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PRODUCTION AND PHYSICOCHEMICAL ANALYSIS OF TOILET SOAP FROM BLENDED OILS

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ABSTRACT
The process of making soap from fatty acids derived from fats and oils is a proven technology. However, the fatty acid makeup of various oils varies, which accounts for the various qualities of the soaps that are created from them. Four different kinds of oils were used in this study. Four distinct toilet soap samples were created by blending them in different proportions. The various characteristics of these samples were examined in order to determine the most cost-effective and suitable soap quality for toilet soap. Every sample's lathering and cleaning qualities were compared. With 48.40% TFM, 97.40% yield and 8-10 pH, the optimal toilet soap formulation was determined to be a 3:1:3:3 blend of palm kernel oil, palm stearin, beef tallow, and cotton seed oil. All of the blends were examined for a variety of characteristics using accepted techniques, and the results were contrasted with those reported in the literature. The corresponding oils' iodine and saponification levels were assessed. As a result, soap made with the four blended oils—palm kernel oil, palm stearin, cow tallow fat, and cotton seed oils—in a 3:1:3:3 ratio offers superior qualities than soap made with other blends. Toilet soap has distinct characteristics in terms of its composition, properties and uses, and it's formulted to serve a specific purpose.

Keywords: Caustic soda, Fat, Saponification, Soap, Total fatty matter

INTRODUCTION

Toilet soap has distinct characteristics in terms of its composition, properties and uses, and it's formulated to serve a specific purpose. Generally, soap is a cleaning and / 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 three salts (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). While the hydrocarbon end is non-polar and highly soluble in non-polar substances, the ionic end is soluble in water (Adaku and Melody, 2013; Zauro et al., 2016). The structure of the soap molecule is shown below:

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

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

The ability of soaps to emulsify, or disperse, water-insoluble compounds and retain them in a water suspension is what gives them their cleaning properties. The molecular structure of soaps demonstrates this capability. The soap or detergent molecules encircle the oil droplets when soap is applied to water that includes oil or other substances that are insoluble in water. While the ionic end enables the oil to dissolve in water, the oil dissolves in the alkyl groups of the soap molecules. Therefore, the oil droplets can be rinsed away after being distributed throughout the water (Warra, 2013)

According to Simmons and Appleton (2007), all animal fats and vegetable oils used to make soap should be as devoid of unsaponifiable matter as possible, have a pleasing color and look, and be in a sweet, fresh state .Animal or vegetable sources must provide the fats and oils needed to create soap. It is not possible to use oil that comes from other sources, including mineral oil. A single type of fat or oil, animal and vegetable oil, or multiple vegetable oils can be combined to make soap. Hard fats are those found in animals. Animal-fat-only made soap is hard, often gritty, and has low lather. On the other hand, soap derived solely from vegetable oils does not properly harden, although it does lather nicely. A combination of the two or more types of fats or oils brings out the best qualities of both (Aiwizea and Achebo, 2012). Other oils that can be used are olive, cottonseed, maize, soybean, groundnut, safflower, sesame, linseed, etc.

Palm and coconut oils work well for soap production. Tallow and lard are the two animal or hard fats that are typically used to manufacture soap. The fat from lamb or cow is called tallow. The fat from hogs is called lard. It's okay to use butterfat. However, according to Francioni and Callings (2002), chicken fat is considered oil and is not a hard fat. The method of manufacturing soap and the final product's quality are influenced by several factors (AOAC, 2000). The qualities of the oil used to produce this soap, as well as the proportions of water and caustic soda, determine its properties. The amount of free fatty acids in the oil, the heat of the interaction between the oil and the caustic soda, and the speed of the reaction 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. (Aiwizea and Achebob, 2012).

Heat, rapid mixing, and free fatty acid concentrations expedite the specified soap-making process. When a decent soap doesn't contain chemicals that can't be broken down by its natural ingredients, it's biodegradable. Additionally, it doesn't

include any chemicals that could hurt the ecosystem or create excessive environmental destruction. A good soap dissolves readily in water, creates enough suds, and removes stains from clothing, human skin, or any other item being cleaned.
It gives a clear and sparkling kind 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 (Zauro et al., 2016). 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.

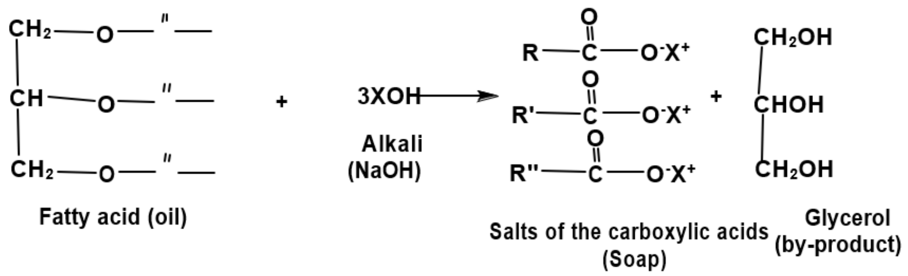

Figure 1: Saponification reaction of a triglyceride and alkaline to produce soap

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.

Sample Collection and Materials Used in the soap formulation

The equipment used were bowls, buckets, pots, (Aluminum material should never be used as caustic destroys aluminum), other materials used were, measuring cups of glass or enamel, spoons, paddles, or smooth sticks for stirring. (These were made from wood), containers for molding soap, these can be wooden, cardboard, or waxed cartons. Cotton cloth, waxed paper, or other material for lining molds were used. 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, Hot plate, thermometer with the range of 0 to 100°C were also used.
Name of all the Reagents used were 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 Soap

One liter cm^3 Pyrex beaker was filled with 300 cm^3 of the blended oil. To speed up the interaction between the fat and the alkali, it was heated. A calculated amount of NaOH was weighed and a fixed amount of distilled water was added to it to make a 0.2 N NaOH solution. The caustic soda was swirled well using a stirring rod until it combines with the fat. To ensure complete mixing of the solution, the caustic soda was added very gradually while being gently swirled in one direction. To keep the fat from solidifying before the soap was well mixed, the plastic container was covered with bits of fabric. The soap combination was mixed with a small amount of sodium silicate, sodium sulfate, and sodium carbonate.
In order to determine whether or not the saponification process is complete, a "ribbon test" was conducted. In this test, a small sample of the soap was taken from the beaker and cooled. When a small quantity of the cooled soap is pressed between the thumb and forefinger, the soap should come out clear. Sodium sulphate is added during the soap's clarification but in the molten stage. It aids in the binding of the soap chemicals and induces the foaming ability of the soap—it serves as both a binder and an extender.
There is too much water in the soap, if the cooled sample separates into threads, and more boiling is necessary to remove the remaining water. The soap is oily and needs more caustic, if the opaque ends appear and disappear; if the soap is grainy, or turbid and slightly white, it has a lot of unreacted caustic and needs more oil. To ascertain the amount of caustic, a physical examination known as the taste test was also conducted. The soap was then molded into the appropriate shape and stored in filter paper. To remove the moisture, this soap was placed in an air oven. The weight of the soap was taken before it was placed in the oven. The soap is stored for three hours in the oven maintained at 110-115ºC. The weight of the soap is again taken. The above method is followed to prepare soap using different blends of oils.

Calculation of Yield

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

Comparison of Properties of Soaps

Alkalinity

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

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 forms a permanent lather and it was noted whether there is 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 is 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 extent to which the oil get washed out of the filter paper strip was observed. 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.

Moisture Content

A sample of the 5.0g scrapped soap was put into a petri dish and placed in an oven for 3 hours 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 relatively to each other for all the soap samples.
Penetrometer was also used to observe the extent of penetration on all the soap samples.
The properties of the soap were tabulated and compared with each other (Uduma et al., 2023).
But the primary objective of this work is to blend different varieties of oils in different ratios and prepare toilet soap samples and compare their properties.

RESULTS AND DISCUSSION

Comparison between Soap Samples

Table 1: Yield of Toilet Soap Using Different Oil Blends

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.

Table 1, shows that the yield of soap depends on the soap making oil used. 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 making (Uduma et al., 2023).

Table 2: pH, Lathering Power, Cleansing Power of 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 cleansing power and lather produced by different soap can be explained based on the fatty acids composition of oil used in soap formulation. It has been found out that, lauric acid and myristic acid, which are all saturated fatty acids produces soap with fluffy lather and high cleansing power. However, the observed difference in the cleansing power and nature of lather formed in the soap formulation as shown in Table 2, above may be due to the method used in the soap preparation in addition the nature of fatty acid composition of the fat or oil. Here the blend of palm kernel oil, palm stearin, beef tallow and cotton seed oil, in the ratios of 3:1:3:3 is found to have both high cleansing and lathering power.

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

Oil blends	Ratios	Moisture content (%)	Hardness
PKO+PS+BT	7:2:1	9.5	Very hard
PKO+PS+BT+CSO	3:1:2:4	8.7	Soft
PKO+PS+BT+CSO	4:1:3:2	9.2	Hard
PKO+PS+BT+CSO	3:1:3:3	9.3	Very hard

Table 3 shows the hardness and moisture content of all the blends. Blend of cotton seed oil which is a soft oil and the rest of the oils (palm kernel, palm stearin and beef tallow oils) which are hard oils produces a very hard soap. This is the benefit of blending which brings in the characteristics of both oils enhancing the property of the soap produced from the blend of both the oils. The soap produced from other oil blends with high percentage of cotton seed oil is very soft. The blend that does not contain cotton seed oil is very hard too but it is not cost effective. The moisture affects the lathering and cleansing property of the soaps. However this moisture is reduced with passage of time (Uduma et al., 2023).

Table 4: Total Fatty Matter of Best Blends of Oils for Toilet 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	3.85	77.0
PKO+PS+BT+CSO	3:1:2:4	5.0	3.50	70.0
PKO+PS+BT+CSO	4:1:3:2	5.0	3.65	73.0
PKO+PS+BT+CSO	3:1:3:3	5.0	3.82	76.4

Soaps are graded in terms of total fatty matter or TFM, Table 4. TFM or total fatty matter is a measure for identifying the amount of fatty matter present in soaps. The TFM measures the quality of soap and the accepted percentage value for toilet soap is between 76-77% while that of laundry soap is between 45-50%. The best blend is selected mostly on the basis of TFM and cost effectiveness. For oil blend of palm kernel oil, palm stearin, beef tallow and cotton seed oils (3:1:3:3), the TFM is high at 76.4% and 46.6% for toilet and laundry soaps respectively. The blend is also cost effective, which falls in the range of TFM required for toilet and laundry soap respectively. TFM is what lends soap its soapy feel and it is the TFM and the insoluble matter in the soap that largely distinguishes soap from the others. Other soap blends also have appreciable TFM content for the ratio 4:1:3:2 with 73% and 46.6% also can be used for toilet and laundry soaps respectively. The worst is the ratio of 3:1:2:4 with 70% and 44% for laundry which makes it fit for toilet and laundry soaps respectively (Mak-Mensah and Firempong, 2011).

Analysis of the Best Blended Oil

After analysis of all the oils and soaps produced from the blends, it was affirmed that blend of palm kernel oil, palm stearin, beef tallow and cotton seed oil in the ratio of 3:1:3:3 is the best one. Thus we explore into the properties of these oils which affect their soap making characteristics and see whether it is agreeable.

Table 5: Saponification Value of the Oil Blend

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

In Table 5, saponification value gives information concerning the characteristics of the fatty acids, the longer the carbon chain of the fatty acid, the less acid is liberated per gram of fat hydrolyzed. It is also considered as a measure of the average molecular weight (or chain length) of all the fatty acids present. The long chain fatty acids found in fats have low saponification value because they have a relatively fewer number of carboxylic functional groups per unit mass of the fat and therefore high molecular weight. Oils with high saponification values such as palm kernel oil (245.0) and palm stearin (209.0) are better used in soap making. Soap manufacturers blend their oils with palm kernel oil because of its high saponification value. When it is blended with other oils with low saponification values, however, the saponification number of the blend is higher than that of 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

In Table 6, 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 and palm stearin. 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.

Table 7: Acid value of the oils

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

Acid value Table 7, 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 conditions.

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

In Table 8, Free Alkali (FA) content in all the soap samples were analyzed and the highest value obtained was 0.07%. The set standard for Free Alkali (FA) in soaps by SON is a maximum of 0.1%.

CONCLUSION

Various combinations of cottonseed oil, cow tallow fat, palm kernel oil, and palm stearin were used to make toilet 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 improves both the quality and affordability of soap. To choose the best blend among all the blends, all the essential characteristics were examined, including pH, Hardness, Total Fatty Matter, Lathering Power, Cleaning Power, Moisture Content, and Yield.

The optimal combination was determined to be a 3:1:3:3 ratio of cottonseed oil, cow tallow fat, palm kernel oil, and palm stearin. With a TFM rating of 48.4%, it falls within the range of toilet soaps. With a 97.3% output, it had the highest yield of any soap. Both the lathering and cleaning properties of the toilet soap were outstanding. Because beef tallow, palm kernel, and palm stearin oils are known to make extremely hard soap, combining them with cottonseed oil also results in very hard soap.

The saponification values, iodine values of the respective oils were evaluated. 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 soap making 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. Other oil/fat blends and NaOH/KOH combinations should be used in similar investigations.

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