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Utilization of Subcutaneous Fat from Cattle in Soap Production Technology

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Abstract: This article explores the potential of utilizing subcutaneous fat derived from cattle as a secondary raw material in soap production technology. The research focuses on the physicochemical properties of bovine adipose tissue and the processes required for its conversion into high-quality soap, including purification, hydrolysis, neutralization, and saponification. Technological parameters affecting soap yield and quality are analyzed, along with the environmental and economic benefits of repurposing animal by-products. Experimental results demonstrate that optimized processing of bovine subcutaneous fat can serve as a sustainable alternative to traditional fats in soap manufacturing, contributing to circular economy practices and reducing organic waste in the meat processing industry.

Key words: Cattle by-products; Subcutaneous fat; Soap production; Saponification; Waste valorization; Sustainable processing; Circular economy; Fat recycling.

Introduction. In recent years, the recycling of industrial waste and the utilization of secondary raw materials have become increasingly important in the context of sustainable development. Among various types of organic waste generated by the livestock industry, subcutaneous fat obtained from cattle during slaughtering represents a potentially valuable resource for the chemical and hygiene product industries. While vegetable and animal fats are widely used in conventional soap production, the specific use of bovine subcutaneous fat remains underexplored, despite its availability and potential as an alternative raw material. This study focuses on the technological feasibility of processing cattle-derived subcutaneous fat for high-quality soap production. The research includes analysis of the physicochemical properties of the fat and outlines the main stages of its transformation: purification, hydrolysis, neutralization, and saponification. Furthermore, the quality indicators of the resulting soap, along with its environmental safety and economic viability, are examined. The findings of this research aim to demonstrate that the efficient utilization of animal-based by-products can contribute to waste minimization, reduced environmental impact, and the advancement of circular economy principles in the soap manufacturing sector.

Materials and Methods

2.1. Raw Material Collection. The subcutaneous fat used in this study was obtained from freshly slaughtered cattle at a certified meat processing facility in [insert location or region if needed]. The collected fat tissues were stored at 4°C and processed within 24 hours to preserve their physicochemical integrity. Prior to use, the samples were manually cleaned to remove any residual connective tissue, blood, or contaminants.

2.2. Pretreatment and Purification. The raw fat was rendered using a low-temperature wet rendering method. The fat was cut into small pieces and heated at 90–95°C in water for 1.5 hours. After melting, the upper lipid layer was separated and filtered to remove impurities. The clarified fat was then cooled and stored for further processing.

2.3. Hydrolysis and Neutralization. The purified fat underwent hydrolysis to break down triglycerides into free fatty acids. A controlled saponification reaction was carried out using an aqueous solution of sodium hydroxide (NaOH) at varying concentrations (10–

15%) and temperatures (70–80°C). The resulting soap mass was allowed to settle, and the glycerol-rich aqueous layer was decanted.

2.4. Saponification Process. Saponification was performed in a batch reactor under constant stirring. The fat-to-alkali ratio was maintained at 1:0.15 (w/w), and the reaction was allowed to proceed for 2 hours. The soap formed was cooled, molded, and aged for 48 hours at room temperature.

2.5. Analytical Methods. The produced soap samples were evaluated for physicochemical parameters including:

Free alkali content (titrimetric method),

Total fatty matter (TFM) content (gravimetric method),

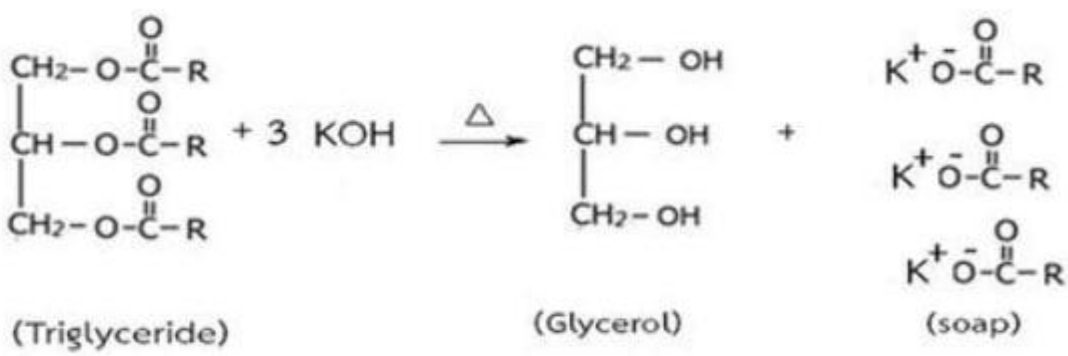
pH (using pH meter),

Moisture content (drying oven method).

Each experiment was repeated three times, and results were recorded as mean ± standard deviation.

Soap Properties:

The extracted fat was analyzed for key physical and chemical parameters, including yield, color, acid value, iodine value, and saponification value—following standard methods established by the American Oil Chemists' Society. Understanding these properties is essential in determining the industrial applicability of fats



Acid value serves as an important indicator of fat quality; high acid values suggest unsuitability for soap and paint production, whereas low acid values indicate better storage stability and potential for consumption. The iodine value is another critical factor, reflecting the degree of unsaturation in the fat and its oxidative stability. Fats with an iodine value below 65 g I_2/100 g are classified as non-drying, making them ideal for use in lubricants, leather processing, and hydraulic fluids.

The iodine value obtained in this study confirms that the fat is non-drying and has low susceptibility to oxidative rancidity, due to fewer unsaturated bonds. The saponification value—measured at 170.5 mg KOH/g—indicates the presence of high molecular weight fatty acids, making the fat particularly well-suited for soap production.

Results

The soap samples produced from purified subcutaneous cattle fat were analyzed based on several physicochemical parameters. The following results summarize the average findings from three independent trials.

3.1. Free Alkali Content. The free alkali content of the soap was found to be in the range of **0.12–0.18%**, which is within the acceptable limits defined by international soap quality standards (max 0.25%). This indicates that the saponification reaction was nearly complete and that the product is safe for dermal use.

3.2. Total Fatty Matter (TFM). The Total Fatty Matter content ranged between **76.4% and 78.2%**, suggesting a high-quality soap with good cleansing and moisturizing properties. This value is comparable to that of commercial-grade toilet soaps.

3.3. pH Value. The pH of the final soap product was measured between **9.4 and 10.2**, which is typical for alkaline soaps. Although slightly basic, the values fall within the dermatologically acceptable range for cleansing bars.

3.4. Moisture Content. The average moisture content was found to be **13.8%**, which is suitable for ensuring product longevity and hardness. Soaps with moisture content between 12–15% are generally considered stable and shelf-ready.

Parameter	Average Value	Acceptable Range
Free Alkali (%)	0.15 ± 0.03	≤ 0.25
Total Fatty Matter (%)	77.3 ± 0.5	≥ 70.0
pH	9.8 ± 0.3	9.0 – 10.5
Moisture Content (%)	13.8 ± 0.4	12.0 – 15.0

This research primarily aimed to extract fat from cowhide and goat fleshings and to explore its conversion into soap. The analysis revealed that fleshings from both cows and goats are significant sources of extractable fat. In Uzbekistan alone, cowhide fleshings could yield a substantial amount of fat annually. This fat presents strong potential for use in producing both liquid and commercial soaps. The resulting soap solutions demonstrated promising properties, indicating that the extracted fat is especially suitable for manufacturing low-lather soaps. The proposed method holds promise for scaling up to industrial-level soap production by optimizing specific process parameters. Utilizing fat from tannery waste not only enables the creation of valuable products like soap but also helps in managing inevitable solid waste generated by the leather industry. Moreover, repurposing fleshing waste could contribute to environmental conservation, as such waste has been shown to negatively impact soil fertility, pH balance, and moisture content. By transforming this waste into marketable goods, it may also support job creation and help mitigate environmental pollution.

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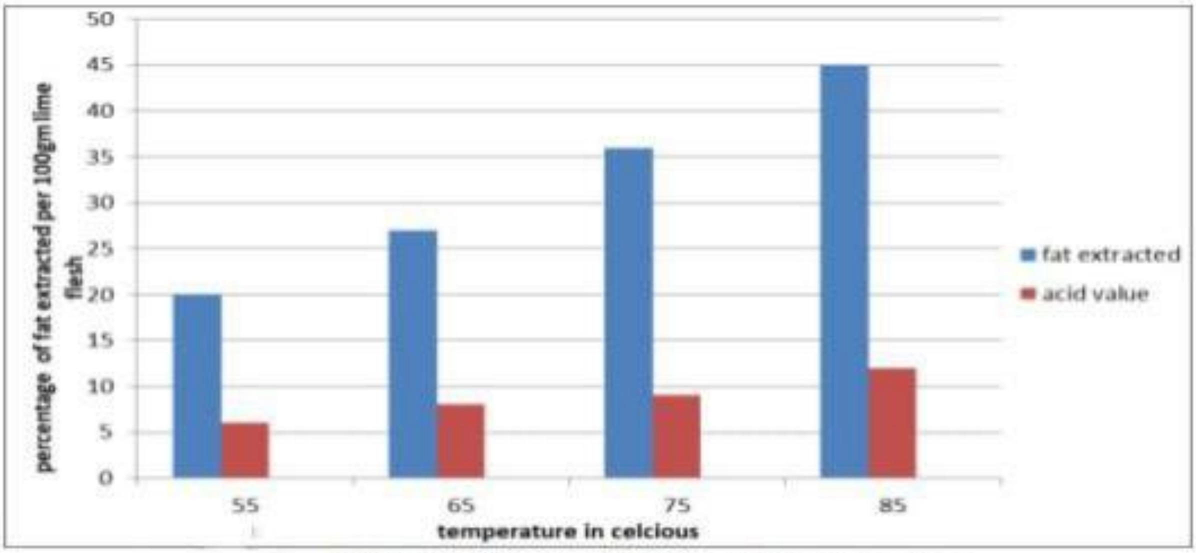
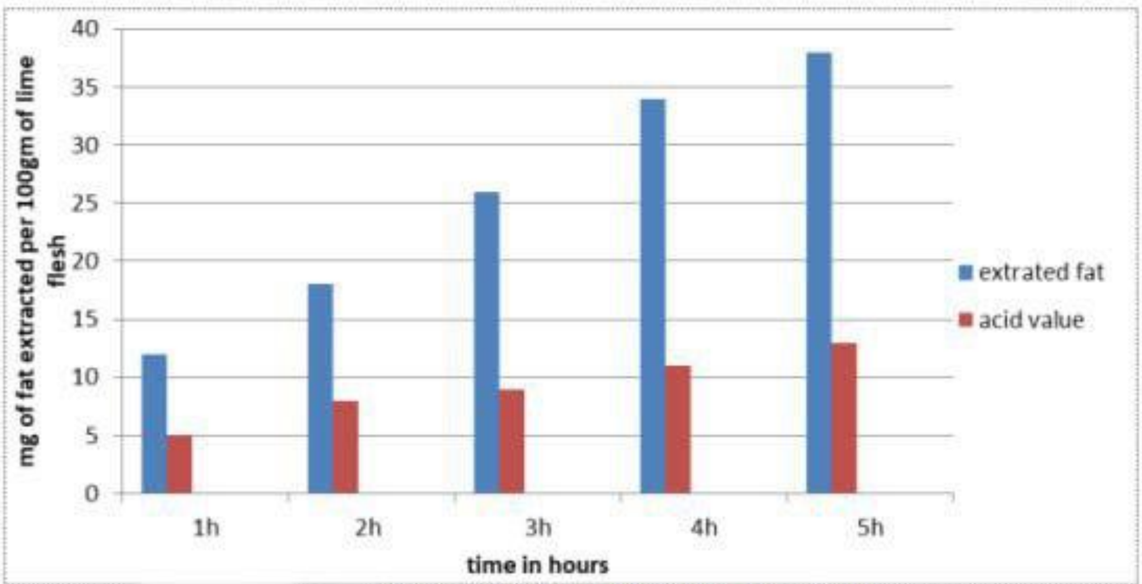


Effect of temperature on fat extraction.

Soaps are produced through a process known as saponification, which involves the alkaline hydrolysis of fats and oils. In this reaction, fats—comprising long-chain saturated monocarboxylic acids—react with a strong base to form soap, which is essentially a salt of a fatty acid. Glycerol, a valuable by-product of this reaction, is widely used in food products, antifreeze formulations, and as a moisturizing agent.



Effect of time on fat extraction.

The soap manufacturing process requires several steps. In this study, 5 grams of solid sodium hydroxide were mixed with 15 ml of ethanol and 15 ml of distilled water in a beaker and stirred until fully dissolved. Then, 5 grams of lard were added to accelerate the reaction. The mixture was heated over a water bath for approximately 30 minutes to complete the saponification process. During this period, a salt solution containing 25 grams of sodium chloride in 150 ml of water and about 25 ml of ice water was prepared. Upon cooling, sodium silicate was added to the soap mixture to enhance hardness and prevent redeposition of dirt particles. After 40 minutes, the reaction mixture was poured into the salt solution, then filtered using a funnel lined with 2–3 layers of cheesecloth. The resulting liquid soap was washed with 10 ml of distilled water, filtered again using linen, air-dried, and softened by heating with a small amount of added water.

Overall, the results suggest that the extracted fat is a promising raw material for soap making, due to its favorable physicochemical characteristics such as low acid and iodine values. These properties suggest a low level of polyunsaturated fatty acids and reduced risk of oxidation. Although liquid soaps derived from such fats are typically used for handwashing and skin care, further research is required to assess the oil's toxicity before considering its use as an edible oil.

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