International Journal of Mechanical and Thermal Engineering

E-ISSN: 2707-8051
P-ISSN: 2707-8043
IJMTE 2025; 6(1): 13-20
www.mechanicaljournals.com/ijmte
Received: 09-10-2024
Accepted: 14-11-2024

Umeuzuegbu JC
Department of Chemical Engineering, Chukwuemeka Odumegwu Ojukwu University, Uli, Anambra State, Nigeria

Nwanekezie MN
Department of Chemical Engineering, Chukwuemeka Odumegwu Ojukwu University, Uli, Anambra State, Nigeria

Corresponding Author:
Umeuzuegbu JC
Department of Chemical Engineering, Chukwuemeka Odumegwu Ojukwu University, Uli, Anambra State, Nigeria

Production, characterization and improvement of local black soap by saponification of palm oil using palm bunch ash extract

Umeuzuegbu JC and Nwanekezie MN

Abstract
The art of production of local black soap in Nigeria has been an age long practice. However this crude practice is knocked by absence of aesthetics of the soap and standard method of production. This research work focused on production, characterization and improvement of local black soap by saponification of palm oil using palm bunch ash extract. The physiochemical properties of the palm oils used was characterized base on American Standards of Testing Materials (ASTM) method. The palm bunch ash was as well characterized for the physiochemical properties. The physiochemical properties of the local black soap and the improved soap were characterized. The physiochemical properties of the crude palm oil and the heat bleached palm oil respectively are: acid value 3.35, 3.42 mgKOH/g; iodine value 50.2, 51.8 mgI_2/100 g; peroxide value 2.75, 2.95 mEq/Kg: saponification value 203.20, 201.6 mgKOH/g; density 0.889, 0.882 Kg/m^3; moisture content 1.80, 2.0%; Kinematic viscosity 47.50, 46.20 mm^2/s; refractive index 1.465, 1.470. The characteristics of palm bunch ash was evaluated as follows, ash content 4.54%, alkaline content 14.02%, pH 12.02. Comparative analysis of physiochemical properties of the local black soap and the improved soap respectively gave: colour black, light brown; texture rough, smooth and soft; moisture content 9.10, 9.40%; pH 9.10, 9.50; total fatty matter 65.35, 69.50%; total caustic alkali 0.25, 0.21%; free caustic alkali 0.22, 0.22%; free carbonate alkali 0.12, 0.11%; Foamability 50 cm^3, 60 cm^3; foam stability 20, 30minutes. The results from this work revealed that palm bunch ash extract provides sufficient alkali for saponification of palm oil to produce soap. Based on TFM, TCA and moisture content of the soaps produced, they qualified as quality soap which could serve as toilet soap.

Keywords: Acid value, crude palm oil, palm bunch ash alkali, total fatty matter, saponification value

1. Introduction
Soap is a hydrolysis product of oil or fat with a strong alkali such as sodium hydroxide (NaOH) or potassium hydroxide (KOH) to form salt of the triglyceride (Soap) and glycerol [1, 2]. They are cleansing agents used as surfactants in washing, bathing and cleaning [3]. Apart from cleaning, soaps are used in textile spinning and as a component of lubricants. They are produced from long chain carboxylic acid like lauric acid, stearic acid and linoleic acid usually in the form of bars, flakes, granules and liquid form [4, 5]. Cleaning action of soap stem from the removal of fatty matter by fat soluble part of the soap or the 'tail' and removal of nonefatty matter by non-fat soluble part of the soap or the 'head'.
Palm oil is an edible oil obtained from the ripe mesocarp of the fruit of oil palm tree (Elaeis guenensis). Two types of oil are derived from the oil palm fruit namely crude palm oil (CPO) from the mesocarp and palm kernel oil (PKO) from the kernel [6-8]. The saponification value of palm oil is in the range of 232-280 which is relatively high, indicative of high concentration of fatty acid and therefore suitable for soap production. Currently the world highest producers of palm oil are Indonesia, Malaysia, Thailand, Nigeria and Columbia [9]. Production of local black soap has been an age long practice. The quantity and quantity of the ingredients in soap making affect the quality of the soap and also its demand [10]. In order to produce high quality local soap therefore the oil and alkali involved in the production must be of high quality. This necessitates purification of the oil and the alkali used in the production of soap. Palm oil consist mainly of palmitic acid and oleic acids, is semisolid at room temperature. CPO possess deep orange red colour as a result of carotene content. The dark red color can be heat-bleached to low level when the carotene has not been oxidized and fixed.

Local black soap production employs the alkali derived from palm bunch ash (PBA).The dark colour of the palm bunch ash alkali can be decolorized with activated carbon.
The art of soap making using palm oil and palm bunch ash extract have been practiced in West Africa over a long time [11]. Ash derived alkali provide cheap alternative to synthetic alkali. It has been reported by [12-14] that agricultural wastes such as palm bunch chaff, cocoa pod, plantain peel, banana peel, maize cob, wood, sugar beet etc contain good amount of potash. When these materials are dried and burnt the ashes provide the much needed potassium and sodium oxides which dissolves in water to give potassium hydroxide (KOH) and sodium hydroxide (NaOH) that are needed for saponification of oil to produce soap. The viability of modern soap requires the soap to be relatively inexpensive, effective in cleaning, and of good esthetics unlike the local black soap which is black in colour and rough in texture. As a result, this research work focused on production, characterization and improvement of local black soap via saponification of palm oil using palm bunch ash alkali (PBAA).

2. Materials and Methods

2.1 Materials and Equipment

Crude palm oil (CPO) as well as empty palm bunches was purchased from Oye Uga in Aguata local Government Area, Anambra State, Nigeria. The reagents used are of analytical grade purchased from Gerald Chemicals Ltd. Ogbete Market in, Enugu, Nigeria, Glasswares and equipment.

2.2 Experimental Methods

2.2.1 Characterization of palm oil

The crude palm oil was characterized for the physiochemical properties and fatty acid composition using American Society for Testing of Materials (ASTM) methods. Gas chromatography mass spectroscopy (GC-MS) was employed to determine the functional groups in the oil.

2.2.1.1 Acid value

0.5 g of the palm oil was weighed into a dry 250 ml conical flasks. 20 ml of ethanol and 3 drops of phenolphthaleine indicator were added into the flask and the contents were thoroughly shaken. The solution was titrated with 0.1N sodium hydroxide until pink colour which persist for 20 to 30 seconds was observed (V).

$$\text{Acid Value} = \frac{\text{Titre Value x Normality of the base x 56.1}}{\text{Weight of the sample used}}$$

$$\text{Acid value} = \frac{V * N * 56.1}{W} \quad (1)$$

Where, 56.1 =Molecular mass of potassium hydroxide
N = Normality of potassium hydroxide
V = Titre value
W = Weight of the oil used

Percentage free fatty acid (% FFA) was determined by multiplying the acid value with the factor 0.503 [15]. Thus;

$$\% \text{ FFA} = 0.503 \text{ x acid value} \quad (2)$$

2.2.1.2 Iodine value

The iodine number was determined based on ASTM D4067-86 (1986) by using the sodium thiosulphate volumetric method. 0.5 g of the oil sample (W), was introduced into 250 ml conical flasks. 25 ml of Wiji's solution (mixture of iodine, acetic acid and chloroform) was then added into the conical flask and the flask contents mixed properly by vigorous shaking. The flask was tightly covered and kept in a dark place for 30 mins at room temperature. At the end of the 30 minutes, 10 ml of 10% potassium iodide solution and 150 ml distilled water were added into the flask and the solution turned reddish.
Then, 5 ml of 5% starch solution was added into the flask content as an indicator. The solution in the flask turned blue-black and this was then titrated with 0.1N sodium thiosulphate solution until black precipitate appear in colourless solution (V_1). A blank titre (V_2) was obtained by carrying out the above experiment without the oil sample. Iodine value is given by the expression:

$$\text{Iodine value} = \frac{12.69 * N * (V_2 - V_1)}{Weight\ of\ sample\ (W)} \quad (3)$$

Where
12.69 = Molecular mass of iodine
N = Normality of sodium thiosulphate
V_2 = Blank titre value
V_1 = Sample titre value
W = Weight of sample

2.2.1.3 Saponification value

This was determined by weighing 0.5 g of the oil sample (W) into 250 ml round bottomed flask. 50 ml of 0.5N ethanolic potassium hydroxide was added onto the sample in the flask. The mixture was then refluxed to get perfect dissolution of the oil sample. After refluxing and cooling, 3 drops of phenolphthaleine solution was added onto the mixture and the unreacted potassium hydroxide in the mixture back-titrated with 0.5 N hydrochloric acid until the pink colour disappears (V_1). A blank titre (V_2) was obtained by carrying out the above experiment without oil sample. Saponification value was calculated using the expression:

$$\text{Saponification value (number)} = \frac{56.1 * N * (V_2 - V_1)}{W} \quad (4)$$

Where;
56.1 = Molecular mass of potassium hydroxide
N = Normality of HCL
V_2 = Titre value of blank
V_1 = Titre value of sample
W = Weight of the sample used

2.2.1.4 Peroxide value

0.5 g of the oil sample (W) was weighed into a 250 ml conical flask followed by addition of 25 ml solvent mixture (Glacial acetic acid and chloroform 2:1 v/v). 1 ml of 10% potassium iodide was added and the flask content vigorously shaken, stoppered and kept in the dark for 1 minute. 35 ml of freshly made starch indicator was added. The solution was then titrated with 0.02N sodium thiosulphate solution when it turn from pale blue to white (V_1). A blank titre (V_2) was obtained with the above procedure but with no oil sample when the colour changed from pale yellow to white. Peroxide value was calculated using the expression;

$$\text{Peroxide value} = \frac{100 * N * (V_1 - V_2)}{Weight\ of\ sample\ (W)} \quad (5)$$

Where
N = Normality of sodium thiosulphate ($Na_2S_3O_3$)
100 = Peroxide value constant
V_1 = Titre value of sample
V_2 = Titre value of blank
W = Weight of the sample

2.2.1.5 Refractive Index
Refractive index was determined using a digital table top refractometer (HI96800) manufactured by Hanna Instruments, Romania. The device was initially calibrated to zero using distilled water. Samples were placed at the glass prism and refractive index value read off using the refractive index key. Air bubbles were eliminated from distilled water and sample respectively before calibration.

2.2.1.6 Specific gravity/Density
This was determined using specific gravity bottle of volume 50 ml (V). The bottle was washed, dried and weighed (W_1). It was then filled with the oil sample and reweighed (W_2). Again the bottle was washed, dried, and filled with water and reweighed (W_3). The specific gravity is given by the expression:

$$\text{Specific gravity (S.G)} = \frac{W2 - W_1}{W_3 - W_1} \quad (6)$$

The density of the oil is given by the expression:

$$\text{Density} = \frac{Mass}{Volume} = \frac{W2 - W_1}{V} \quad (7)$$

2.2.1.7 Moisture content
Moisture content was determined by oven drying method. 1.0 g of the oil sample (W_1) was introduced into a petrdish and the combine weights noted (W_2). The sample in the petri-dish was then placed in a thermostatically controlled oven at a temperature of 105 ^{0}C for 1 hour to drive off the moisture. The sample was allowed to cool in a desicator after which the weight of the petri dish and the dried oil content was taken (W_3). The percentage moisture content was given as:

$$\% \text{ moisture content} = \frac{W_2 - W_3}{W1} * 100 \quad (8)$$

2.2.1.8 Kinematic viscosity
A u-tube viscometer manufactured by Poulten Selfe and Lee Ltd (PSI ASTM-IP 350) was used to determine the kinematic viscosity. A micropipette was used to introduce 5 ml of oil sample into the viscometer and to bring up the sample to the upper meniscus of the bulb. The flow time of the oil sample from the upper to the lower meniscus of the bulb was determined in seconds at 40 °C.

$$\text{Kinematic viscosity} = ct\ (mm^2s^{-1}) \quad (9)$$

Where
c = viscosity constant = 0.4891
t = flow time of the oil from the upper to the lower bulb meniscus.

2.2.2 Heat bleaching of the palm oil
500 ml of oil was introduced into a 1000 ml round bottomed flask and heat-bleached in a water bath maintained at 80 ^{0}C for 1hour. When cooled the oil was similarly characterized as the CPO.

2.2.3 Determination of ash content of palm bunch
The ash content of the palm bunch was determined by the method described by [16]. 5 g of pieces of the palm bunch was placed in a previously weighed crucible (w_1) and the sample and crucible was weighed (w_2) and placed in a muffle furnace. The sample was incenerated at 700 ^{0}C for 3 hours. When cooled to 100 ^{0}C the crucible and the content was carefully transferred into a desicator to cool to room temperature when it was reweighed (w_3). The difference in the weight of the sample before and after burning expressed as percentage gave the ash content of the bunch expressed as:

$$\%Ash = \frac{(w2 - w3) \times 100}{(w2 - w1)} \quad (10)$$

2.2.4 Determination of alkali content of the PBA
!00 ml of the extract was titrated with 0.1MHCL to phenolphthalene end point. The amount of alkali in the extract was calculated based on the expression,

$$M_A\ V_A = M_E\ V_E$$

$$M_{E\ (g/L)} = \frac{M_A}{V_E} V_A$$

Where
MA – Molarity of acid
ME =Molarity of extract
VA = Volume of acid
VE –Volume of extract
ME= Molarity of extract

2.2.5 Determination of pH of PBA
The PH of the palm bunch ash was determined to know its degree of alkalinity. The electrode of Hanna pH meter was dipped into the aqueous extract of the PBA contained in a beaker. The pH was determined by pressing the button when the pH value was digitally exhibited on the meter.

2.2.6 Preparation of palm bunch ash extract
The palm bunch ash extract (PBAE) was prepared in two sets depending on the type of soap.

Palm bunch ash extract (A) for production of local black soap
The palm bunch was cut in pieces and sundried for14 days. It was then burnt in the open air where complete combustion took place. On cooling, the ash obtained was packaged in a plastic container and tightly covered. 200 g of the ash obtained was introduced into 1 liter round bottomed flask containing 500 ml of water. The mixture was well stirred using a spatula and then heated in a water bath maintained at 80 ^{0}C for 30 minutes. On cooling the mixture was filtered using muslin cloth.

Palm bunch ash extract (B) for production of improved soap

The pieces of palm bunch dried for 14 days was burnt in a muffle furnace at 700 ^{0}C for 4hours and then allowed to cool. It was then crushed and sieved using 126x10-4 micron mesh in order to obtain uniform particle size. The ash was packaged in a plastic container with tight cover ready for use. 200 g of the ash obtained was introduced into 1 liter round bottomed flask containing 500 ml of water. Onto the mixture in the flask was added 5 g of activated carbon and the overall mixture was well stirred using a spatula, heated in a water bath maintained at 80 ^{0}C for 30 minutes. On cooling, the mixture was filtered using muslin cloth and then re-filtered using No.1 Watman filter paper to obtain a clearer filtrate.

2.2.7 Production of local black soap and its improved variant

200 cm^3 of the PBAE (A) was run into 1 liter beaker. The beaker and content was placed on a hot plate maintained at 100 ^{0}C until the extract volume was reduced to a third. 200 cm^3 of the crude palm oil was slowly added onto the extract with thorough stirring and heating until a thick mixture of the local black soap results when the beaker was removed from the heat source. The soap was poured into a mold and left for 24 hours to solidify. The improved soap was similarly prepared but with PBAE (B) and heat bleached palm oil.

2.2.8 Characterization of the soaps produced

2.2.8.1 Determination of pH of soap

The pH of soap was determined by the use of pH meter (HANNA INSTRUMENT pH Lab. Model). 10g of soap sample was dissolved in 100ml of distilled water. This was transferred to 1000 ml volumetric flask and made up to the mark with distilled water, vigorously shaken and left to settle. The electrode of the pH meter was dipped into the solution and the pH of the soap read off.

2.2.8.2 Determination of moisture content of soap

10g of the soap sample was introduced into a previously weighed porcelain dish of weight w_1 and the total weight measured as w_2. The dish with the soap sample was placed in a thermostat control oven and dried at a temperature of 105 ^{0}C till the dish and sample gave a constant weight. The dish and the soap sample therein was then transferred into a desicator where it cools without absorption of moisture and then reweighed, w_3. The percentage moisture content of the soap is given by the expression,

$$\%Moisture = \frac{w3-w1x100}{w2-w1} \quad (12)$$

2.2.8.3 Determination of total fatty matter (TFM)

5g of the soap was placed in a 400ml beaker. 100ml of hot distilled water was added onto the soap for complete dissolution on shaking.

Then 20 ml of 2M H_2SO_4 was added into the beaker for liberation of the fatty matter. As the mixture in the beaker cools, the fatty matter settle at the top leaving the liquid portion underneath the beaker. This is decanted and the fatty matter washed with distilled water until it becomes neutral to litmus. The fatty matter was then dissolved in 70 ml of hot neutral ethanol and then titrated with !M NaOH using phenolphthalene indicator. The total fatty matter obtained is given by the expression

$$\%TFM = \frac{MVx100}{W} \quad (13)$$

Where
TFM = total fatty matter
M = molarity of NaOH (g/cm^3)
W = weight of soap sample (g)
V = volume of NaOH solution (cm^3)

2.2.8.4 Determination of total free alkali (TFA) in soap

2 g of soap sample was placed in a 250 ml conical flask and 20 ml of neutral ethanol was added onto it. The flask and content was placed in a water bath and warmed at 50 ^{0}C with stirring until the soap was completely dissolved. The solution was then heated to boiling when 2 ml of 0.1M $BaCl_2$ and 2 drops of phenolphthalene indicator was added and then titrated to a colourless end point. The total free alkali is given by the expression,

$$TFA = M_A m_{NaCO3} V_A \quad (14)$$

Where
MA = Molarity of acid
m_{NaCO3} = molar mass of $NaCO_3$
V_A = Volume of acid

2.2.8.5 Determination of free caustic alkali (FCA) in soap

2 g of the soap sample was dissolved with 50 ml of hot distilled water in a 200 ml beaker. 2 ml of 0.1M $BaCl_2$ solution and 2 ml of phenolphthalene indicator was added onto the solution. After settling of the precipitate, 25 ml of the clear solution was withdrawn and titrated with 0.1M H_2SO_4. The free caustic alkali in the soap is obtained with the expression

$$FCaA = TFA + FCA \quad (16)$$

Where
MA = Molarity of acid
m_{BaCl2} = Molar mass of $Bacl_2$
V_A = Volume of acid

2.2.8.6 Determination of free carbonate alkali (FCaA) in soap

The free carbonate alkali in soap is given by the difference between the total free alkali and free caustic alkali:

2.2.8.7 Foamability of soap

The ability of soaps to foam is measured by the volume the foam formed when the soap is dissolved and shaken in a cylindrical container. 2 g of soap sample was placed in a measuring cylinder and 10 ml of distilled water was added and the cylinder with the content vigorously shaken. The cylinder was left to settle and the volume of the foam in the cylinder was measured and recorded. The experiment was carried out in triplicate and the average volume calculated as the foamability of the soap.

2.2.8.7 Foam stability of soap

Foam stability is given by the average time period at which the foam formed disappear as proposed by [17]. 2 g of soap

sample was dissolved in 10 ml of distilled water in a measuring cylinder. The cylinder and the content was vigorously shaken until the foam occupy a constant volume or height in the cylinder.

3. Results and Discussion

3.1 Physiochemical properties of palm oil

The physiochemical properties of the palm oil used are as outlined in table 2.

Acid value

The acid value of the crude oil use was 3.53 mgKOH/kg while that of the heat bleached oil was 4.25 mgKOH/kg. The upper limit of acceptable value of acid value is in the range of 10-15 mgKOH/kg [18, 19]. Acid value in excess of 12.0 is adjudged high and will quickly end up in rancidity of the oil [20]. The low acid value of the oil used indicates the freshness of the oil that is devoid of rancidity.

Iodine value

The iodine value is a parameter that indicates the degree of un-saturation of the oil. The iodine value of the crude palm oil tested was 50.2 mgI_2/g while that of the bleached oil was 51.8 mgI_2/g the relatively low iodine value of the palm oil shows that it is an unsaturated and non-drying oil and therefore not susceptible to oxidative rancidity over a short period of storage [21].

Peroxide value

The peroxide value measures the degree of susceptibility of the oil to oxidative stability. The peroxide value of the palm oil was obtained as 2.75 mEq/kg and 2.95 mEq/Kg respectively for the crude and heat bleached oil. Peroxide value of the oil like its iodine value is also an indicator of susceptibility of the oil to oxidative rancidity [21]. It has been reported by the researcher [22, 23] that rancidity in excess of 8.80 mEq/kg indicates the goodness of the quality and non-adultration of the oil and therefore its acceptability for domestic and industrial use. The low peroxide value of the oil shows the oil to be of high oxidative stability, ostensibly as a result of the antioxidants like carotene contained in the oil.

Saponification value

The saponification value is the number of milligram of KOH required to completely neutralize the fatty acid in 1g of the oil. The saponification value obtained for the crude and bleached palm oil were 203.20 mgKOH/g and 200.60 mgKOH/g respectively. The relatively high saponification value of the palm oil indicates that it has high concentration of triglyceride which makes it suitable for for soap making [24].

Moisture content

The moisture content of oil is an important parameter for assessing its quality. The amount of water content in foodstuff determines its level of water activity. High moisture content of oil is indicative of its ease of deterioration, microbial growth, and hydraulic rancidity [24, 25]. It has been reported by [26, 27] that the moisture content of palm oil depends on its ultimate extraction and clarification processes. The moisture content of the palm oil used 1.80% and 2.0% are relatively low suggestive of relative stability and non-susceptibility of the oil to short storage time degradation.

Density and specific gravity

Density is expressed as mass per unit volume of a substance while the specific gravity can be expressed as the ratio of density of a substance to density of equal volume of water. Since oil is measured volumetrically, the knowledge of its density is necessary for evaluating the mass given the volume of the oil. The results obtained for the palm oil used are o.889 kg/dm3 and o.880 kg/dm^3 for the crude and bleached palm oil respectively. These values approximate the literature values 0.870-0.910 and 0.904-0.918 reported by [28, 29].

Viscosity

Viscosity is a measure of resistance of fluid to flow or deform under share stress and is commonly experienced as thickness or resistance to flow. The kinematic viscosity of the used palm oils are 47.50 and 46.2 mm^2/s which conforms with the literature values of 45-46 mm^2/s reported by [30].

Refractive index

Refractive index is a physical constant employed in determining the identity and purity of a substance. The evaluated refractive indices of the oils used are 1.465 and 1.470. This agrees with the literature values of 1.4620-1.4840 by [26] but less than 1.47-1.562 by [31].

Fatty acid profile of palm oil

Table 1 shows the fatty acid composition of palm oil. The main constituent fatty acid of palm oil are palmitic acid 44%, oleic acid 39.2%, Linoleic acid 10.1% and stearic acid 4.5%. Palm oil thus is composed of triglyceride of nearly equal proportion of saturated and unsaturated fatty acids that makes the oil neither saturated nor unsaturated.

3.2 Characteristics of palm bunch ash

The characteristics of the palm bunch ash are as shown in table 3.

Ash content

The ash content of palm bunch was determined as 4.5%. This value is greater than 1.45% of plantain peels but less than 7.73% of coco pod as reported by [31, 32]. Palm bunch, plantain peel, cocoapod ash yields sufficient alkali for saponification of oil to produce soap.

pH

The pH value of palm bunch ash was evaluated as 12.02. The pH value compares with that of cassava peel 9.17, mango peel, 11.98, and banana peel 12.06 of the same mass dissolved in equal volume of water as reported by [31, 34, 35]. The high value of the pH indicates that palm bunch ash contain sufficient alkali to saponify the oil used.

Alkaline content

Palm bunch ash extract yields alkali content of 14.54/dm^3. This value is less than the alkaline content of plantain peel 64.75 g/dm^3, 64.57 g/dm^3 and 74,75 g/dm^3 reported by [31, 33] and [32] respectively but compares with that of mango peel 12.13 g/dm^3 and cassava peel ash 4.82g/dm^3 as reported by [35] and [36] respectively.

Table 1: Fatty acid profile of palm oil

Common name	Lipid number	Concentration (%)
Lauric acid	C12:0	0.0
Myristic acid	C14:0	1.1
Palmitic acid	C16:0	44.0
Palmitoleic acid	C16:1	0.1
Stearic acid	C18:0	4.5
Oleic acid	C18:1	39.2
Linoleic acid	C18:2	10.1
Linolenic acid	C18:3	0.4
Arachidiuc acid	C20:0	0.4

Table 2: Physiochemical properties of palm oil

Properties	Crude palm oil	Bleached palm oil
Acid value (mgKOH/g)	3.35	3,42
Iodine value (mgI2/100g)	50.20	51.8
Peroxide value (mEq/Kg)	2.75	2.95
Saponification value (mgKOH/g)	203,20	201.6
Density (Kg/dm^3)	0.889	0882
Moisture content (%)	1.80	2.0
Kinematic viscosity (mm^2/s}	47.50	46.2
Refractive index	1.465	1.470

Table 3: Characteristics of palm bunch ash

Characteristics	Value
Ash content (%)	4.54
Alkali content (mg/dm3)	14.54
pH of extract	12.02

3.3 Comparative analysis of physiochemical characteristics of the local black soap with those of the improved soap: Table 4 shows the comparative analysis of the characteristics of the local black soap and the improve variant.

pH value of soap

The *pH* value of soap indicates its degree of alkalinity or acidity. The experimentally determined pH value of the local black soap was 9.10 while that of the improved variant was 9.40. The BSI stipulated range of pH of soap is 7-10. Soaps of high pH value are likely to be corrosive to the skin with the pH range of 5.4-5.9 [35]. Strongly alkaline soap therefore neutralise the protective barrier of the acid to bacteria and virus [36]. High pH of soap results from incomplete hydrolysis of saponification processes. However, high pH value of soap can be reduced by superfattning or addition of excess oil or by application of pH adjuster to reduce the harshness or corrosivity on the skin [39]. The pH of the soaps produced is in the range of East African Standards (EAS) for toilet soap 7.5-9.5 [40]. On the basis of pH therefore the local black soap and its improved variant should be suitable as toilet soap.

Moisture content of soap

The moisture content of soap is the amount of free water present in the soap. High moisture content in soap results in hydration of the unsaponified fat to fatty acid and glycerol by the excess water. The evaluated moisture content of the soaps is 9.10 for local black soap and 9.40 for its improved variant. The moisture content of the soaps correspond with that from literature [41, 42]. Variation of moisture content of the soaps ostensibly arose from the treatments of the raw materials and the method of production.

Total fatty matter of soap

The total fatty matter (TFM) is the most significant factor for determination of high quality soap. According to International Standards Organization (ISO) TFM for toilet soap is 76%. However soaps of TFM 70-80% are generally regarded as high quality soap. High TFM of soap indicates the soap contain high amount of fat required for rehydration and lubrication of dry skin [43, 44]. The TFM of the local black soap and its improved analogue are 68.90% and 69.50% respectively and so do not show significant difference ostensibly as a result of their methods of preparation. These TFM values compares with the literature values 55.43-62% [42, 45].

Total caustic alkali (TCA}

The total caustic alkali {TCA) is the determinant of abbressivness of soap. High caustic alkali content of soap results from incomplete saponification of the oil. The recommended value for laundry soap is 0.24% while that for toilet soap is 0.20% [46]. The relatively low total caustic alkali obtained in this work 0.25% and 0.22% indicates that the soap will not give adverse reaction such as irritation and itching on the skin [47].

Free caustic alkali (FCA)

The free caustic alkali in soap also determines the degree of abbressivness of the soap. A high quality soap should contain little or no free caustic alkali [48]. High free caustic alkali in soap leads to skin irritation and wear of cloth during usage. It can also result to dry and scaly skin which is susceptible to fungal attack as the excess alkali can saponify the skins protective fatty cover to soluble soap which is washed away leading to exposure of the skin to dryness [37]. The free caustic alkali obtained in this work, 0.22% for both soaps is much higher than 0.09% and 0.02-0.06% reported by [42] and [50] respectively but in agreement with 0.2% and 0.21± 0.03 reported by [45] and [52] respectively.

Free carbonate alkali (FCaA)

The free carbonate alkali (FCaA) is the value obtained by subtracting free caustic alkali from total free alkali

$$FC_a A = TFA - FCA \quad (15)$$

The values of FCaA in this work are 0.12% and 0.11% for the local black soap and its improved analogue respectively. This is lower than the literature value of [45, 51] who investigated saponification of palm oil using cassava peel ash and mango peel ash alkali and reported the values of 3.80 and 1.10% respectively.

Foamability of soap

The foamability of soap is a measure of volume of foam formed when the soap is dissolved in water and vigorously shaken in a graduated cylindrical vessel. The foamability in this work is 60cm^3. This compares with the literature values of 50-60cm^3 [47, 52].

Foam stability of soap

The foam stability of soap is given by the average of the time period at which the foam formed disappears. The foam stability of the soaps produced are 20minutes and 23minutes

respectively for the local black soap and its improved variant.

Table 4: Comparative analysis of Physiochemical properties of local black soap and the improved soap

Characteristics	Local black soap	Improved soao
Colour	black	Light brown
Texture	rough	Smooth and soft
Moisture content	9.10%	9.40%
pH	9,10	9.50
Total fatty matter	68.90%	69.50%
Total alkali content	0.25%	0.22%
Free caustic alkali	0.22%	0.22%
Free carbonate alkali	0.12%	0.11%
Foamability	50 cm^3	60 cm^3
Foam stability	20 minutes	23 minutes

4. Conclusion

The data obtained from this work revealed that bleached palm oil saponified with decolourisd palm bunch ash extract yielded high quality soap suitable as toilet soap. Apart from palm bunch ash, the ashes of other agricultural waste materials like cocoa pod, cassava peels, banana and plantain peels, cocoanut husk etc have been reported to contain sufficient oxides of potassium and sodium that dissolves in water to provide the alkali needed for oil saponification to produce soap. It is therefore advisable for the developing countries like ours to pay more attention to develope the ash sourced alkali to industrial scale in other to reduce the cost of soap production using synthetic alkali.

5. References

1. Ajongbolo K. Chemical properties of local black soap produced from cocoa pod ash and palm waste. International Journal of Trend in Scientific Development. 2020, 713-715.
2. Zauro SA, Abdullahi MI, Aliyu A, Mohammed A, Abubakar I, Sani YM. Production and analysis of using locally available raw materials. Elixir Applied Chemistry. 2016;96:41479-41483.
3. Okolie CP, Ezeliora CD, Iwenta CO, Sinebe JE. Optimization of soap production mix using response surface modeling: A case of Nigerian base soap manufacturing industry Onitsha, Anambra State, Nigeria. International Journal of Science and Technology Research. 2014;3(9):346-352.
4. Awize EA, Achebo JI. Liquid soap production with blends of rubber seed oil and palm kernel oil using locally sourced caustic potash. Nigerian Journal of Technology. 2012;31(1):63-67.
5. Warra AA. A report on soap making in Nigeria using indigenous technology and raw materials. African Journal of Pure and Applied Chemistry. 2013;7(4):139-145.
6. Berger KO, Noraini I. Formulation of zero-trans fatty acid shortening and margarines and other food fats with products of palm oil. Journal of the American Oil Chemists' Society. 2005;86:775-782.
7. Gourachon H. Analysis of incentives and disincentives for palm oil in Nigeria. Technical Notes Series, MAFAP, FAO. 2013.
8. Robbelen G. Mutation breeding for quality improvement: A case study of oilseed crops. Mutation Breeding Review. 1990;6:1-44.
9. USDA. Oilseeds: World markets and trade. Foreign Agricultural Service Circular Series. 2009;POP 11-09.
10. Nalawade KM, Nale A. A study of consumer buying behavior for bath soaps in Pune City. International Journal of Marketing and Technology. 2013;3(3):100-119.
11. Nwoko VO. Chemical processing development. Proceedings of the 10th Annual Conference of the Nigerian Society of Chemical Engineers. 1980, 40-43.
12. Bhattacharrya DK, Chatterjee B. Palm oil fatty acids in soap and detergent formulation. Journal of the American Chemical Society. 1984;61:417-419.
13. Edewor JO. Chemical production from local fossil fuels and the Nigerian balance of trade. Journal of Wiley for the Nigerian Society of Chemical Engineers. 1984;3:5-9.
14. Onifade KK. The potential application of cocoa pod husk for the manufacture of caustic potash. Journal of Agricultural Technology. 1994;2:59-64.
15. Akubuogwo IE, Chinyere GC, Ugbogu AE. Comparative study of oil from some common plant seeds in Nigeria. Pakistan Journal of Nutrition. 2008;7:570-572.
16. Nielson SS. Food analysis from midaines from animal cell culture. 4th ed. Springer, New York. 2007. https://doi.org/10.1007/978-1-4419-1478-1.
17. Belhaij A, Al-Mahdy O. Foamability and foam stability of several surfactant solutions: The role of screening and flooding. Journal of Petroleum and Environmental Biotechnology. 2015, 6(4).
18. Standard Organisation of Nigeria. Standard edible refined palm oil and its processed form. Standard Organisation of Nigeria. 2000;1:2-5.
19. Onyeka EU, Onugbu NL, Onuoha NU, Ochonogor F. Effect of extraction pretreatment on the composition and characteristics of seed and pulp oil of African black pear (*Dacryodes edulis*). Nigerian Food Journal. 2005;23:13-20.
20. Tanzid HM, Alam MT, Islam M. Physiochemical and nutritional studies of *Terminalia bellirica* Roxb seed oil and seed kernel oil. Journal of Biological Sciences. 2007;15:117-126.
21. Umeuzuegbu JC. Synthesis and optimization of biodiesel from castor seed oil. World Journal of Innovative Research. 2020;8(5):47-60.
22. Agbaire PO. Quality assessment of palm oil in some major markets in Delta State, Southern Nigeria. African Journal of Food Science and Technology. 2012, 223-226.
23. Udensi EA, Iroegbu F. Quality assessment of palm oil sold in major markets in Abia State, Nigeria. Journal of Agro-Science. 2007;6(2):23-27.
24. Umeuzuegbu JC. Synthesis and characterization of biodiesel from avocado pear oil. International Journal of Innovative Engineering, Technology and Science. 2020;3(1):14-26.
25. Frazier WC, Westhoff DU. Food Microbiology. 2nd ed. McGraw-Hill Company Limited, New York, USA. 1978.
26. Porku K. Small-scale palm oil processing in Africa. FAO Agricultural Services Bulletin. 2002, 148. ISBN-13:978-9251048597.

27. Orji MU, Mbala TI. Effect of extraction methods on the quality and spoilage of Nigerian palm oil. African Journal of Biotechnology Research. 2008;2(9):192-198.
28. Enyoh EC, Enye CE, Amobi CE. Quality assessment of palm oil from different palm oil factories in Imo State, Nigeria. World Science News. 2017;88(2):152-157.
29. Akinola FF, Oguntibeju OO, Adisa AW, Owojuyigbe OS. Physicochemical properties of palm oil from different local factories in Nigeria. Journal of Food, Agriculture and Environment. 2010;8(3):264-269.
30. Karkika OP, Dwi S, Erliza H, Darmono T. Processing characteristics and potential application of red palm oil: A review. International Journal of Oil Palm. 2008;3(2):40-55.
31. Omoruwou F, Olayebi O. Process optimization using response surface methodology (RSM) for the production of modified local black soap using plantain peel as a source of alkali. Direct Research Journal of Engineering and Information Technology. 2022;9(6):268-284.
32. Gyedu-Akoto E, Yalami D, Safa S, Owusu D. Natural skin care product; The case of soap made from cocoa pod husk potash. Advances in Research. 2015;4(6):365-370.
33. Ume-Idika A, Maduakor M. Soap production using waste materials of cassava peel and plantain peel ash as an alternative active ingredient, implication for entrepreneurship. IOSR Journal of VLSI and Signal Processing. 2013;3(3):01-05.
34. Ogbosho MD, Obasuyi EI. Production of local soap using alkali derived from mango and plantain peels. NIPES Journal of Science and Technology Research. 2022;4(4):90-95.
35. Okunola OJ, Ahaotu EO, Osuji CN, Ibeh CC. Production of soap using palm bunch ash. International Journal of Applied Science and Engineering. 2013;1(2):78-83.
36. Osagie DF, Fekarurhobo GK. Cleansing agents from natural rubber seed oil (RSO) and cassava peel ash extract. Chemistry and Materials Research. 2014;6(9):25-36.
37. Firempong C, Mak-Mensah CK. Chemical characteristics of toilet soap prepared from neem (*Azadirachta indica* H. Juss) seed oil. Asian Journal of Plant Science. 2011;2:617-623.
38. Vivian OF, Nathan O, Osano A, Mosopiri L, Omuoyo WN. Assessment of the physical properties of selected commercial soaps manufactured and sold in Kenya. Open Journal of Applied Sciences. 2017;4:433-440.
39. Awara AA, Atiku FA, Wawata IG, Gunu SI. Soap preparation from Soxhlet extraction of Nigerian cotton seed oil. Advances in Applied Science Research. 2016;2:617-623.
40. Draft East African Standards. EAS 186-2:2020.
41. Zauro SA, Abubakar I, Sani YM. Production and analysis of soap using locally available raw materials. Elixir Applied Chemistry. 2016;96:41479-41483.
42. Ogunsuyi HD, Akinnowo CA. Quality assessment of soaps produced from palm bunch ash-derived alkali and coconut oil. Journal of Applied Science and Environmental Management. 2012;19(4):363-366.
43. Hassan KL, Zubairu MS, Olayemi OR. Production of soap from neem seed oil and acacia seed oil. International Journal of Modern Organic Chemistry. 2015;4(1):70-84.
44. Betsy KJ, Jun M, Fatima R, Vakey JT. Determination of alkali concentration and total fatty matter in cleansing agents. Asian Journal of Science and Applied Technology. 2013;2:8-12.
45. Beetsch CL, Anza. Chemical characteristics of local black soap (*Chaha Lmtse*) made using cassava peel ash (Alkali base) and palm oil in North Central Zone of Nigeria. Civil and Environmental Research. 2013;3(4).
46. Encyclopedia of Industrial Chemical Analysis. Interscience Publication Division of John Wiley & Sons. 2007;18:179-180.
47. Taiwo AA, Oluwadare I, Shobo AO, Amolegge S. Extraction and potential application of caustic potash from kola nut husk, Ugwu pod husk, and plantain peels. Scientific Research and Essays. 2008;3(10):515-517.
48. Nemgbe IG, Zukdimma NA, Wulen BM, Lawam NN. Quality survey and safety of some toilet soaps in Nigerian market: A case study of Brinkin Ladi, Bokkos, and Pankshin, Plateau State. IOSR Journal of Applied Chemistry. 2014;7:29-35.
49. Safaraz AM, Razia C, Syed THS. Evaluation of physicochemical properties in selected branded soap. Pakistan Journal of Analytical Chemistry. 2019;20(2):177-183.
50. Mak-Mensah E, Firempong C. Chemical characteristics of soap prepared from neem (*Azadirachta indica*) seed oil. Asian Journal of Plant Science Research. 2011, 2.
51. Akunna TO, Ahaotu EO, Osuji CN, Ibeh CC. Production of soap using palm bunch ash. International Journal of Applied Science and Engineering. 2013;1(2):79-82.
52. Yahaya MK, Gimba CE, Achebo JI, Shuaibu MA. Physicochemical analysis of soap produced from tallow (Animal fat) and *Sesamum indicum* seed oil blends. Islamic University Multidisciplinary Journal. 2020, 7(4).