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Production and Analysis of Laundry Soaps from Blended Oils

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Blended oil,
Caustic soda,
Saponification,
Soap,
Total fatty matter.

ABSTRACT
Stearic acids or any other fatty acids' sodium or potassium salts are what soaps are. The saponification method, which involves reacting triglyceride-containing oil with caustic soda (NaOH) to produce soap, is how they are made. However, the fatty acid makeup of various oils varies, which accounts for the various qualities of the soaps that are created from them. The aim of this study is to produce and analyze laundry soaps made from blended oils. Four different kinds of oils were used in this study. Four distinct soap samples were created by blending them in varying proportions. To determine which soap was the best, all soap samples were compared for their cleansing and lathering qualities, and the blend of palm kernel oil, palm stearin, beef tallow, and cotton seed oil at 3:1:3:3 ratio was determined to be the best with 76.4% total fatty matter (TFM) and 98.30% yield. The blends were examined for a variety of properties and compared with those found in the literature. The saponification and iodine values of the individual oils were also examined, and the results showed that soap made with the four oils in the 3:1:3:3:3 ratio had superior qualities to soaps made with other blends, was most cost-effective and ideal for laundry. Various characteristics of these samples were examined.

CITATION
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INTRODUCTION

Laundry soap has specific characteristics in terms of its composition, properties and uses, and it's formulated to serve a specific purpose. However, soap is a cleaning or emulsifying agent that is produced by reacting vegetable or animal fats or oils with potassium or sodium hydroxide. Triglycerides are hydrolyzed using a base (often NaOH or KOH) in the "saponification" process, which yields soap and glycerol. A soap molecule is defined by a long chain of hydrocarbons with a carboxylic acid group at one end that forms an ionic interaction with a metal ion, usually sodium or potassium (Onyegbado et al., 2002, Bhujbal et al., 2023). While the hydrocarbon end is non-polar and highly soluble in non-polar substances, the ionic end is soluble in water (Mak -Mensah et al., 2011; Yadav et *al.,* 2021). Below is a representation of the soap molecule's structure:

$$CH_3\text{-}CH_2\text{-}CH_2\text{-}\ CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}\ CH_2\text{-}CH_2\text{-}\ CH_2\text{-}CH_2\text{-}\ CH_2\text{-}CH_2\text{-}\ CH_2\text{-}CH_2\text{-}\ \overset{\overset{\Large O}{||}}{C}\text{-}O^-\ Na^+$$

Non-polar hydrocarbon chain (soluble in nonpolar substances) — ionic end (soluble in water)

The cleaning action of soaps are because of their ability to emulsify or disperse water-insoluble materials and hold them in the suspension of water. This ability is seen from the molecular structure of soaps. When soap is added to water that contains oil or other water-insoluble materials, the soap or detergent molecules surround the oil droplets. The oil is, dissolved in the alkyl groups of the soap molecules while the ionic end allows it to be dissolved in water. As a result, the oil droplets are to be dispersed throughout the water and can be washed away (Fang et al., 2015). All animal fats and vegetable oils intended for soap-making should be as free as possible from unsaponifiable matter, of a good color and appearance, and in a sweet, fresh condition. Tiwari & Patel, 2020). Fats and oils used to make soap must come from animal or vegetable sources. Oil derived from another sources such as mineral oil, cannot be used. Soap can be made by using only one kind of fat or oil, by blending animal and vegetable oil or blending more than one vegetable oil. Animal fats are hard fats. Soap that uses only animal fat is hard, tends to be grainy, and lathers poorly. Conversely, Soap made only from vegetable oils lathers well but does not harden properly. A mixture of the two or more types of fats or oils brings out the best qualities (Naji et al., 2021). Other oils that can be used are olive, cottonseed, maize, soybean, groundnut, safflower, sesame, linseed, etc. Coconut and palm oils are very good for soap making. The animal or hard fats are generally used to make soap are tallow and lard. Tallow is the fat from beef or lamb. Lard is the fat from hogs. Butterfat is acceptable. However, chicken fat is not a hard fat, and is regarded as oil.

A number of things affect the soap-making process and the quality of this soap produced (AOAC, 2000). The characteristics of this soap depend on the quality of oil, and the amounts of the caustic soda and water used to make it. The speed of the reaction between the oil and the caustic soda is influenced by free fatty acid content of the oil, the heat of the components before mixing, and how vigorously the mixing is to be done.

A good soap does not contain chemicals that cannot be broken down by its natural ingredients, it is biodegradable. Neither does it contain chemicals that can be harmful to the environment or cause undue destruction to the environment.

A good soap gets dissolved easily and remove stains from the clothes, human skin or any material being cleaned. It gets dissolved in water and generates enough suds. It delivers a clear and dazzling form of cleanliness. It gives a pleasant smell. A good soap does not leave sticky traces on the clothes or on the skin. It has a good color that is even and does not streak. It disinfects and kills germs. It does not damage the fibers or textiles.

Studies have demonstrated that a higher saponification number results in higher-quality soap. Additionally, since blended oils have a higher saponification value than any single oil, increasing the number of oils used in the soap-making process will also result in higher-quality soap (Aremu et al., 2015). Thus, this study looks at the physicochemical characteristics of the soap that is made utilizing four blended oils (palm kernel oil, palm stearin, beef tallow, and cotton seed oil), lye of NaOH, and other ingredients.

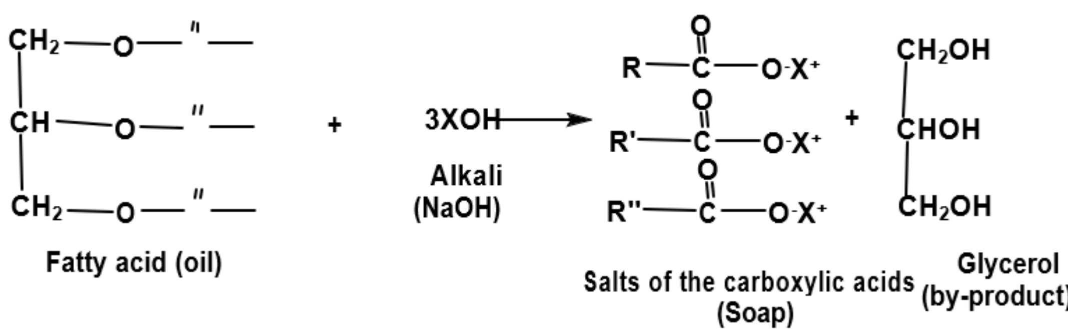

Figure 1: Saponification reaction of a triglyceride and alkaline to produce soap

MATERIALS AND METHODS

Sample Collection and Materials Used

The raw materials used in the soap formulation (lye/alkali and palm kernel, palm stearin, beef tallow and cotton seed oils) were bought from authorized and authentic commercial dealers at Sabon Garri market, Kano and transported to the laboratory for use.

Equipment

i. Bowls, buckets, pots, (Aluminum material should never be used as caustic destroys aluminum),
ii. Measuring cups of glass or enamel,
iii. Spoons, paddles, or smooth sticks for stirring. (These should be made from wood or enamel),
iv. Containers for molding soap, these can be wooden, cardboard, or waxed cartons.
v. Cotton cloth, waxed paper, or other material for lining molds. Cut the cloth or paper into two strips, one a little wider than the mold and the other a little longer than the mold. This lining will ease the removal of the soap from the molds,
vi. Hot plate,

vii. Thermometer with the range of 0 to 100°C.

Name of all the Reagents used

Caustic soda, Potassium Iodide, Sodium chloride, Methanol, Sodium sulphate, Ethanol, Sodium carbonate, Starch, Sodium silicate, Chloroform, Nitric acid, Phenolphthalein, Sulphuric acid, Diethyl Ether, Calcium carbonate, Sodium Thiosulphate, Barium chloride, Potassium Hydroxide, Iodine mono-chloride The chemicals used were analytical grade reagents. Distilled and deionized water were used throughout the research

Preparation of the Soap

One liter Pyrex beaker was filled with 300 cm^3 of the blended oil, which was heated on a hot plate to speed up the reaction between the fat and the alkali. It was then filled with a fixed amount of distilled water and a calculated amount of NaOH to create a 0.2 N NaOH solution. A stirring rod was used to mix the caustic soda thoroughly until it blended with the fat, and it was poured very slowly while being gently stirred in one direction to ensure that the solution was thoroughly homogeneous. The plastic container was covered with cloths to prevent the fat from solidifying before the soap was thoroughly mixed.

In order to clarify the mixture while it was still molten, calculated amount of sodium sulphate was added during the soap-making process. It promotes the soap's ability to froth and aids in the chemical binding of the soap. It functions as both an extender and a binder. Once the soap has cooled, sodium silicate was added. The soap is hardened with sodium silicate. It facilitates dirt removal and stops dirt particles from depositing. The "ribbon test" was used to determine whether or not the saponification process had completed. A tiny amount of the soap was removed from the beaker and allowed to cool for this test. A small amount of the cooled soap should form a solid substance when pressed between the thumb and forefinger.

If the cooled sample draws out in threads, there is excess water present in the soap, and further boiling is required to evaporate more water. If the opaque ends appear and vanish, the soap is oily and requires more caustic, while if the soap is grainy, or turbid and somewhat white, it indicates a high level of unreacted caustic, and requires more oil. A physical test - the taste test – was also done to determine the level of caustic alkali. After this the soap was molded into a proper shape and kept in a filter paper. This soap was taken in air oven to dry up the moisture. Before taken into the oven the weight of soap was taken. The soap was left in the oven for three hours.

Calculation of Yield

For all the soap samples prepared using different blends of oils, weight of the soap was taken after they were taken out of the air dry oven. Yield is calculated by dividing the weight of the soap by the weight of the oil taken and multiplied by 100. It is calculated for all the samples.

Comparison of Properties of Soaps

Alkalinity

1% of soap solution was prepared by dissolving about 0.5 g of the soap in 50 mL of distilled water. It will help to heat the water to get the soap to dissolve completely. Using a pH meter the alkalinity of the soap solution was determined. The electrode of the pH meter was dipped inside the soap solution. The pH value of the solution was recorded. This is carried out for all the cases (Uduma et al., 2023).

Lathering Power

2mL of distilled water was added to two large test tubes. An equal amount of soap solution was added to one test tube of water and shaken vigorously by placing a stopper in the tube. This should give a permanent lather that lasts for at least 30sec. If the lather doesn't last, add another 10 drops of soap solution and shake vigorously. 2 mL of 5% calcium chloride solution to each of the two remaining test tubes of water was added. An equal amount of soap solution to one of the tubes containing calcium ion was added and shaken vigorously. It was observed whether this solution formed a permanent lather and it was noted whether there was any flocculent precipitate in the tube.

Cleansing Power

A drop of used engine oil, was placed on two separate thin strips of filter paper. It was made sure that the strips of filter paper will fit in the test tubes used in the previous step. One filter paper with oil spot in the tube containing soap in water. Another strip is placed in the tube containing soap in calcium solution. Each one is shaken well and made sure that the filter paper is immersed in the solution. After 2 min the filter paper was removed and rinsed with tap water. The oil got washed out of the filter paper strip. The solutions were thrown in the sink. The paper strips were thrown in the trash can. The cleaning power of soap was compared. This reaction was carried out for all the samples prepared (Uduma et al., 2023).

Moisture Content

A sample of the 5.0g scrapped soap was put into a petri dish and placed in an oven for 3 hour at 110°C. It was allowed to cool down and then weighed. The moisture content in percentage was calculated.

Hardness

The hand felt hardness was determined relative to each other for all the soap samples. Penetrometer was also used to determine the extent of penetration. The properties of the soap were tabulated and compared with each other. The primary objective of this work is to blend different varieties of oils in different ratios and prepare soap samples and compare their properties.

RESULTS AND DISCUSSION

Comparison between Soap Samples

Table 1: Yield of Laundry Soap from Different Blended Oils

Oil blends	Ratios	Weight of soap before drying (g)	Weight of soap after drying (g)	Yield (%)
PKO+PS+BT	7:2:1	298	290	96.7
PKO+PS+BT+CSO	3:1:2:4	304	296	98.7
PKO+PS+BT+CSO	4:1:3:2	302	290	96.7
PKO+PS+BT+CSO	3:1:3:3	303	292	97.3

Note: PKO=Palm kernel oil, PS=Palm stearin, BT=Beef tallow and CSO=cottonseed oil.

The yield of soap depends on the quality of oil used in making the soap. This also depends on the particular carboxylic acid and base that make up the soap. The higher the yield, the more economical the process of soap formulation.

Table 2: pH, Lathering Power, Cleansing Power of laundry Soap from Oil Blends

Oil blends	Ratios	pH of the soap solution	Lathering power	Cleansing power
PKO+PS+BT	7:2:1	9.5	High	Good
PKO+PS+BT+CSO	3:1:2:4	8.7	Good	High
PKO+PS+BT+CSO	4:1:3:2	9.2	High	Good
PKO+PS+BT+CSO	3:1:3:3	9.3	High	High

The fatty acid composition of the oil used in soap manufacturing can be utilized to explain the lather and cleansing capability of various soaps. Lauric acid, myristic acid, and other saturated fatty acids have been found to generate soap with a high cleansing power and a fluffy lather. However, the method used in the soap preparation process as well as the type of fatty acid composition of the fat or oil may be the cause of the observed differences in the cleansing power and type of lather formed in the soap formulation. Here, it is discovered that a 3:1:3:3 blend of palm kernel oil, palm stearin, beef tallow, and cotton seed oil has a high lathering and cleaning power.

Table 3: Moisture and Hardness of Soap Samples from blended Oils

Oil blends	Ratios	Moisture content (%)	Hardness
PKO+PS+BT	7:2:1	7.1	Very hard
PKO+PS+BT+CSO	3:1:2:4	9.7	Soft
PKO+PS+BT+CSO	4:1:3:2	8.0	Hard
PKO+PS+BT+CSO	3:1:3:3	7.9	Hard

The hardness and moisture content of each blend are displayed in this table. The benefit of blending is that it brings in the qualities of both oils, making the soap produced from the blend of both oils very hard. The soap made from other oil blends with a high percentage of cotton seed oil was very soft, but the blend that did not contain cotton seed oil was very hard, but was not cost effective. The moisture affects the lathering and cleaning properties of the soaps, but this moisture was reduced with passage of time.

Table 4: Total Fatty Matter of the Blended Oils for Laundry Soap

Oil blends	Ratios	Mass of soap taken (g)	Mass of fatty matter (g)	Total Fatty Matter (%TFM)
PKO+PS+BT	7:2:1	5.0	3.00	60.0
PKO+PS+BT+CSO	3:1:2:4	5.0	2.20	44.0
PKO+PS+BT+CSO	4:1:3:2	5.0	2.42	46.6
PKO+PS+BT+CSO	3:1:3:3	5.0	2.33	48.4

Total fatty matter, or TFM, is used to grade soaps. Total fatty matter, or TFM, is a metric used to determine how much fatty matter is in soaps. When it comes to laundry soap, the TFM's approved percentage figure ranges from 45 to 50 percent. TFM and cost-effectiveness are the primary criteria used to choose the optimal blend. The TFM for laundry soaps is 48.4% for an oil mix consisting of palm kernel oil, palm stearin, beef tallow, and cotton seed oils (3:1:3:3). The combination, which is within the TFM range needed for laundry soap, is also reasonably priced. TFM is what gives soap its soapy sensation, and along with it, the soap's insoluble matter, is what sets soap apart from the others. Other soap blends with a 4:1:3:2 ratio and a TFM content of 46.6% are also suitable for laundry soaps. The worst ratio, which is lower than the typical TFM for laundry soap, is 3:1:2:4 with 44% for laundry.

Analysis of the Best Oil Blend

The combination of palm kernel oil, palm stearin, beef tallow, and cotton seed oil in the 3:1:3:3 ratio is the best, according to an examination of all the oils and soaps made from the blends. Therefore, we investigated the qualities of these oils that influence their soap-making capabilities and determine if they are acceptable.

Table 5: Saponification Value of the Oils

Oils	Saponification value
Palm kernel oil (PKO)	245
Palm stearin oil (PS)	209
Beef tallow (BT)	197
Cotton seed oil (CSO)	195

It provides details about the makeup of the fat's fatty acids; the longer the carbon chain, the less acid is released per gram of hydrolyzed fat. The average molecular weight (or chain length) of all the fatty acids present was also taken into consideration. Because they have a high molecular weight and comparatively fewer carboxylic functional groups per unit mass of the fat, the long chain fatty acids present in fats have a low saponification value. When manufacturing soap, oils with high saponification values—like palm kernel oil (245.0) and palm stearin (209.0)—work well. Because palm kernel oil has a high saponification value, soap producers utilize it to combine their oils. When combined with other oils that have low saponification values, the blend's saponification number is higher than the lower value.

Table 6: Iodine Values

Oils	Iodine values
Palm kernel oil (PKO)	14.6
Palm stearin oil (PS)	29.5
Beef tallow (BT)	32.5
Cotton seed oil (CSO)	102

High iodine value justifies utilization of the oil in soap and shampoo productions. Palm kernel oil, palm stearin and beef tallow are examples of nondrying oils whose iodine numbers are less than 100, they have the advantage of not undergoing oxidation to form a film, hence are useful in the manufacture of soaps. The palm kernel oil has a very low iodine value because of the saturated fatty acids present. The blend has a moderately high iodine value which makes it suitable for soap making but does not make a soft soap because of the presence of palm kernel oil. The higher the iodine value for an oil, the greater the percentage of these acids, and thus the softer the soap produced from the oil. The soft oils have high iodine numbers and are readily oxidized. The iodine number thus indicates the hardness of the soap, the lower the number, the harder the soap produced. The variation in colors is due to the degree of unsaturation of the fatty acids. Increase in double bonds causes increase in intensity of color (Adetuyi, 2016)

Table 7: Acid Value of the Oil

Oils	Acid values
Palm kernel oil (PKO)	203
Palm stearin oil (PS)	189
Beef tallow (BT)	194
Cotton seed oil (CSO)	208

Acid value indicates the proportion of free fatty acid present in an oil or fat and may be defined as the number of milligrams of caustic potash required to neutralize the acid in 1 g of the sample. A high acid value indicates a stale oil or fat stored under improper conditi ons.Acid value of the individual oils conformed to the minimum purity to get yield of better quality soaps.

Table 8: Free Alkaline

Oil blends	Ratios	Free Alkali (%)
PKO+PS+BT	7:2:1	0.07
PKO+PS+BT+CSO	3:1:2:4	0.06
PKO+PS+BT+CSO	4:1:3:2	0.06
PKO+PS+BT+CSO	3:1:3:3	0.04

Free Alkali (FA) content in all the soap samples were analyzed and the highest value obtained was 0.08%. The set standard for Free Alkali (FA) in soaps by SON is a maximum of 0.1%.

CONCLUSION

Various combinations of cottonseed, beef tallow, palm kernel, and palm stearin oils were used to produce laundry soaps. Numerous physicochemical characteristics of the soaps were examined, and comparisons were conducted. A single soap-making oil lacks some of the qualities needed to make high-quality soap. As a result, combining oils and fats improve the soap's quality and affordability. To choose the best blend among all the blends, all the essential characteristics were examined, including pH, hardness, total fatty matter, moisture content, yield, lathering power, and cleaning power. The optimal combination of beef tallow, cottonseed oil, palm kernel oil, and palm stearin was determined to be 3:1:3:3. Its TFM value, which falls within the laundry soap range, was determined to be 76.4%. With a 98.3% output, it had the highest yield of any soap. The laundry soap was quite effective in cleaning and lathering. As palm kernel, palm stearin and beef tallow oils are oils that produce very hard soap, their blend with cottonseed oil gives a very hard soap too. The corresponding oils' iodine and saponification values were assessed. Thus, soap prepared using the four oils in the ratio of 3:1:3:3 for palm kernel oil, palm stearin, beef tallow and cotton seed oils has better properties than the soaps prepared by other blends. The 3:1:3:3 oil blend mentioned above is a very good blend and is therefore strongly recommended for soap manufacturers. This combination should be strongly favored for soapmaking due to its high iodine and saponification numbers. Since the formed soap is extremely hard, a high iodine number has no effect on the soap that is made. Alternative oil/fat blends and NaOH/KOH combinations should be used in related research.

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