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Formulation of Laundry Soap Using Locally Made Palm Kernel Oil in Nigeria

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Abstract
Soap is one of the most important thing used for human daily life activities in cleansing and skin care purposes. Palm Kernel Oil is an edible oil that has many advantages in soap making, shampoo, and other skin care products. It also has so many medicinal properties like removal of toxins from the body. Palm Kernel Oil locally produced in Anyigba (Nigeria) was used to prepare the soap with lye aqueous solution using both Sodium hydroxide (NaOH) and Potassium Hydroxide (KOH) and other additives using cold process. The pH- value, Solubility and foam height were checked. The pH-values of the soap samples was found to be 9.88 – 10.00 and was within the limit set by standard organization of Nigeria. The prepared soap with the pH-values above does not irritate the skin and has good cleaning and foaming property.

Keywords: Soap, Palm Kernel Oil, Toxins, Lye Solution, pH-, solubility

INTRODUCTION
Soap is a surfactant used together with water for washing, bathing, and cleaning that is available in solid bars and in the form of viscous liquid (Willcox, 2000). In a chemical term, soap is referred to as the salt product of a fatty acid (Stroebinger *et al*., 2021). It is equally used as an agent of textile spinning and is a key component in lubricants. Soap is generally

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obtainable by reacting vegetable/animal oil and fat with alkaline solution like NaOH, KOH or soda ash (sodium bicarbonate), (Willcox, 2000). The aqueous alkaline solution, is usually termed as lye, and give rise to saponification reaction as presented below (Figure 1). In saponification reaction, triglyceride fats are hydrolyzed at the beginning to give free fatty acids, which later react with the aqueous alkali to yield crude soap (Willcox, 2000).

$$(C_{17}H_{35})_3C_3H_5 + 3NaOH \rightarrow 3C_{17}H_{35}COONa + C_3H_5(OH)_3$$

Fat Soap Glycerol

Figure 1: Saponification reaction

The precise origin of soap remains obscure, although the Romans reported that it started about 600B C, when Phoenicians prepared it from goats tallow and wood ash (Jimoh and Jimoh, 2021). Soap was used by Celts, from Britain. Soap was used widely throughout the Roman Empire. Soap was not identified as a cleanser until second century A. D. By the eight century, soap was common in Italy, France, and Spain, but it was rarely used in the rest of Europe until as the 17th century (Jimoh and Jimoh, 2021).
Soap is made up of the following reagents:

Water: The water used is distilled and deionized.

Lye: This is usually alkali of either KOH or NaOH.

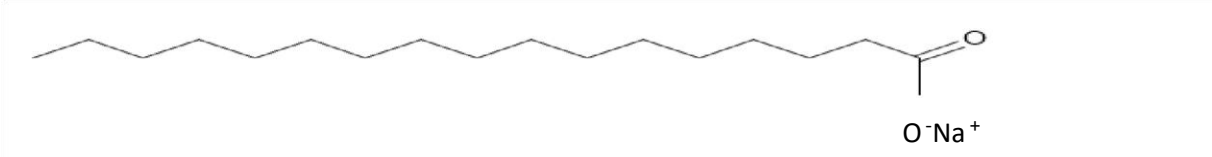
Fat/Oil: This is obtained in solid form from animals, processed in the production of soap and other products, while oil is a liquid substance obtained from vegetables oil such as Palm Kernel Oil.

Colorant: Different type of colors are used to beautify the produced soap. The color can either be from an organic or inorganic origin such as Carmosine red, sunset yellow, Allura red etc.

Perfumes: This is used to give a nice scent to the soap.
Soap is classified based on the nature of oil employed in its production. Based on this, soap can be classified into drying (manufactured using drying oils like cotton seed oil, coconut oil, Palm Kernel Oil etc.) and non-drying soap manufactured in the form of liquid using non-drying oils. Sometimes drying oils can equally be used (Gupta, 1990).

Soap is produced using either cold processes or hot process. In the cold process, soap is made by reacting fatty acid and NaOH or KOH together. The acid can generally be any oil. Cold process of soap making combines both art and science into action. The shortened form of this process is that there is a certain ratio of lye (NaOH) and water to fatty acid that forms the reaction known as saponification. In the course of saponification, the oil and lye solution mixed to produce soap weeks. It takes this whole process not less than six weeks to complete. The following safety equipment like hand gloves, goggles, nose mask etc are required while using cold process. Soap produced using this process are known for their hardness and their quality depends on the type of oil used (Garzena, 2004; Willcox, 2000; Jimoh and Jimoh, 2021). While, in the hot process the whole materials used for the soap making are added together in a pot or any container on which heat is applied like stove. The sample on the fire is stirred frequently until the whole stages of soap making are undergone. The excess water is dried off and the soap is cooled before use (Garzena, 2004; Willcox, 2000; Jimoh and Jimoh, 2021).

The cleansing property of soap is defined by its polar and non-polar structures together with principle of solubility, the hydrocarbon part is non-polar and hydrophobic while, the salt is ionic and hydrophilic as shown in the structure below.



Hydrophobic tail Hydrophilic head

Figure 2: Soap structure (Jabr, 2020)

When oil (that is, a non-polar hydrocarbon) is mixed with a soap solution, the soap molecule works as an intermediate between water (polar) molecules and non-polar molecule. This is because, soap molecule has both polar and non polar properties and therefore acts as an emulsifier. An emulsifier has the ability of diffusing one liquid to another immiscible liquid (David, 2009).

Palm Kernel Oil is extracted from oil palm fruits (from its kernel). It is in the lauric oils family just like coconut oil. Meaning, it possess a high concentration of lauric acid, which is a saturated fatty acid. Initially, the oil is yellowish-brown in color, but after purification becomes white-yellowish fat. Palm Kernel Oil is solid at normal temperature, but at body temperature it melts rapidly with a nice cooling effect. This is the reason why it is commonly found in ice confection, ice cream coatings, cocoa glazes, and cool-melting confectionery fillings. It is equally used in margarine production. Palm Kernel Oil is the primary raw material for making intermediate materials that are used in cosmetics and cleansing (Liu *et al*., 2019).

Table 1: Approximate percentages of individual fatty acids in Palm Kernel Oil.

Acids	Number of Carbon	Percentage (%)
Lauric saturated	C12	48.2
Myristic saturated	C14	16.2
Palmitic saturated	C16	8.4
Capric saturated	C10	3.4
Caprylic saturated	C8	3.3
Stearic saturated	C18	2.5
Oleic monounsaturated	C18:2	15.3
Linoleic polyunsaturated	C18	2.3

(Jimoh and Jimoh, 2021).

However, there are several studies on soaps across the globe, but in our area Anyigba, there has never been any research on soaps manufactured using palm kernel oil made locally in the same area using traditional methods. Since many people in the area uses soap for their day to day cleansing activities, it became very important to produce the soap using local raw materials available in the villages as the soap produced was studied to be safe with good cleansing ability; hence, this research is very necessary.

Materials and Methods

Apparatus
pH meter, Beakers, Cornical flask, Glass rod, Measuring cylinder, Volumetric flask, Heating mantle, Weighing balance, Hand mask, Viscometer

Reagents.
NaOH, KOH, Palm Kernel Oil, Potassium Carbonate (KCO_3), Hydrochloric acid (HCl), Distilled water, Ethanol, Perfumes, and Colorants.

Preparation of Reagent
4.5 M Sodium hydroxide: 60 g NaOH was dissolved in 333 cm^3 distilled water.
3.5 M Potassium carbonate: 115.5 g potassium carbonate was dissolved in 333 cm^3 of distilled water.
0.5 M Ethanol Potassium hydroxide: 7 g Potassium hydroxide was dissolved in 10 cm^3 ethanol in a 250 cm^3 volumetric flask

Preparation of Palm Kernel Oil
Palm oil produce are gotten from milling and refining processes, starting with fractionation and crystallization followed by separation practices to obtain a solid stearin containing higher proportion of saturated fatty acids and liquid olein. The impurities are then removed by melting and gumming followed by the filtration of the oil and deodorized bleached palm oil is made. The produced Palm Kernel Oil contains the high amount of pure fatty acids used in soap making, washing powder an important raw-material in the manufacture of soap, washing powder and other personal care products.

Production of Soap using NaOH
200 cm^3 of palm kernel oil was measured, melted and then mixed with 100 cm^3 of 4.5 M sodium hydroxide, stirred in one direction at a room temperature for 15 minutes until a viscous mixture is obtained. Followed by addition of additives such as 1 g of colorant (pink), 10 cm^3 of perfumes. The mixture was left to solidity for one week to obtain the so lid soap (Jimoh and Jimoh, 2021).

Production of Soap using KCO_3
40 cm^3 of palm kernel oil was weighed into a breaker containing 20 cm^3 of potassium carbonate and 20 cm^3 of 4.5 M sodium hydroxide was filtered and added with continues stirring until viscous mixture was obtained. Mixture was left to solidify (Garzena, 2004; Jimoh and Jimoh, 2021).

Determination of Saponification Value
250 cm^3 capacity round bottom flask was weighted and 1 g of warmed palm kernel oil was introduced into the flask. 25 cm^3 of 0.5 M KOH solution was also added. The mixture was refluxed for one hour after which the heating was stopped and 5 drops of phenolphthalein was added. The resultant hot soap was titrated against 0.5 M HCl. The process was done three more times and the average value was taken. A blank titration was equally done out by titrating 25 cm^3 of 0.5 M ethanol potassium hydroxide against 0.5 M HCl (Jimoh and Jimoh, 2021).

Coloration and Staining Properties of Soap
Coloration is the act of imparting color to a substance so as to beautify the substance. 1 g of pink color was used in this saponification process and obtained a pink colored soap.

On the other hand, staining is the ability to leave or make color patches or dirty marks on some things especially ones that are difficult to remove. A white cotton fabric was cut and the soap was used to wash it, and the staining property was checked (Bratovcic *et al*., 2018).

Determination of pH

pH is the degree of the acidity or alkalinity of an aqueous solution. The pH value increases with increasing alkalinity and deceases with increasing acidity. The pH was checked using a pH meter (pHep) made in China. 10 g of the sample was measured and dissolved in deionized water in a 100 mL volumetric flask. This was used to prepare 10 % solution of the soap in line with what is in the literature (Adane, 2020). The electrode of the pH meter was put into the solution and reading was taken for the soap sample. The same procedure was done for all the prepared samples and the results obtained are shown in Table 1.

Foaming Property

Foaming is the ability of soap to form lather while using (Kunatsa and Katerere 2021). In this, 2.0 g of soap sample was drop into 500 mL measuring cylinder and 100ml of distilled water added to form a soap solution (Issa *et al*., 2020). The mixture was shaken continuously in order to generate foam. After continuous shaking for 2 minutes, the cylinder was made to stand for 10 minutes. The foam height in the sample solution was taken and recorded as shown in table 2.

Results and Discussions

Table 2: The pH-Values, weight and the melting point of the soap.

Formula of soap	Colour	Weight (g)	pH-value
$CH_3(CH_2)_{10}COONa+$	Pink	25.61	9.88
$CH_3\ (CH_2)_{10}COOK+$	Pink	25.88	10.00

From the Table 2, it is seen that there is no much difference in the pH-value of the prepared soaps, and all the pH-values are within the range set by standard. This shows that the non-soap particles added during the production does not affect the pH. However, for efficient soap making, pH-values must be within the range of 7-10 as reported by the International Organization of Soap Makers. The finished soap to an extent is alkaline, but soap with pH value above 10 is likely to irritate the skin.

Table 3: The foaming property of the soap

Formula of soap	Hard water	Soap Water
$CH_3(CH_2)_{10}COONa+$	Moderately foam	Heavily foam
$CH_3\ (CH_2)_{10}COOK+$	Moderately foam	Heavily foam

In order to produce standard soap, lather formation is a very important factor to consider. From the Table 3, it can be seen that both the soap made forms a heavy lather with soft water and moderate lather with hard water.

Table 4: The solubility property.

Formula of soap	Soap Water	Hard water
$CH_3(CH_2)_{10}COONa+$	Soluble	Insoluble
$CH_3\ (CH_2)_{10}COOK+$	Soluble	Insoluble

Saponification Value of Palm Kernel Oil (Sample A)

With the availability of enough data on the exact composition of oil, and its molecular weight, it has become very easy for us to determine the accurate percentage of lye (NaOH) required to completely solidify a given amount of a certain oil, so as not to have any extra lye in the soap such that the soap will not exasperate the skin. The amount of milligrams (NaOH) solution required to fully saponify one gram of a given oil is known as the saponification value (Paulin and Irène 2019). Therefore, saponification value is calculated using titration process and the result is show in Table 5.

TABLE 5: SAMPLE A

Burette readings	1st	2nd	3rd
Final	5.50	5.00	5.40
Initial	0.00	0.00	0.00
Vol. of A used	5.50	5.00	5.40

Therefore, Average titre value = (5.50+5.00+5.40) /3 = 5.0

Sample B (Blank)

Burette readings	1st	2nd	3rd
Final	14.03	14.20	14.30
Initial	0.00	0.00	0.00
Vol. of B used	14.03	14.20	14.30

Therefore, titre value = (14.03+14.20+14.5) /3 = 14.18

Saponification value is not in any way useful for identification purpose but is useful in determining the mean molecular weight of constituent fatty acid. Titre value of sample A = 5.00; Titre value of sample B = 14.24

Therefore, saponification value = [(B - A) 25.00] / Weight of sample (g)
= (25.00x14.18 -25.00x5.00) / 1
= 229.5
Since 218.6 – 230 is the saponification value range of Palm Kernel Oil, therefore the value obtained is within the range set by standard organization of Nigeria.

CONCLUSION

Our research has shown that a good quality soap can be produced using Nigerian local palm kernel oil with good cleaning and foaming property. The good class of the soap produced above depends on the excellent properties of the Palm Kernel Oil used above during its production. As seen from the result, soap with pH values of 9.88-10.00 form a heavy lather, and does not stain a white clothes, and very safe on the skin.

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