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**Preface**

The Scientific Project Colloquium offers a platform for publishing Diploma Science final year projects (FYP). The objective is to effectively distribute research findings throughout all scientific disciplines. The primary objective of including final year projects into the course curriculum is to encourage students to put their theoretical knowledge into practical applications.

We would like to express our gratitude to our primary establishment, the Faculty of Applied Sciences and Universiti Teknologi MARA, Perak Branch, for their invaluable assistance.

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# UTILIZING EXPIRED GOAT MILK IN SOAP PRODUCTION: SYNTHESIS, CHARACTERIZATION, AND BIOLOGICAL ASSESSMENT

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**Abstract:** This study explored the synthesis of soap using expired goat milk powder and assessed its antibacterial efficacy and moisturizing properties. Two soap variants were created: one with plain expired milk and another with strawberry-flavored expired milk. Cooking oil served as the primary fat, and lye was used for saponification. Despite initial challenges with ingredient ratios and rapid solidification, the experiment successfully produced usable soap, which was solid, bubbled well, and was suitable for everyday use. Antibacterial efficacy was tested using Staphylococcus epidermidis. The spread plate and Kirby-Bauer disk diffusion methods were employed, but the soap demonstrated no inhibitory effect on bacterial growth across multiple trials, indicating that the soap lacked antibacterial properties in its current formulation. Moisturizing effectiveness was evaluated on 26 participants over several weeks, revealing a decline in hand moisture levels, likely due to the absence of essential moisturizing ingredients. Although the soap effectively facilitated saponification, it did not contribute to skin hydration. Overall, while expired goat milk can be effectively used to produce soap, the study identified significant limitations in the soap's antibacterial and moisturizing capabilities. Future formulations should incorporate stronger antibacterial agents and moisturizing ingredients to improve the soap's overall performance.

***Keywords:*** *Expired, Goat Milk, Soap, Biological Assessment*

## INTRODUCTION

Goat milk has long been praised for its beneficial effects on human skin, making it a valuable ingredient in skincare products. Rich in alpha hydroxy acids, vitamins, and minerals, goat milk offers several advantages for skin health. Lactic acid, a key alpha hydroxy acid found in goat milk, acts as a gentle exfoliant, aiding in the removal of dead skin cells to reveal fresher, healthier skin. Additionally, goat milk is notably high in vitamin A, essential for repairing damaged skin tissue and maintaining overall skin health. The presence of minerals such as potassium and magnesium further enhance its skincare benefits; potassium helps to lock in moisture, while magnesium soothes irritated skin and reduces the appearance of acne (Hawkins, 2017).

Given the increasing concerns about food waste, the use of expired goat milk powder presents an innovative approach to creating environmentally friendly skincare products. In the United States alone, it is estimated that 40% of food is wasted annually, amounting to over 90 billion pounds at retail and consumer levels. Dairy products, including milk, cheese, and yogurt, comprise approximately 17% of this waste. Moreover, a survey by the National Science Foundation revealed that 78% of consumers discard milk and other dairy products once the expiration date has passed, contributing to this significant waste issue (Buzby, 2014). Utilizing expired goat milk powder to produce soap not only reduces food waste but also promotes sustainability by repurposing otherwise discarded materials.

Goat milk also stands out when compared to other types of milk, such as cow and sheep milk. It is more easily digestible and better tolerated by individuals with lactose sensitivity. Unlike cow milk, which can cause inflammation due to its higher allergen content, goat milk is less likely to trigger adverse reactions. While sheep milk is rich in nutrients, its high fat content can be a deterrent for some consumers. Goat milk's lower fat content and higher availability make it a more accessible and preferable choice for both dietary and skincare applications (Link, 2023).

The history of soap-making dates back to ancient Babylon, around 2800 B.C., where early forms of soap were made by boiling fats with ashes. This process, later identified as saponification, involved the creation of soap through the reaction of animal fats with lye, a strong base derived from wood ashes. The term "soap" is believed to have originated from a Roman legend about Mount Sapo, where animal fat and ashes from sacrifices formed a

soap-like substance that was discovered by women washing clothes. Over time, soap-making evolved with the synthesis of lye and the addition of various oils and essences to create more refined and pleasant soaps (Koeppel, 2021). Saponification remains the fundamental technique in soap production today. This chemical reaction involves the combination of oils, which contain triglycerides, with alkaline substances like lye. The reaction breaks down the triglycerides into fatty acids and glycerol, with the fatty acids then reacting with lye to form soap molecules. These molecules possess hydrophilic heads that attract water and hydrophobic tails that repel it, allowing the soap to effectively trap and remove oil and grease from the skin (What Is Saponification: Mechanism, Application & Example, n.d.). Moisturizing soaps are particularly important in skincare for their ability to preserve the skin's natural oils and prevent excessive dryness. Ingredients like glycerin, a byproduct of saponification, act as humectants, drawing moisture to the skin's surface and maintaining hydration. Regular use of moisturizing soaps not only improves skin texture but also strengthens the skin barrier, reducing dryness and irritation. This contributes to overall skin health, helping to protect against environmental stressors and promoting a radiant complexion (Hawkins, 2017).

In this study, we explore the synthesis of soap using expired goat milk powder, evaluate its antibacterial efficacy, and assess its moisturizing properties. By repurposing expired goat milk, we aim to create a sustainable product that leverages the natural benefits of goat milk while addressing the issue of food waste.

## METHODOLOGY

### 1. Method of making soap

The soap synthesis process involved the preparation of two variants: one utilizing plain milk powder and the other using strawberry-flavored milk powder. Initially, 27 g of milk powder, 68.05 g of pure water, and 317.50 g of cooking oil were precisely weighed. The milk powder was dissolved in pure water by heating the mixture in a 1000 mL beaker. Once dissolved, the milk solution was added to the cooking oil in a separate beaker and mixed thoroughly using a hand blender. In parallel, a lye solution was prepared by weighing 64.10 g of lye powder and 68.05 g of pure water, which were then combined and mixed with a hand blender in a separate beaker. This lye solution was then gradually incorporated into the milk-oil mixture and blended until the soap mixture reached trace. The mixture was promptly poured into silicone molds before it could solidify. The same procedure was repeated with strawberry milk powder to create the second variant of soap.

### 2. Microbial screening

The bacterial culture of Staphylococcus epidermidis was prepared by first disinfecting the work surface with 70% alcohol spray. The mouths of the broth bottles and the bacterial culture bottle were sterilized using a Bunsen burner, as was the inoculating loop. The broth solution was then inoculated with the bacterial culture, and the inoculated broth was incubated in an incubator shaker for 24 hours. Bacterial growth was assessed by observing the turbidity of the broth.

The antibacterial efficacy of the soap was tested using the spread plate technique and Kirby-Bauer disk diffusion method. The broth solution was first diluted to three different concentrations (10^1, 10^2, and 10^3) using 1 mL of the broth mixed with 9 mL of saline solution. Agar plates were labeled with the dilution factor, date, and sample names (D for distilled water, De for Dettol, P for plain soap, and S for strawberry soap). A 15 µL aliquot of the diluted bacterial sample was pipetted onto the center of the plate and spread evenly using a sterilized glass spreader. This process was repeated for each bacterial concentration, with three sets prepared for each sample. For the Kirby-Bauer disk diffusion method, sterilized filter paper disks were placed on the agar plates, and three drops of distilled water, Dettol, plain soap, and strawberry soap were applied to the respective disks. The plates were incubated in an inverted position, and after incubation, the zones of inhibition around each disk were observed and measured.

### 3. Moisturizing Test

The moisturizing effectiveness of the soap was evaluated using a moisture test detector, which measured the moisture levels on participants' hands before and after weekly use of the soap. Measurements were recorded weekly to assess changes in skin moisture levels over time.

**FINDINGS**

The experiment aimed to synthesize soap using expired goat milk powder and evaluate the product's quality and usability. Initially, 27 g of expired goat milk powder was mixed with 68.05 g of pure water, and the mixture was heated in a 1000 mL beaker. Cooking oil served as the primary fat component, and lye was prepared separately in another beaker by mixing with pure water. The lye solution was then carefully poured into the pre-mixed solution of cooking oil and expired milk, followed by immediate blending to initiate saponification. The mixture was quickly poured into molds to avoid premature solidification. Two variants of soap were produced, one with plain expired milk and the other with strawberry-flavored expired milk.

The experiment faced several challenges during the soap-making process. In the first attempt, an incorrect ratio of cooking oil caused the milk and oil mixture to be immiscible, making it difficult to pour into the molds. Adjustments were made to achieve a miscible solution that was easy to handle and pour. Another significant issue arose when the mixture of lye and cooking oil solidified too quickly, preventing it from being poured into the molds. To overcome this, a new method was employed where the expired milk solution, cooking oil, and lye solution were kept in separate beakers. This approach allowed for better control over the temperature of each component, reducing the risk of premature solidification and ensuring that the soap mixture could be properly poured into molds.

Despite the initial setbacks, the experiment successfully produced usable soap (Figure 1). The final product was solid but not overly hard, making it suitable for regular use. The soap was also capable of producing bubbles, indicating proper saponification. These findings suggest that while the process of making soap from expired goat milk can be challenging, with careful adjustments and precise control of ingredient ratios and temperatures, a high-quality soap product can be achieved.

Figure 1: Plain milk soap and Strawberry milk soap

The study on the antimicrobial efficacy of expired goat milk soap faced considerable obstacles, ultimately resulting in poor outcomes despite repeated attempts. The spread plate approach was utilized to assess the antibacterial efficacy, employing Staphylococcus epidermidis bacteria as the test organism for the soap solutions. This technique spanned multiple weeks and entailed rigorous experimentation.

In the first and second experiments, the soap solutions were immediately applied to agar plates containing the original, undiluted bacterial culture broth. The observed outcome of this method resulted in significant bacterial proliferation on the agar, suggesting that the soap did not demonstrate any antibacterial properties. The findings were equivocal, as the soap did not have any inhibitory impact on bacterial growth.

Further experiments included the process of diluting the bacterial culture broth in order to decrease bacterial growth. In the third and fourth experiments, the initial bacterial culture was diluted with a saline solution at a ratio of 1:9 (1000 µL of culture broth and 9000 µL of saltwater). The dilution was subsequently separated into three different concentrations: $10^{\wedge 1}$, $10^{\wedge 2}$, and $10^{\wedge 3}$. In spite of these modifications, the soap solutions did not exhibit any antibacterial efficacy on the agar plates during the third experiment. In the fourth trial, the testing was extended to nine agar plates, however, the results remained unaltered, as there was no discernible reduction of bacterial growth.

In the fourth trial, an extra precaution was taken to avoid cross-contamination by using separate micropipette tips for each sample, which was not done in the previous trials. Notwithstanding these safeguards, the outcomes were consistently unfavorable. The lack of ability to prove the effectiveness against germs could be due to possible contamination or the insufficiency of the testing settings.

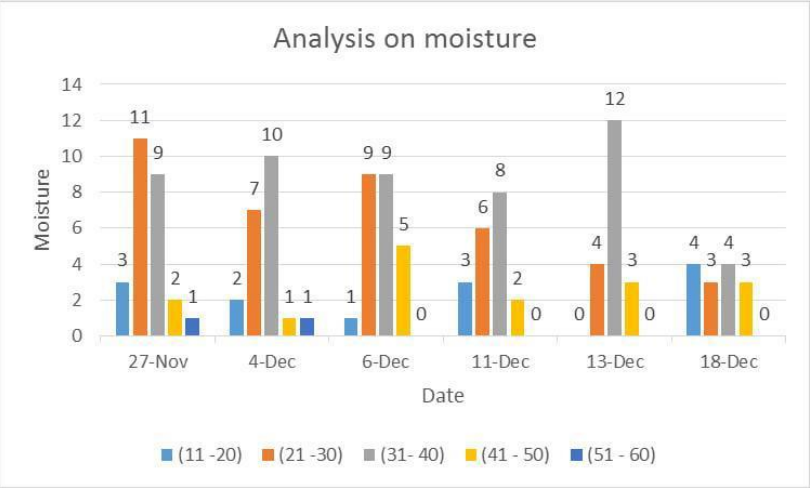


Figure 2: Moisturizing data for 26 participants

Moisturizing tests (Figure 2) were conducted on 26 participants who used the expired goat milk soap according to a daily usage protocol provided by the research team. Moisture levels were measured weekly on Mondays and Wednesdays using a moisture test detector. The results revealed that the soap did not effectively maintain or enhance hand moisture. Over the study period, there was a noticeable decline in the moisture levels of the testers' hands. Despite this reduction, no adverse side effects were reported by the participants.

The decrease in hand moisture is attributed to the lack of key moisturizing ingredients in the soap. The primary function of lye in the soap formulation was to facilitate saponification, which neutralizes bacteria, viruses, yeasts, fungi, and endotoxins. However, lye does not contribute to skin hydration (Saponification, 2023). Thus, while the soap proved effective in its antibacterial properties, it lacked components necessary for moisturizing the skin. This underscores the importance of incorporating additional moisturizing agents in future soap formulations to better support skin hydration.

**CONCLUSIONS**

This study aimed to synthesize soap using expired goat milk powder and evaluate its quality, usability, and potential benefits. Despite the successful production of soap, the experiment faced several challenges, primarily related to ingredient ratios and the rapid solidification of the soap mixture. These issues were addressed through adjustments in the method, resulting in a usable soap product that was solid, capable of producing bubbles, and suitable for regular use.

The antimicrobial testing of the expired goat milk soap, however, did not yield positive results. Across multiple trials using the spread plate technique with Staphylococcus epidermidis as the test organism, the soap solutions failed to demonstrate any antibacterial efficacy. This suggests that the soap, as formulated, lacks sufficient antibacterial properties. Possible factors contributing to these results include contamination or inadequate testing conditions, though these could not be definitively confirmed. Future work should consider the inclusion of more potent antibacterial agents to enhance the soap's effectiveness in this regard.

Additionally, the moisturizing efficacy of the expired goat milk soap was assessed through a study involving 26 participants. The results indicated a decrease in hand moisture over time, highlighting a significant limitation of the soap. This decline is attributed to the absence of key moisturizing ingredients in the formulation. While lye effectively facilitated saponification and neutralized harmful microorganisms, it did not contribute to skin

hydration. This finding underscores the need for incorporating moisturizing agents, such as olive oil, in future formulations to improve the soap's ability to maintain or enhance skin moisture.

In summary, the study demonstrates that while expired goat milk can be utilized to produce a functional soap, there are critical areas for improvement, particularly in enhancing the soap's antibacterial and moisturizing properties. Theoretical implications include the potential for using food waste in environmentally friendly personal care products, though practical considerations must address the formulation's limitations. Future research should focus on optimizing ingredient ratios and exploring alternative antibacterial and moisturizing agents to create a more effective and skin-friendly product.

## COMPLIANCE OF ETHICAL STANDARDS

The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Universiti Teknologi MARA.


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