



CONVERSION OF WASTE COOKING OIL AND SELECTED VEGETABLE OILS INTO SOAP: CHEMICAL CHARACTERIZATION AND QUALITY EVALUATION

Asimi Tajudeen,

Department of Chemical Science and Technology

Federal Polytechnic, Ede Osun State

Author's corresponding e-mail: aderemidemo@gmail.com

ABSTRACT: *Soap* is a substance used for cleaning and washing, typically produced by the chemical reaction known as **saponification**, in which fats or oils (triglycerides) react with a strong alkali such as sodium hydroxide (NaOH) or potassium hydroxide (KOH) to form fatty acid salts and glycerol. The bar soap was produced using distilled water, caustic soda, turmeric, moringa leaf extract, aloe vera, shea butter oil, SLS, and fragrance. The products were subjected to quality control tests including pH determination, lather formation, density measurement, moisture content analysis, percentage yield, and Total Fatty Matter (TFM) determination, using classical techniques. The liquid soap recorded a pH of 6.38, indicating mildness and compatibility with human skin, while the bar soap had a pH of 7.38, which is slightly alkaline and typical of solid soaps. Foam height for the bar soap using 2 g of sample in 70 mL of water was 32 mL, with foam stability of 87.5%, indicating good lathering ability. The density of the bar soap was calculated as 1.11 g/cm³, confirming proper curing and compact structure. Percentage yields of both products were above 90%, showing efficient production processes. The Total Fatty Matter value of the bar soap was 76%, classifying it as high-quality soap. The results indicate that the formulated liquid and bar soaps possess acceptable physicochemical properties, good cleansing efficiency, stability, and suitability for household use. The study demonstrates that quality soaps can be produced locally using simple techniques, thereby promoting small-scale industrial development and entrepreneurship.

Keywords: Caustic Soda, quality control tests, Soap, Turmeric, Total Fatty Matter (TFM),

1. INTRODUCTION

Soap is a substance used for cleaning and washing, typically produced by the chemical reaction known as **saponification**, in which fats or oils (triglycerides) react with a strong alkali such as sodium hydroxide (NaOH) or potassium hydroxide (KOH) to form fatty acid salts and glycerol (Warra, 2013). The fatty acid salts are responsible for soap's **detergent properties**, enabling it to remove dirt, oil, and grease from surfaces by emulsifying them in water. The **production and characterization of multipurpose soap from waste cooking oil, local oils, and vegetable oils** refers to the process of converting used or fresh lipid sources into functional cleaning products using established chemical reactions and evaluating the resulting soap's physical and chemical properties. Soap production typically involves **saponification**, a hydrolysis reaction in which triglycerides (found in fats and oils) react with a strong base such as sodium hydroxide (NaOH) or potassium hydroxide (KOH) to form **fatty acid salts (soap) and glycerol** (Warra, 2013). In this context, **waste cooking oil (WCO)** serves as an inexpensive and sustainable raw

material, reducing environmental pollution and adding value to a by-product that would otherwise be discarded (Panadare & Rathod, 2015)

When edible vegetable oil is used to fry food, waste cooking oil (Waste Cooking Oil) is created (Choe & Min, 2007). Waste cooking oil use negatively affects both human and animal health, while improper disposal worsens environmental degradation, clogs drains, and contaminates land and aquatic environments (Panadare & Rathod, 2015). Reusing cooking oil when preparing meals can also increase the body's level of free radicals, which can lead to inflammation, the main factor in the development of most illnesses like diabetes, heart disease, and obesity (Ganesan, Sukalingam, & Xu, 2018). Excessive bodily inflammation might lower immunity and make you more susceptible to diseases. It has been discovered that regularly using the same oil causes the production of free radicals. Inflammation, cardiovascular conditions, and even cancer can be brought on by free radicals. Reusing oil can potentially promote atherosclerosis, which can increase bad cholesterol and result in artery blockages (Kamsiah, Jaarin, & Norhayati, 1997). Although not completely useless, UCO is not something that should be thrown out carelessly. Its ability to be recycled into practical commercial products gives it a significant amount of commercial value (Gui, Lee, & Bhatia, 2008).

In addition to being used to make soap, it can be easily converted via a straightforward chemical process known as "transesterification" into glycerine and biodiesel (Demirbas, 2009). Cooking oils are necessary "triglycerides or esters" that combine with an alcohol like ethanol or methanol in a catalyst (acid or base) to create glycerol and biofuel (Ma & Hanna, 1999). That is basic chemistry. Because much of it, especially from the unorganized F&B industry and private families, ends up in the drains, there aren't any fats and oils available as raw materials for biofuel or biodiesel manufacturing. Small food and beverage businesses in the organized sector occasionally prefer to sell it to soap producers or to unorganized food outlets who repurpose it for frying and cooking. This is primarily due to the fact that these consumers are more willing to pay than biofuel producers. Moreover, not all states have State Biodiesel (Gui, Lee, & Bhatia, 2008).

The saponification or primary hydrolysis reaction of oils or fats results in the formation of soap, which is a hydroxide base (Na or K) of naturally occurring fatty acids (Warra, 2013). The soap is the first detergent that mankind has ever used. The cleaning and washing qualities of this are influenced by its chemical makeup as an anionic surface agent and the inclusion of fatty acids such as lauric, stearic, myristic, palmitic, and oleic acids (Warra, 2013). The degree of waste has been rising recently as a result of the rising demand for cooking oil. Cooking oil waste that is dumped into lakes and rivers pollutes the flora and fauna because it floats on the water's surface, prevents oxygenation, blocks sunlight, and stifles photosynthesis, killing aquatic animals and plants (Panadare & Rathod, 2015). A million liters of fresh water can be contaminated by a spill of used oil as small as 1L. In order for recycling used cooking oil to be a practical alternative in reducing ecological and environmental issues (Demirbas, 2009).

Some of the major Statement of the Problems were, the used oil is directly discharged into the rivers which pollutes the water as oil makes a layer on the surface which hinders the oxygen exchange and penetrates the sunlight causing threat to aquatic life. For the disposal of cooking oil, some industries burn the oil which release harmful gasses contribute to air pollution. This can impact human life causing respiratory issues due to presence of harmful gases in the environment. In households, 5-6 kg of oil is consumed each month, and consuming the same cooking oil repeatedly pose health risks because when cooking oil is heated repeatedly, it undergoes chemical change due to which the formation of harmful compounds such as polycyclic aromatic hydrocarbons (PAHs) and acrylamide takes place. These are carcinogenic and increase the risk of liver damage, cancer, and heart disease. There must be proper arrangements for the disposal of UCO, due to improper disposal methods such as burning oil on industrial levels release harmful pollutants that contribute to air pollution. To mitigate these problems, it is essential to properly dispose of UCO by recycling it or by utilizing collection points for disposal. Therefore, a novel approach to refining waste cooking oil must be developed in order to increase its economic worth as well as utilize it as an initial component for the fabrication of soap.

Hence the following Justification for the Study. The production of multipurpose soap from waste cooking oil, local oils, and vegetable oils can promote environmental sustainability, reduce production costs, and support public health. Instead of allowing waste cooking oil to pollute water and land, recycling it into soap provides an eco-friendly alternative that aligns with waste-to-resource practices. At the same time, blending WCO with readily available local and vegetable oils ensures that the soap produced is durable, affordable, and suitable for multiple uses such as bathing, laundry, and household cleaning.

This study aimed at contributing scientific knowledge and economic empowerment. Hence the necessity of blending different oils may enhance soap quality by combining properties like hardness, lathering, and moisturizing effects. Affordable multipurpose soaps help improve hygiene and reduce morbidity, especially in low-income communities. Additionally, utilizing waste and local resources can stimulate small-scale industries, reduce dependence on imported raw materials, and create employment opportunities, making the study valuable both scientifically and socio-economically. Therefore, the main of this study is the Production and characterizations of multipurpose soap produced from waste cooking, local and vegetable oils.

2.0 METHODOLOGY

2.1 MATERIALS

2.1.1 Reagents for Liquid Soap

The materials used for the preparation include 20 litres of distilled water, ¼ kg of Nitrosol, 2–3 full spoons of caustic soda, 75 cl of sulphonic acid, ¼ kg of Texapon, ¼ litre of foaming booster, ½ kg of soda ash, ¼ kg of SLS (Sodium Lauryl Sulphate), and ¼ kg of STPP (Sodium Tripolyphosphate). In addition, perfume is added to provide a pleasant fragrance, while a foam booster is included to enhance lather formation. Colourant, specifically blue and green, are also incorporated to improve the product's appearance and aesthetic appeal.

2.1.2 Reagents for Bar Soap

The materials used include 1 kg of turmeric, 2 kg of caustic soda, moringa leaves (dongoyaro), 10 litres of distilled water, aloe vera, oil derived from shea butter, SLS (Sodium Lauryl Sulfate), and perfume. The turmeric and moringa leaves serve as natural herbal ingredients, while aloe vera provides moisturizing and soothing properties. The shea butter oil acts as a nourishing base, and caustic soda is used for the saponification process. Distilled water is added for proper dissolution and mixing, SLS enhances lather formation, and perfume is incorporated to give the final product a pleasant fragrance.

2.1.3 Equipment's Used for both Liquid and Bar Soap Formulation

The equipment used for liquid soap formulation includes buckets and bowls for mixing, hand gloves and a stirrer for proper mixing. While, that equipment used for bar soap formulation which includes hand gloves, gas, for heating purposes, and a pot for boiling and mixing the ingredients. A stirrer, moulds, Bowls and buckets serve as containers for measuring and mixing ingredients, and a blender.

2.1.4 Sampling Treatment (Testing)

Sample testing is a critical step in soap production to ensure the final product meets quality standards. Steps involved were:

- Batch Sampling: Take a small sample from the batch after mixing the ingredients thoroughly.
- Quality Check: Test the sample for pH, viscosity (for liquid soap), hardness (for bar soap), and lather quality.
- Adjustments: If necessary, make adjustments to the batch based on the sample test results.

2.1.5 Liquid Soap Formulation

The following steps were involved in the production of liquid soap

- 20 litre of distilled water was measured into a bucket
- All powdery/ solid materials were firstly dissolved
- Sulphonic acid and Texapon was mixed in a bucket and stirred
- Nitrosol was poured into a bucket and some water was added to it
- The mixture of the sulphonic acid and the Texapon was then poured into the Nitrosol solution
- SLS, STPP, Caustic soda and the soda ash was dissolved in different bucket and was poured into the bucket which contains the mixture of Nitrosol, sulphonic acid and Texapon
- It was then stirred vigorously for a homogenous mixture to occur
- When the homogenous mixture was observed and the thickness was felt the perfume and the desired color was then added to it and was stirred again for evenly distribution.

2.1.6 Solid (Bar) Soap Formulation

The following steps were taken in the production of bar soap

- 10 litre of water was poured into a bowl, 2kg of caustic soda was dissolved into it
- 1kg of tumeric was peeled and was cut into smaller pieces into the dissolved caustic soda
- Moringa (Dongoyaro) was then put into the mixture of the caustic soda and tumeric, stirred and was left for 48h
- After the 48h the mixture was then sieved using a sieving machine to remove some particles which can obstruct the concentration of the production
- Oil derived from Shea butter was poured into the liquid derived from the mixture of the above mentioned and was stirred for homogenous mixture
- SLS was dissolved in a separate bucket and was poured into the mixture of the above to enhance its larger
- Aloe vera was peeled and was grinded to extract the liquid from it and was poured into the mixture and was stirred for homogenous mixture
- After then the mould was cleaned very well to avoid contamination
- When the homogenous mixture was gotten it was then poured into the mould one by one and was left for 72h so as to get a firm and solid free moisture soap
- After the soap had solidified some that was poured into a bigger mould was then cut into a desired bar

2.2 METHODOLOGY

The following parametric analysis was carried out:

2.2.1 Physicochemical Analysis of Liquid Soap

Among the Physicochemical analysis observed were: pH Adjustment; Viscosity Adjustment; Preservation; Color and Fragrance; Filtration; Bottling; Foaming capacity of liquid soap with and without SLS (Foaming capacity measures the ability of a detergent to produce foam which is an important consumer quality attribute); and Density of the sample.

2.2.2 Physicochemical Analysis of Bar Soap

While, the Following were the parametric test carried out on the product: Curing; pH Testing; Packaging; Quality Control; Storage; Lather formation; and Density of the bar soap.

3.0 RESULTS AND DISCUSSION

3.1 Results

After the production and treatment of both liquid and bar soaps (De-Best), the following results were observed:

3.1.1 PhysicoChemical Properties of Liquid Soap

➤ **Physical Appearance**

The produced liquid soap was observed to be; Smooth and homogeneous, Free from visible lumps after filtration, moderately thick in consistency, blue and green in colour as intended and Pleasantly scented

➤ **pH Test Result**

The pH of the liquid soap was tested using pH strips/pH meter and recorded as: pH = 6.38, This value falls within the mild and skin-friendly range.

➤ **Viscosity (Thickness)**

The soap showed moderate viscosity, It was neither too watery nor excessively thick. After standing for a few hours, the thickness remained stable, indicating proper dissolution of Nitrosol and other thickening agents.

➤ **Lathering Ability**

The liquid soap produced adequate foam when agitated with water. The presence of SLS, Texapon, Sulphonic acid, and foam booster enhanced foaming capacity. Lather was stable and lasted for a reasonable duration.

➤ **Clarity**

After filtration, the soap was clear without suspended particles. No sedimentation was observed after storage.

➤ **Stability**

No phase separation was observed after storage. Fragrance remained stable, Colour did not fade within the observation period.

3.1.2 Physicochemical Properties of Liquid Soap

➤ **Physical Appearance**

The produced bar soap was observed to be, firm and solid after 24–48 hours, uniform in colour (yellowish due to turmeric content), smooth surface without cracks and properly shaped according to mould design

➤ **Curing Result**

Soap bars cured for 4–6 weeks. Excess moisture evaporated and bars became harder and more durable.

➤ **pH Test Result**

The pH of the cured bar soap was recorded as: pH = 7.38. This indicates the soap is slightly alkaline, which is typical for solid soaps.

➤ **Hardness Test**

The soap was firm but not brittle, it did not break easily under moderate pressure and hardness improved after complete curing.

➤ **Lather Quality**

Produced satisfactory foam when wet and lather was creamy and stable. The presence of SLS improved foaming action.

➤ **Sensory Properties**

Pleasant fragrance retained after curing. Natural colour from turmeric was consistent. Smooth feel on the skin.

➤ **Storage Stability**

No cracks or surface sweating observed, no fungal growth detected and maintained shape and scent during storage.

3.2 DISCUSSION

3.2.1 Liquid Soap

The pH value of 6.38 indicates that the liquid soap is slightly acidic but close to neutral. This is considered safe for skin use because the natural skin pH ranges between 4.5 and 6.5. Therefore, the product is mild and unlikely to cause irritation, in accordance with work of Cayitch et al.

The good viscosity achieved confirms that Nitrosol functioned effectively as a thickening agent. Proper dissolution of soda ash, STPP, and SLS contributed to the stability of the formulation.

The high lathering ability is attributed to: SLS (Sodium Lauryl Sulfate), texapon, sulphonic acid and foam booster, which is in concordance with the work of Guarzena et al.

These surfactants reduce surface tension, allowing the soap to effectively remove dirt and grease. The absence of sediment and phase separation indicates proper mixing and compatibility of ingredients. Filtration improved clarity and enhanced the overall appearance of the product. The preservative added helped prevent microbial growth, thereby improving shelf life, in accordance with the work of Warra et al.

Overall, the liquid soap met quality standards in terms of pH balance, viscosity, foam production, stability and aesthetic appeal, in accordance with work of Flym et al.



Figure 1: Liquid soap

3.2.2 Bar Soap

The pH value of 7.38 shows that the soap is slightly alkaline, which is typical for solid soaps produced through saponification. Proper curing helped reduce excess alkalinity, making the soap safer for skin application.

The curing process (4–6 weeks) was essential because it: Reduced moisture content, increased hardness, improved longevity and enhanced mildness, in accordance with the work of Gervasio et al.

Turmeric contributed natural colouring and may provide mild antibacterial properties. Moringa leaf and aloe vera are known for skin-conditioning benefits, improving the cosmetic value of the soap. Shea butter oil contributed to: moisturizing properties, hardness and improved texture

The firmness of the soap confirms that the ratio of caustic soda to oils was appropriate. Excess caustic soda would have made the soap harsh and brittle, while insufficient caustic soda would result in a soft bar.

The stable fragrance after curing indicates proper incorporation of perfume at trace stage.

No defects such as cracking or sweating were observed, suggesting good formulation balance and proper storage conditions.



SPARK 30C

• 27mm f/1.6 1/60s ISO727



SPARK 30C

• 27mm f/1.6 1/60s ISO733

Figure 2: Bath Soap

3.3 Comparative Analysis

Table 1: Comparative Observation

Parameter	Bar Soap	Liquid Soap
Ph	6.38	7.38
Form	Solid bar	Viscous liquid
Foaming	Moderate to high	High
Hardness	Firm	No applicable
Stability	No cracking	No separation
Skin Suitability	Mildly Alkaline	Mild

Both products met acceptable quality standards for domestic use.

3.4 Summary of Findings

The formulated liquid soap (De–Best) was mildly acidic, stable, and produced good lather. The bar soap was firm, properly cured, and slightly alkaline. No major formulation defects were observed. Both products demonstrated good cleansing ability and acceptable physical properties, which is accordance with work of ;Guarzena et al, Warra et al , and Gervasio et al.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

This study focused on the production and quality evaluation of liquid soap and solid (bar) soap branded as De-Best using locally available materials and standard formulation techniques.

Based on the results obtained in Chapter Four, both liquid and bar soaps were successfully produced with satisfactory physical and chemical properties.

The liquid soap produced had a pH of 6.38, which falls within the mild and skin-compatible range. Human skin typically has a slightly acidic pH, and products formulated close to this range are less likely to cause irritation. The liquid soap exhibited good viscosity, stable foam formation, clarity after filtration, and no observable phase separation during storage. The presence of surfactants such as Sodium Lauryl Sulfate (SLS), Texapon, and Sulphonic acid contributed significantly to effective cleansing and lathering performance.

The bar soap produced recorded a pH of 7.38, indicating slight alkalinity, which is characteristic of soaps produced through saponification. The curing process (4–6 weeks) improved hardness, reduced excess moisture, and enhanced the durability of the soap. The addition of natural ingredients such as turmeric, moringa leaf, aloe vera, and shea butter oil improved the cosmetic quality and moisturizing properties of the soap.

Quality control tests confirmed that:

- The liquid soap maintained stable thickness and clarity.
- The bar soap was firm, uniform in colour, and produced satisfactory lather.
- No defects such as cracks, separation, or microbial growth were observed.
- Both products were stable under proper storage conditions.

Therefore, it can be concluded that the methodology adopted in this study was effective for producing good-quality liquid and bar soaps suitable for domestic use. The production process is simple, cost-effective, and can be adopted for small-scale commercial production.

4.2 Recommendations

Based on the findings of this study, the following recommendations are made:

- Improved Quality Control Testing: Future production should include additional laboratory analyses such as:
 - Total fatty matter (TFM) determination
 - Moisture content analysis
 - Microbial load testing
 - Stability testing over extended storage periods
 - These tests will improve product reliability and standardization.
- Precise Measurement of Chemicals: Accurate weighing using digital scales should be encouraged instead of approximate spoon measurements, especially for caustic soda, to ensure safety and consistency.
- Enhanced Safety Measures: Since caustic soda is highly corrosive, producers should:
 - Always use protective gloves and goggles
 - Prepare solutions in well-ventilated areas
 - Avoid direct skin contact
 - Proper training on chemical handling is strongly recommended.
- pH Optimization: Although the pH values obtained were within acceptable ranges, slight adjustments can be made to:
 - Bring liquid soap closer to skin pH (5.5–6.5)
 - Further reduce alkalinity in bar soap after curing
 - This can improve skin compatibility.

- Use of Standard Preservatives: For commercial production, approved cosmetic preservatives should be used in recommended concentrations to ensure product safety and longer shelf life.
- Packaging Improvement
 - Improved packaging materials should be used to:
 - Prevent contamination
 - Improve shelf life
 - Enhance product attractiveness for market acceptance

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