coconut Oil (Cocos nucifera): This oil is included for its excellent cleansing ability and bar-hardening properties. Rich in lauric acid (approximately 45–52%), it generates abundant lather and contributes antimicrobial effects, making it ideal for tropical environments and oily skin types [13].

Olive Oil (Olea europaea): Known for its emollient and moisturizing properties, olive oil is rich in oleic acid (>70%). It promotes skin nourishment, improves soap texture, and helps retain skin elasticity. It also prolongs trace time, offering better control during formulation [14].

Castor Oil (Ricinus communis): This oil contributes significantly to the lathering and conditioning aspects of the soap. High in ricinoleic acid (approximately 85–90%), it functions as a humectant, improves foam stability, and softens the final product [15].

Lavender Essential Oil (Lavandula angustifolia): Incorporated at 2–3% concentration, this essential oil provides a soothing fragrance and potential antimicrobial and anti-inflammatory effects. It contributes to the therapeutic appeal and dermatological safety of the soap [9].

Sodium Hydroxide (NaOH – Lye): Lye is a critical component in cold process soap-making, enabling the saponification of oils into soap and glycerol. Sodium hydroxide is a highly caustic substance that can cause skin and eye burns upon contact [16].

Distilled Water: Used to dissolve the lye, distilled water ensures the absence of minerals or contaminants that could interfere with the soap's texture or shelf life. It supports stable emulsion formation and consistent curing [18].

2.2 Requirements

The equipment and safety materials used include an induction heating unit, food-grade thermometer, dehumidifier, digital weighing scale, heat-resistant pouring jars, graduated measuring cylinders, stainless steel mixing vessel, laboratory-grade spatulas, silicone soap molds, safety goggles, nitrile gloves, face mask, lab apron, parchment paper (for mold lining), and clean towels (for insulation during gel phase). All equipment was accessed from the Incubation Centre of the Department of Biotechnology, Dr. Lankapalli Bullayya College, Visakhapatnam, ensuring a controlled and safe laboratory environment for formulation.

2.3 Use of SOAPCALC

SOAPCALC, a widely used soap formulation calculator, was used to determine the lye and water amounts based on the saponification values of the oils. This ensured a balanced fatty acid profile, appropriate super fatting, and reduced free alkali levels.

2.4 Cold Process Soap Preparation

The carrier oils and additives used in this formulation were sourced from reliable commercial suppliers. Cold-pressed extra virgin coconut oil (Max Care, India), extra virgin olive oil (Disano, India), and cold-pressed castor oil (Rey Naturals, India) were selected due to their minimal processing and ability to retain the natural composition of fatty acids, vitamins, and antioxidants—factors essential for enhancing the emollient and dermatological properties of the final product. Cold pressing avoids heat and chemical solvents, thereby preserving the therapeutic quality of the oils.

Lavender essential oil was obtained from Essancia (India), a reputed manufacturer of therapeutic-grade essential oils, ensuring consistency and aroma stability. For saponification, sodium hydroxide (lye) of high purity, specifically from the brand Veda Oils, which is one of the most commonly used and trusted lye brands among Indian soap makers has been used. It is easily available through online platforms and is known for its consistent quality, fine granulation, and high purity, making it reliable and safe for cold process soap-making applications.

The cold process method was selected for its ability to preserve essential oil bioactivity and natural glycerine content. The steps followed were as below:

- **Weighing and Preparing Oils:**

Each oil—coconut, olive, and castor—was accurately weighed using a digital scale based on the formulation generated by SOAPCALC. The oils were gently heated in a stainless-steel vessel on induction heating unit to 35°C to achieve a uniform mixture with a reduced viscosity. A food grade thermometer was used for constant monitoring of temperature during this process as shown in Figure 1.

Figure1: Oil Mixture

- **Lye Solution Preparation:**

This involves the preparation of the sodium hydroxide solution, also known as lye solution. Sodium hydroxide (NaOH) pellets were slowly added to chilled distilled water (never vice versa) in a heat-resistant container while stirring continuously to avoid splattering, fuming, or even explosive eruptions. This controlled method ensures proper dissolution and minimizes thermal shock or violent reactions, which is essential for safe handling in both laboratory and artisanal soap-making practices. This step was conducted in a well-ventilated area with full personal protective equipment (PPE): gloves, goggles, mask, and apron. The exothermic reaction was allowed to cool naturally to 35–40°C before combining with oils.

- **Combining Oils and Lye:**

Once both the lye solution and oils reached the desired temperature range (35–40°C), the lye solution was gradually poured into the oils while blending with an immersion stick blender. This ensured even saponification and avoided curdling or seizing of the mixture.

- **Reaching Trace:**

The soap mixture was blended until it reached **trace**, a stage where the batter thickens to the consistency of light pudding and retains a visible trail on the surface when dripped. This indicates that the saponification reaction has begun as shown in Figure 2.

Figure 2: Tracing

- **Incorporating Lavender Essential Oil:**

At trace, lavender essential oil (at approximately 2–3% of total oil weight) was added and gently stirred in. Care was taken to avoid overheating or over-blending, which could accelerate trace or cause essential oil volatilization.

- **Molding and Insulation:**

The soap batter was poured into silicone molds and tapped gently to eliminate air bubbles. Molds were covered with parchment and insulated with towels to maintain residual warmth and promote gel phase development.

Figure 3: Pouring the batter into the molds

- **Curing:**
  After 48 hours, the soap was unmolded. The soap bars were then cured in a dry, well-ventilated space away from direct sunlight for 6 weeks. This allowed the water to evaporate and the saponification reaction to complete fully, improving hardness and shelf stability. To ensure consistent drying conditions and prevent excess moisture absorption during the curing period, a **dehumidifier** was used in the curing space. This helped maintain optimal humidity levels, supporting uniform water evaporation from the soap bars and reducing the risk of surface sweating or microbial growth, particularly important in humid coastal environments like Visakhapatnam. Figure 4 shows how a cold processed Lavender Soap looks like.

Figure 4: Cold Processed Lavender Soap

2.5 Parameters for Evaluation

Soap samples were submitted to **Visakha Enviro Labs and Consultants Pvt. Ltd.**, a NABL-accredited laboratory, for physicochemical analysis in accordance with **IS 286:1981** specifications for toilet soap.

Testing Procedure (Overview)

1. **Sample Preparation**: Approximately 112 grams of cold-processed lavender soap was packed in a sterile plastic cover and submitted to the lab.
2. **Moisture Content**: Determined by heating a known quantity of the sample and measuring weight loss.
3. **Total Fatty Matter (TFM)**: Assessed via solvent extraction and titration to quantify the number of fatty acids and their salts.
4. **Free Alkali**: Evaluated by titration against standard acid to detect residual unreacted sodium hydroxide.
5. **Unsaponified Matter**: Extracted using organic solvents and quantified gravimetrically.
6. **Alcohol and Water Insoluble**: Determined by dissolving the soap in respective solvents and filtering to measure residue.
7. **Glycerol and Electrolyte (Na, K) Content**: This is measured using standard spectrophotometric and flame photometric methods.

3. Results and Discussion

The soap analysis report is summarized in table 2.

The cold-processed lavender soap formulation was evaluated for critical quality parameters. The results are summarized below:

Table 2: Physicochemical Properties of the Formulated Cold Process Soap

Parameter	Observed Value	Standard Limit	Inference
Total Fatty Matter (TFM) (%)	73.8	70–80 (IS 286:1981, Grade 1)	Meets Grade 1 standards: good cleansing and moisturizing potential
Moisture Content (%)	3.98	<10–15	Indicates longer shelf life and improved hardness
Free Caustic Alkali (%)	0.13	<0.25 (max); <0.1 (ideal)	Slightly above ideal; within safe range
Unsaponified & Unsaponifiable Matter (%)	3.11	<2	Elevated due to excess oils; enhances skin conditioning
Alcohol-Insoluble Matter (%)	0.48	<0.2	Higher value likely due to botanical additives
Volatile Matter (%)	1.06	0.5–2	Acceptable; indicates fragrance retention
Water-Insoluble Matter (%)	0.09	<0.5	Acceptable; suggests good rinsability
Total Alkalinity of Water-Insoluble Matter (%)	0.14	<0.2	Within permissible range; free from excess residues
Glycerol (%)	0.84	0.5–2	Indicates natural retention; improves skin hydration
Sodium (%)	0.67	Acceptable range*	Contributes to bar firmness and lather quality
Potassium (%)	0.23	Acceptable range*	Supports solubility and cleansing properties

*Note: No explicit limit specified in IS 286:1981, but values fall within typical soap formulation ranges.

The analyzed soap formulation exhibited physicochemical parameters largely within acceptable or desirable limits as per IS 286:1981. A high TFM value (73.8%) indicates superior cleansing and emollient properties. Low moisture content (3.98%) enhances storage stability and hardness. Though free caustic alkali (0.13%) is slightly above the ideal level, it remains within the safe usage limit.

Elevated unsaponified matter (3.11%) is attributed to superfatting, enhancing skin conditioning. The presence of botanical additives likely contributed to the higher alcohol-insoluble matter (0.48%). Other values, including volatile matter, water-insoluble matter, total alkalinity, and glycerol content, were within acceptable ranges, supporting overall product quality. Sodium and potassium levels also reflect a balanced formulation with good cleansing and lathering characteristics. The physicochemical profile of the formulated lavender soap confirms its compliance with Indian standards for toilet soap. Minor deviations in free alkali and unsaponified matter are acceptable and may even enhance dermatological benefits due to retained emollients. The formulation strategy, coupled with proper curing, resulted in a high-quality natural soap suitable for personal care applications.

4. Conclusion

The present work highlights the successful formulation and evaluation of a cold-processed lavender soap incorporating cold-pressed coconut, olive, and castor oils along with lavender essential oil. The calculated formulation, developed using SOAPCALC, resulted in a high-quality soap that meets key physicochemical parameters outlined in IS 286:1981 standards. With a Total Fatty Matter of 73.8%, low moisture content (3.98%), and retained natural glycerol, the formulation demonstrates desirable cleansing, moisturizing, and stability properties.

Minor deviations observed in unsaponified and alcohol-insoluble matter were within acceptable limits and contribute positively to skin-conditioning benefits. Testing conducted through a NABL-accredited laboratory affirms the soap's quality and safety for personal use. This work supports the potential of using natural oils and essential oils in cold-process soap formulations as a sustainable and skin-friendly alternative to commercial synthetic products.

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