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A Comparative Analytical and Synthetic Study on Soap Samples: Bridging Laboratory Research with Commercial Formulation

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Abstract

The following work reports a thorough comparative analysis of some commercial soap preparations and a lab-prepared soap synthesized through classical saponification. The main aim of this research is to fill the methodological and practical gap between chemical academic research and bulk soap production, identifying thereby the potential to create sustainable and economically viable alternatives. The study examines crucial physicochemical characteristics such as pH, total fatty matter (TFM), water content, and foaming power. The sample of soap was prepared in controlled laboratory conditions with rice bran oil and sodium hydroxide as major reactants, with ethanol being utilized to aid miscibility and phase separation. Through analysis, the resultant soap had similar performance compared to some commercial products, especially in pH compatibility and safety of alkali, although it lagged behind in TFM and foam characteristics. This research demonstrates the possibility for academic procedures to form the basis of reproducible, consumer-oriented soap bases with favourable chemical characteristics and skin tolerance.

1. Introduction

Soap production and usage, as a surfactant produced by the alkaline hydrolysis of triglycerides (saponification), have transitioned from primitive home methods to highly developed commercial processes that are regulated by regulatory, economic, and consumer pressures. Although there has been precedence in the history of soap through its use since 2800 BCE in Babylon and the refinement thereof in Egypt, Rome, and 19th-century Europe, contemporary soap making remains an active area of research in the fields of green chemistry, dermatological safety, and industrial process optimization.

Commercial soaps are generally developed with a mix of fatty acid salts, surfactants, and chemical additives and are tested for important physicochemical and organoleptic factors governing user perception and therapeutic tolerance. In contrast, scientific research is more concerned with underlying reaction mechanisms, controlled experiments, and durability of raw materials. A careful examination of whether laboratory-scale soap synthesis can provide comparable or superior quality products compared to commercial ones is therefore warranted.

Therefore, this current study aims to examine the synthesis and analytical analysis of a laboratory-prepared soap from rice bran oil and NaOH, and to compare its chemical and physical properties with a varied array of market-dominant commercial soaps. The overall goal is to improve the translational potential of laboratory observations to real-world industrial processes and encourage environmentally friendly, functionally better soap products.

2. Materials and Methods

2.1 Commercial Sample Selection

Five market-available brands of soap — Santoor, Lux, Lifebuoy, Patanjali, and Dove — were purchased according to market availability and diversity in formulation approaches (herbal, antiseptic, cosmetic). Each sample was systematically tagged, numbered, and underwent a set of physicochemical tests.

2.2 Laboratory Synthesis of Soap

Soap was prepared in a laboratory setting using rice bran oil, selected due to its appropriately weighted fatty acid profile containing high levels of oleic and linoleic acids which have been shown to improve both cleansing ability and moisturization of the skin. Sodium hydroxide (NaOH) was utilized as the alkaline substance to catalyse the saponification reaction and ethanol was incorporated to induce homogeneity as well as effective phase separation between the soap and by-products glycerol and excess lye.

The saponification reaction was carried out at a constant temperature of 60–70°C under continuous mechanical stirring for uniform thermal distribution and dispersion of reactants. The soap was cast into silicone Molds after about 60 minutes of reaction time and was put through a curing process of 7–10 days to facilitate evaporation of excess moisture and completion of saponification. The post-synthesis process improved the structural integrity and physicochemical stability of the product.

2.3 Sensory and Analytical Evaluation

Quantitative and qualitative assessments were carried out with standard methods. pH was recorded by a calibrated pH meter in aqueous soap solution 1%. Moisture content was gravimetrically calculated. Total alkali was analysed by acid-base titration, whereas TFM was determined gravimetrically as per BIS (Bureau of Indian Standards) guidelines. Foam height was determined by a standard shaking test. Other sensory tests like texture, colour, and Odor were also performed to determine cosmetic attractiveness and ease of use.

3. Results and Discussion

3.1 Comparative Physicochemical Parameters

Sample	Moisture (%)	pH	Total Alkali (%)	TFM (%)	Foam Height (cm)
Santoor	28.6	10.36	2.356	76.0	5.5
Lux	22.4	9.60	2.232	62.3	6.8
Lifebuoy	18.46	9.20	1.581	79.01	4.9
Patanjali	33.8	9.50	1.705	56.0	5.3
Dove	45.6	10.60	1.519	71.0	8.3
Synthesized Soap	21.8	9.15	2.01	61.9	5.0

3.1.1 pH Profile

All the commercial soaps revealed pH values spanning from fairly alkaline (9.2 in Lifebuoy) to extremely alkaline (10.60 in Dove). The laboratory-synthesized soap, however, yielded a pH of 9.15 and was thus the least alkaline sample in the study. Though traditional saponification naturally provides alkaline products, lower pH levels are preferable for skin friendliness, particularly for those with sensitive skin or dermal conditions like dermatitis. The relatively acidic nature of the soap produced hereby is a positive formulation attribute, providing lesser potential for disruption of skin barrier.

3.1.2 Moisture Content

Moisture content affects both the physical stability and microbial stability of soap. Dove, with its label as a moisturizing bar, had the greatest moisture content (45.6%), which, although useful for skin moisturizing, might shorten shelf life through increased water activity. The moderate moisture content of the synthesized soap (21.8%) gave equal balance to product stability and skin feel, hence increasing usability and storage potential.

3.1.3 Total Alkali and TFM

The free residual alkali present in the prepared soap was 2.01%, well within the permissible safety limit (<2.5%), signifying controlled and complete saponification. Commercial samples ranged from 1.519% (Dove) to 2.356% (Santoor). The TFM, a major indicator of quality of soap, was highest in Lifebuoy (79.01%), followed by Santoor (76%), both Grade 1 soaps according to BIS standards. The synthesis soap, which had a TFM of 61.9%, slightly missed this criterion but still showed acceptable cleanliness potential.

3.1.4 Foaming Ability

Foam height, while not a direct measure of cleaning performance, is an important consumer-perceived attribute. Dove and Lux showed the greatest foam heights (8.3 cm and 6.8 cm respectively), as might be expected given their levels of surfactant and additive. The foam height for the synthesized soap was intermediate at 5.0 cm, similar to that for Patanjali and Santoor, implying good performance in actual usage washing conditions.

4. Sensory Evaluation

The sensory properties of the resultant soap comprised a firm and smooth feel, off-white colour indicative of low synthetic additives, and an agreeable sandalwood fragrance from essential oil incorporation. These properties combined maximize consumer attractiveness, particularly for users looking for naturally sourced, perfume soaps with beauty acceptability. Comparative analysis with commercial soaps showed that although such brands as Lux and Dove offer a luxury user experience, the synthesized soap is able to match or approximate these sensory benchmarks using less complex, greener formulation approaches.

5. Conclusion

The results of this study demonstrate that laboratory-made soap, if formulated with precision-selected vegetable oils and optimized saponification conditions, can attain physicochemical properties comparable to renowned commercial brands. The made soap was superior in pH compatibility and alkali control but compromised on the acceptable level of foam production and structural integrity. While the TFM was mediocre, optimization using oil mixtures like coconut, castor, or olive oil is conceivable.

This research highlights the potential of academic research to play an important role in developing safe, effective, and environmentally friendly soap formulations. In addition, using standardized analytical procedures in teaching laboratories can equip future chemists to become quality assurance scientists for the personal care industry. Addressing the academic-industry divide calls for ongoing experimentation, formulation innovation, and implementation of green chemistry principles.

6. Future Directions

Future research can investigate:

1.Improvement of TFM with high-lipid natural oils.

2. Combination of medicinal plant extracts having antifungal or antibacterial activity.

3. Application of FTIR, DSC, and NMR to study soap composition and follow saponification kinetics.

4. Application of AI-based process modeling for formulation optimization and cost savings.

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