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Enhancing the Cleaning Efficiency and Fragrance of Recycled Used Cooking Oil-Based Soap with Citrus Fruits

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Abstract: ***This study aimed to find out the effects of combined recycled UCO and citrus essential oil on the cleaning efficiency, foaming capacity, and scent of bar soap. Three formulations were made with different percentages of UCO and essential oil (1:1, 1:2, and 1:3) and were tested for pH, cleansing, foam and fragrance retention. The pH results showed that the 1:1 formulation produced the most appropriate soap, with a pH almost as low as commercial products and with a good texture stability. On the other hand, 1:2 formulation resulted in too much alkalinity, and the 1:3 ratio produced a softer and less stable bar. The performance tests indicated that the UCO based soap made with optimum conditions was a better cleaner than the commercial soap, since it was able to remove more oil in the 6-second and 8-second tests. Besides, the UCO soap together with the commercial soap did not perform similarly in terms of long-term foaming ability, as the UCO soap was able to maintain the height of its foam throughout the 17-minute observation period even though it started off at a lower height. The fragrance test showed that the UCO soap was able to keep the scent much longer, especially when the citrus oil volume was high, thus producing a more potent and longer-lasting aroma compared to the commercial variant. In conclusion, the results affirm the practical applicability of UCO infused with citrus essential oil as an eco-friendly and high-performing substitute to chemically manufactured soaps. The research indicates that the right formulation can turn recycled domestic waste materials into efficient hygiene products that promote environmental sustainability and lessen household waste.***

Keywords: ***Used cooking oil (UCO), recycled soap, citrus essential oil, bar soap formulation, pH level, cleansing efficiency, foaming capacity, fragrance retention, eco-friendly products, sustainable hygiene, waste reduction, alternative soap production***

I. INTRODUCTION

Improper waste disposal of used cooking oil is a global growing concern, both for the environment and public health. When poured down pipes or into bodies of water, UCO blocks pipes and sewage systems, contributing to overflows and reduced water quality, thus harming aquatic ecosystems and leading to diseases. In the Philippines, households and small-scale food businesses usually dispose of UCO down sinks or in normal refuse, causing blocked drainage that results in localized flooding and pollution in rivers and coastal waters. These issues emphasize the urgent need for effective and sustainable UCO management. Recycling of UCO into biodegradable soap emerged as one of the practical solutions. Various studies proved that UCO could safely be converted into soap with acceptable physicochemical properties, being an eco-friendly alternative against commercial ones, in addition to decreasing environmental pollution. However, most existing formulations of UCO-based soap usually suffered from problems in texture, lather quality, and stability; hence, they still needed further improvement. This study aims at developing an enhanced formulation of the UCObased soap with the addition of citrus peel. The incorporation of citrus peel addresses organic waste recycling, improves soap quality, and advances sustainable production. By converting household waste into a useful product, this research contributes to proper waste management, pollution reduction, and community livelihood opportunities. This falls in line with SDG 12: Responsible Consumption and Production.

II. OBJECTIVES

To create a biodegradable soap from used cooking oil and citrus peel waste, we aim to reduce environmental pollution, improve sanitation, and support circular economy practices in the Philippines.

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A. Specific Objectives

1) Formulate the correct ration in making the UCO based soap.

2) Determine the pH level of the UCO based soap in different ratios using litmus paper.

3) See how adding citrus peel extracts affects the quality of the USO based soap in terms of :

3.1. Cleaning ability;

3.2. Foaming ability;

3.3. Fragrance.

4) Compare the performance of the UCO-citrus peels soap with commercial soap in the market.

III. MATERIALS AND METHODS

A. Research Design

This study utilized a descriptive– comparative research design to document the preparation of recycled UCO soap enhanced with citrus peel extract and to compare its properties to commercial soap. Such a design allows for an observation of formulation characteristics in terms of texture, fragrance, foaming ability, cleaning efficiency, and safety.

B. Materials

The basic materials used in the experiment were waste cooking oil, orange peels for extracting citrus oil, sodium hydroxide, distilled water, and stearic acid. Other safety materials used during the experiment included lab coats, gloves, measuring cups, pH strips, and soap molds.

C. Procedure

Material Preparation – the UCO, orange peels, NaOH solution, and all other ingredients for the experiment were prepared in accordance with laboratory safety measures. Citrus oil extraction: Washing of peels, drying, grating and soaking in oil for citrus essence extraction was done. Filtration was carried out followed by storage. Soap Formulation (Saponification) - This consisted of making three formulations using UCO with citrus oil in the following ratios: 1:1, 1:2, and 1:3.

Each mixture was added to the NaOH solution, stirred for 30 to 45 minutes, mixed with stearic acid, and molded. A total of three trials were completed for each ratio. Drying and Curing: Samples were allowed to harden for 12 hours. The changes that took place in the texture were noted down. Testing of Soap Samples – pH value, cleaning ability, foaming performance, and fragrance retention were measured in the soaps after curing.

D. Data analysis

Data were analyzed descriptively and comparatively. The characteristics of the soap from each formulation were recorded and compared with commercial soap.

- pH testing determined the safety for use.
- Cleaning efficiency was determined by a plate test based on the weight of oil removed.
- The assessment of the foaming ability used a bottle-shake method, considering the height of the bubble and the stability of the foam.
- Fragrance retention was assessed after an exposure period of 30 min by a simple tissue scent test.

IV. RESULTS AND DISCUSSION

A. pH Level of UCO Soap in Different Ratios

To determine the best ratio of used cooking oil to essential oil, the researchers soaked the UCO soap in 30 mL of water and proceeded with using the litmus paper to ascertain the pH levels.

RATIOS	pH Levels
1:1	10 (Basic)
1:2	11 (Basic)
1:3	8 (Neutral)

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Table 1. Results of pH level test of UCO soap in different Ratios

The data in the table shows a noticeable difference in the pH levels produced by the three mixing ratios of the UCO-based soap. Among the samples, the 1:3 ratio recorded the lowest pH, making it the least alkaline. Following that, the 1:1 ratio produced a slightly higher pH, while the 1:2 ratio resulted in the highest pH value, making it the most alkaline formulation. Since commercial soaps typically fall within a pH range of 7 to 10, all three samples generally align with the acceptable pH range for soap products—except for the 1:2 ratio, which reached a pH of 11 and exceeded the upper limit.

Based on these results, the researchers identified the **1:1 ratio** as the most favorable formulation. Its pH value falls comfortably within the typical commercial range, making it both safe and comparable to standard soap products. Additionally, the 1:1 soap sample exhibited better physical quality, maintaining a more stable and consistent hardness than the other ratios. Although the **1:3 ratio** also falls within the acceptable pH range, it did not meet the expected physical characteristics, as the soap produced was noticeably softer and lacked structural stability.

In contrast, the **1:2 ratio**, despite producing a firm bar of soap, registered a pH level of **11**, which is outside the acceptable commercial range. A pH this high may result in a product that is too alkaline and potentially harsh on the skin. Therefore, the researchers concluded that the 1:1 formulation strikes the best balance between pH suitability and desirable physical qualities, making it the most appropriate ratio for producing UCObased soap.

B. Cleansing Efficiency

Type of soap	Initial Weig t (oz)	Time	Final Weigh t (oz)	Oil Remove d (oz)
UCO	10 oz	6 second s	3 oz	7 oz
UCO	15 oz	8 second s	4oz	11 oz
COMMERCIA L	10 oz	6 second s	4oz	6 oz
COMMERCIA L	15 oz	8 second s	5oz	10 oz

Table 2. Results of Cleansing Efficiency Test

The table shows that the UCO soap consistently removed more oil than the commercial soap in all trials. Whether tested using 10 oz or 15 oz samples and washed for 6 seconds or 8 seconds, the UCO soap always resulted in a lower final weight, which means it dissolved more oil during cleaning. For example, at 10 oz for 6 seconds, the

UCO soap removed 7 oz of oil while the commercial soap removed 6 oz. Likewise, at 15 oz for 8 seconds, the UCO soap dissolved 11 oz compared to the commercial soap's 10 oz.

The results also indicate that longer washing time increases oil removal for both soaps, supporting the idea that duration directly affects cleansing performance. Overall, the data demonstrates that UCO soap has a slightly stronger cleaning ability than commercial soap since it consistently removed more oil across all tested conditions.

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C. Foaming Ability

Type of soap	Initial height of the Foam (Inches)	Time (Initial)	Time (Final)	Final height of the Foam (Inches)
UCO	11 inches	17 mins	2 mins	4 inches
Commercial Soap	11 inches	17 mins	10 mins	3 inches

Table 3. Results of Foaming Ability Test

The table shows that the UCO-based soap demonstrates better overall foam retention compared to the commercial soap. Both soaps were tested using identical 1000 mL bottles, each approximately 11 inches tall, to ensure fair comparison. Although the UCO soap's foam began to collapse slightly after the first two minutes, it continued to maintain a significant amount of foam throughout the test. In contrast, the commercial soap's foam, while initially stable, began to spread out and lose height more noticeably as time progressed. By the end of the 17-minute observation period, the UCO soap had a final foam height of 4 inches, while the commercial soap ended with only 3 inches.

These results indicate that the UCO-based soap holds its foam better over time, maintaining a higher residual foam height compared to the commercial product. While the commercial soap may appear more stable in the early stages, the UCO soap ultimately retains more foam, showing stronger long-term foaming ability. This suggests that the UCO-based soap is more effective in sustaining foam throughout the duration of use, making it a competitive alternative to commercial brands in terms of foaming performance.

D. Fragrance Retention

Type of soap	Amount Applied (mL)	Time	Scent Rating
UCO	4 ml	30 mins	Moderate
UCO	6 mL	30 mins	High
COMMERCIAL	4 mL	30 mins	Moderate
COMMERCIAL	6 mL	30 mins	Moderate

Table 4. Results of Fragrance Retention Test

The table shows that both the UCO soap and the commercial soap were able to retain fragrance after 30 minutes, but the UCO soap demonstrated a stronger scent when a larger amount was applied. When 4 mL of product was used, both soaps received a "Moderate" scent rating, indicating that at lower amounts their fragrance strength is generally comparable. This suggests that, at minimal application levels, neither soap has a clear advantage in terms of scent intensity. However, when the amount was increased to 6 mL, the UCO soap achieved a "High" scent rating while the commercial soap remained at "Moderate." This difference indicates that the UCO soap is more effective at holding and releasing fragrance when used in larger quantities. Overall, the results show that UCO soap exhibits better fragrance retention at higher application levels, while the commercial soap maintains only a moderate scent regardless of the amount applied..

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V. CONCLUSIONS

The study showed that used cooking oil (UCO), when mixed properly with citrus essential oil, can turn into a functional and effective soap product that matches or even beats some commercial soaps. Among the tested mixtures, the 1:1 ratio of UCO to citrus essential oil was the best choice. It produced a stable soap with a pH level that meets commercial standards. In contrast, other ratios had issues with alkalinity and texture. This highlights the need to balance the oil and citrus components for a safe and durable final product.

Performance tests revealed that the optimized UCO-based soap had stronger cleaning efficiency and better foaming ability over time than commercial soap. Its consistent ability to remove oil during time trials shows that citrus-enhanced formulas can significantly improve cleaning power. The better foam retention seen over a 17-minute period indicates improved surfactant behavior, which is important for user experience and cleaning performance. These enhancements confirm that citrus oil adds not just to the soap's scent but also to its overall effectiveness.

When it comes to fragrance, the UCO-based soap showed better scent retention when more citrus oil was used. This reinforces the value of citrus components in boosting sensory appeal. Overall, the findings indicate that recycled used cooking oil, when boosted with citrus essential oil, can produce a soap product that is competitive in cleaning power, stability, fragrance, and foaming ability. Ultimately, this research shows the potential of natural citrus additives and household waste materials to create high-quality, eco-friendly soap that emphasizes both function and sustainability.

VI. RECOMMENDATIONS

Based on the findings of the study "Enhancing the Cleaning Efficiency and Fragrance of Recycled Used Cooking Oil-Based Soap with Citrus Fruits," the following recommendations are proposed to improve future research, strengthen product development, and support sustainable waste management practices:

1) For the Community Households are encouraged to continue and strengthen the proper collection and storage of used cooking oil and citrus fruit peels. Community-based recycling drives may be organized to ensure a steady supply of reusable materials and to promote responsible waste management. Such initiatives can help increase public awareness of sustainable alternatives to commercial hygiene products.

2) For the Environment Local government units and environmental organizations are advised to integrate UCO and citrus peel recycling into existing solid waste management strategies. Conducting seminars, workshops, and demonstration activities can further encourage residents to repurpose household waste materials. These efforts may contribute to reducing water pollution, minimizing clogged drainage systems, and supporting overall environmental conservation.

3) For Entrepreneurs- Aspiring entrepreneurs may use the findings of this study as a foundation for developing eco-friendly soap products. It is recommended that they explore additional natural ingredients such as plant-based stabilizers, herbal extracts, or essential oils to enhance the soap's texture, stability, lather quality, and fragrance retention. A marketability assessment and cost–benefit analysis may also be conducted to determine the commercial potential of UCO and citrus peel soap products.

4) For Future Researchers- It is recommended that future studies conduct preliminary chemical laboratory testing on the properties of the collected used cooking oil, such as its acidity level, impurities, color, and level of degradation, before using it in soap-making. Understanding the quality of UCO can help determine its suitability for soap production and may lead to more consistent results. Researchers may also explore other natural additives, waste materials, or environmentally friendly components to enhance soap formulation and support sustainable product development.

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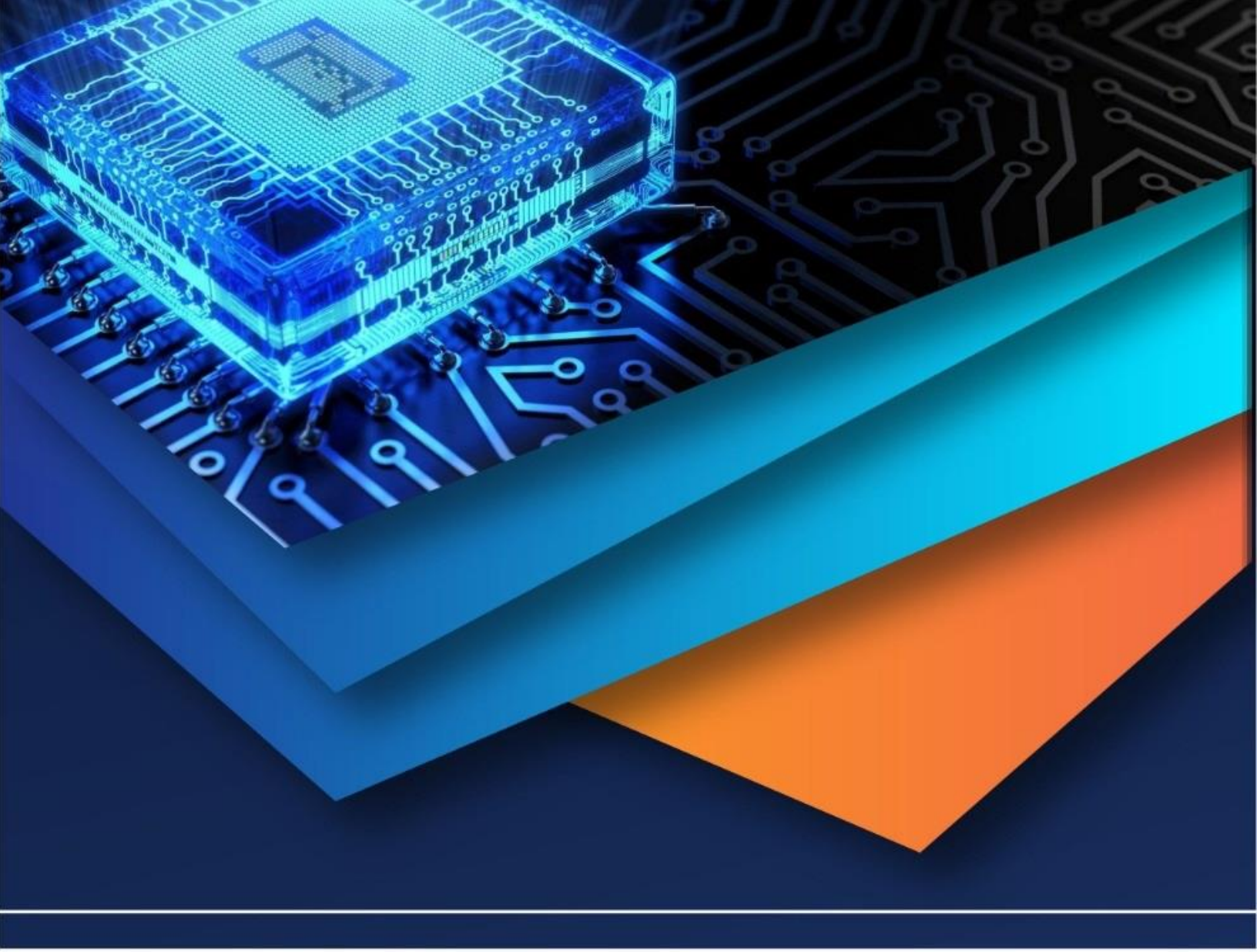
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