Earthline Journal of Chemical Sciences
E-ISSN: 2581-9003; CODEN: EJCSB4
Volume 11, Number 1, 2024, Pages 59-68
https://doi.org/10.34198/ejcs.11124.059068

Comparative Analysis of Soaps Produced Using Locally Made Alkali (*Elaeis guineensis*) and Industrial Made Alkali

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Abstract

This work was done to compare the qualities of soaps produced using locally made alkali and industrial made alkali. Hot method was used in the production of the soaps. The average value ± standard error of chemical parameters of the palm kernel oil were as follows; relative density (g/ml) (0.91±0.07, 0.89-0.910), saponification value (mg/KOH/g) (249.18±1.40, 189-199), iodine value (I2/100g) (18.74±0.86, 50-55), free fatty acid (mg KOH/g) (1.719±0.009, <0.5), acid value (mg/KOH/g) (3.60±0.06, ≤30). The quality parameters of soaps such as; foam stability, total fatty matter and moisture content were analyzed. The value ± standard error of the properties of soap produced with local alkali gotten from palm bunch and industrial alkali were as follows; foam stability (min^{-1}) (4.8±0.65, 3.5±0.40), total fatty matter (72, 75), moisture content (%) (13.0, 8.20). The result showed that palm bunch alkali has almost the same properties as pure potassium hydroxide soap.

Introduction

Soap is common cleansing agent well known to everyone. Many authors defined soap in different ways. Warra [16] regarded it as any cleaning agent, manufactured in granules, bars, flakes, or liquid form obtained from by reacting salt of sodium or potassium of various fatty acids that are of natural origin (salt of non-volatile fatty acids). Soap can also be said to be any water-soluble salt of fatty acids containing eight or more carbon atoms.

Soaps are produced for varieties of purpose ranging from washing, bathing, medication etc. The cleansing action of the soap is due to the negative ions on the

Received: August 28, 2023; Accepted: October 3, 2023; Published: October 25, 2023

Keywords and phrases: relative densities; iodine value; acid value; saponification value; free fatty acid; foam stability; hardness of soap; moisture content.

hydrocarbon chain attached to the carboxylic group of the fatty acids [14]. The affinity of the hydrocarbon chain to oil and grease, while carboxylic group to water is the main reason soap is being used mostly with water for cleaning purposes [1]. In addition to basic raw materials, other substances are added to the composition in order to improve its application. For examples soap made for medicinal purposes other medicinal importance ingredients are added to it to produce medicated soaps [4]. In addition to potassium and sodium salt, other metals such as calcium, magnesium and chromium are also used to produce metallic insoluble soap that are not used as cleaning agents, but are used for other purposes [4]. Other properties of the soap such as hardness are function of the metallic element present in the salt. For example; Soap made up of sodium salts shows little hardness compare to potassium salts soaps, provided the same fat or oil is used in both cases [15]. These are characteristically different from soaps made from divalent metals such as magnesium, calcium, aluminum or iron which are not water soluble, Soaps are use for laundry and cleaning purposes, though the used of calcium soap in the formulation of animal feed have been reported [10].

It is generally known that soap is produced by the saponification of a triglyceride (fat or oil). In the process the triglyceride is reacted with a strong alkali such as; potassium or sodium hydroxide to produce glycerol and fatty acid salts. The salt of the fatty acid is called **SOAP**.

The equations below represent typical saponification reactions;

$$\mathrm{C3H5\,(OOCR)3 + 3KOH \longrightarrow 3KOOCR + C3H5\,(OH)3}$$

Fat Potassium hydroxide Soap Glycerol

OR

$$\mathrm{C3H5\,(OOCR)3 + 3NaOH \longrightarrow NaOOCR + C3H5\,(OH)3}$$

Fat Sodium hydroxide Soap Glycerol

Where; R = Alkyl group.

Fatty Acids are straight-chain monocarboxylic acids. The commonest fatty acid used in soap making contains a range of C_{10}–C_{20} and most often have an even number of carbon atoms including the carboxyl group carbon. An example of such saturated fatty acid is palmitic acid, ($C_{15}H_{31}COOH$) while unsaturated fatty acid is oleic acid, $C_{17}H_{33}COOH$.

The Constituent Components of Fatty Acids Are Chiefly;

- Oleic acid, $C_{17}H_{33}COOH$
- Stearic acid, $C_{17}H_{35}COOH$
- Palmitic acid, $C_{15}H_{31}COOH$
- Lauric acid, $C_{11}H_{23}COOH$
- Myristic acid, $C_{13}H_{27}COOH$

Hydrocarbon oils or paraffin are not suitable for soap-making, as far as chemical combination with the caustic alkalis is concerned. The oils and fats which form soap are those which are a combination of fatty acids and alkali. While glycerin is obtained as a by-product to the soap making industry [16].

The aim of the present studies is to prepare and analyzed soap from industrial alkali and local alkali from local raw materials from palm bunch.

Materials and Methods

Sample collection and preparation

Samples of palm bunch which were used as a source for alkali (local potassium hydroxide) were collected from Chukka's farm Uli central, Anambra state, Nigeria. The samples were prepared by drying them and burning them into fine particles to obtain optimum alkali concentration.

The oil sample used for this study is the palm kernel oil which was randomly sourced in Uli central market. The sample was dried by adding anhydrous sodium sulphate for determinations in which result might be affected by moisture (e.g. iodine value). To retard rancidity, the sample was kept in cool place and protected from light.

Also, the industrial alkali (Potassium hydroxide) was collected from Central Drug House (P) Ltd.

Extraction of Alkali from Palm Frond Ashes

Palm fronds were collected and sun dried for 5 days. The dried palm fronds were heated on a "combustion pan" until the palm fronds ignited. To ensure uniform combustion, a metallic rod with a wooden handle was used to turn the burning frond during combustion. The ignited sample was ashed, crushed, homogenized and sieved to remove large particles. The molarity of the extracted alkali was determined by titrating against 0.1M hydrochloric acid using phenolphthalein indicator [8].

The amount of KOH in the extract was calculated from the equation below;

$$V_{KOH} = \frac{FW_{KOH}N_{KOH} \cdot V_{ex}}{100ml}$$

Where;

V_{KOH} = Amount of KOH in a given volume of extract

FW_{KOH} = Formula weight of KOH

N_{KOH} = Normality of KOH

V_{ex} = volume of extract (3250ml)

Determination of the Physicochemical Properties of the Oil

The analytical estimations were made for relative density, iodine value, acid value, saponification value, and free fatty acid.

Determination of relative density

Approximation method was used to determine the density of the oil as follows; 20ml of oil samples were measured and transferred into a cylinder of known weight.

The weight of the cylinder including its contents was measured and the density of the oil was calculated as follows;

$$\text{Relative Density} = \frac{\text{weight of the sample (g)}}{\text{volume of the sample (ml)}}$$

Aiwizea and Achebob [2].

Determination of saponification value

The number of mg of potassium hydroxide needed to saponify 1 gram of oil/fat is term as Saponification value. A certain amount of the oil (2g) was weighed and placed into a 300ml conical flask, 0.5 M solution of KOH was added to the above solution and heated at 55°C over water bath with continuous stirring. The temperature was raised to 100°C to complete the saponification process. The mixture was allowed to boil for about 1 hour. The excess KOH was titrated against the mixture using phenolphthalein indicator and the saponification value (SV) was determined using equation below:

$$\mathrm{SV} = \frac{\text{Average volume of KOH} \times 28.056}{\text{weight of the oil (g)}}$$

Where,

weight of sample = (weight of cylinder + weight of content) - weight of cylinder

Source: [2].

Iodine value determination

0.3g of the oil sample was placed in a flask and 20cm^3 of carbon tetrachloride was added to dissolve the oil followed by 25cm^3 of Wij's iodine solution. The flask was covered, shaken and kept in the dark for 50 minutes at room temperature. Then 20cm^3 of potassium iodide solution and 200cm^3 of distilled water were added. 'The liberated iodine was slowly titrated against 0.1N sodium thiosulphate solution until the yellow colour disappeared. At this point, about 2cm^3 of starch solution was slowly added and titration continued until the blue colour was discharged.

This process was repeated but without oil added (blank titration) [6]. Iodine value was calculated by the formula below:

$$\text{Iodine Value} = \frac{(\mathrm{B} - \mathrm{S}) \times \mathrm{N} \times 126.9}{\mathrm{W\ (g)}}$$

Where:

S= Volume (titre value) of $Na_2S_2O_3$ with sample titration.

B= Volume (titre value) of $Na_2S_2O_3$ for blank titration.

N= Nolarity of sodium thiosulphate.

Mole weight of Iodine =126.9.

W= weight of sample.

Determination of free fatty acid (FFA) and acid value

To the 25ml of 95% ethanol/ether (1:1) mixture, 2ml of 1% phenolphthalein solution was added. To the above solution, 5g of oil sample was added and the resulting solution was titrated against 0.1N NaOH solution with constant shaking until a pink color was developed and persisted for 30 seconds [13]. The process was replicated thrice for each of the detergent mixtures and the percentage free fatty acid expressed as its lauric acid content and acid values were determined by the formula below:

$$\%\text{FFA} = \frac{\text{vol. of NaOH (ml)} \times \text{normality of NaOH} \times \text{molecular weight}}{\text{sample weight (g)}}$$

$$\text{Acid value} = \%\text{FFA} \times 1.99$$

Analysis of soap composition and properties

Soap analysis was carried out immediately after production.

Determination of total fatty matter (TFM)

A sample of the scrapped soap (10g) was put into a 250cm^3 beaker. 100cm^3 of water was added and the mixture was heated on a water bath until the soap melted. 10cm^3 of 20% H_2SO_4 was added with continued stirring then 5g of candle wax and heating was continued until the wax melted. The whole content was allowed to cool to room temperature. The total fatty matter was then calculated.

Determination of free alkali as Na_2O

A sample of the scrapped soap (10 g) was placed in a conical flask and 100cm^3 of neutralized alcohol was added. The flask and the content therein were placed on a water bath and heated until the soap dissolved. The 10cm^3 of 10% Barium chloride solution and 2 to 3 drops of phenolphthalein indicator were added. The whole content was titrated against 0.1N H_2SO_4 until the solution became colorless. The free alkali as Na_2O was then calculated [5].

Moisture content determination

A sample of the scrapped soap (10g) was put into a dish and placed in an oven for 1 hour at 110°C. It was allowed to cool down and then weighed. The moisture content in percentage was calculated.

Determination of foam stability and hardness of soap

The soap produced was used to form lather in water and the time taken for the foam-to collapse was determined using a stopwatch. The hand feel hardness was determined relatively to each other.

Results and Discussion

Results

The chemical properties of the oil shown in Table 1 in respect to each parameter, statistical values were taken from the practical carried out.

The table showed that the values obtained compared favorably with the Food Agricultural Organization (FAO) standard for palm kernel oil (PKO).

Table 1. Chemical parameters of palm kernel oil (PKO) and FAO standard value.

Parameters	**PKO**	**FAO (Standard value)**
Relative density (g/ml)	0.91±0.07	0.89-0.910
Saponification value(mg/KOH/g)	249.18±1.40	189-199
Iodine value (I_2/100g)	18.74±0.86	50-55
Free Fatty Acid (mgKOH/g)	1.719±0.009	<0.5
Acid Value (mg/KOH/g)	3.60±0.06	≤30

Values are mean ± standard deviation of triplicate determinations.

The properties of soaps produced using locally made alkali and industrial made alkali were shown below;

Table 2. Properties of the soap on palm kernel oil.

Properties of soap	**PKO/local KOH**	**PKO/Industrial KOH**
Foam stability (min^{-1})	4.8±0.65	3.5±0.40
Total fatty matter (%)	72	75
Moisture content (%)	13.0	8.20

Values are mean ± standard deviation of triplicate determinations.

Discussions

Table 2 shows the relationship between locally made alkali and industrial alkali obtained during the analysis of the soap. The results showed that the foam stability (min^{-1}) value for the PKO/ local KOH was at (4.8±0.65) whereas the PKO/ industrial KOH value was at (3.5±0.4) which implied that the soaps produced from local alkali had more lathering properties than soaps produced with industrial alkali. The soap produced from local KOH had total fatty matter of (72%) while that of industrial KOH value was at (75%) which indicated that making use of local KOH in soaps had good qualities in comparison with the industrial alkali. The soap produced from local KOH had moisture content of (13.0%) while that of PKO/ industrial KOH value was at (8.2%) which indicated that making use of local KOH will create a softer soap in comparison to the soap made with industrial KOH.

The physicochemical parameters of the palm kernel oil in Table 1 shows the relative density agrees with FAO standard value and the values obtained by other researchers (0.860-0.873 g/ml) elsewhere (Amaoo *et al.* [3]). The saponification value of palm kernel oil is 249.18±1.40mg KOH/g which is in agreement with 249.90 for palm kernel oils reported by Aremu and Amos [7]. The saponification value of the oils is in agreement with the finding of Kyari [11]. Saponification value of oil is the number of milligrams of potassium hydroxide required to saponify one gram of oil under the conditions specified. The higher the saponification value, the lower the fatty acids average length, the lighter the mean molecular weight of triglycerides and vice-versa. Practically oils with high saponification value are more suitable for soap making. The free fatty acid of palm kernel oil is 1.719±0.009 mgKOH/g and the acid value is 3.60±0.06 mgKOH/g which corresponds favourably to the FAO standard value. The iodine value of palm kernel oil is 18.74±0.86 I_2/100g. It is evident from the above that the saponification and iodine value of the oil is complementary. The higher the saponification values of the oil, the lower the iodine value of the oil and vice-versa. Palm kernel oil is made up of over 80% saturated fatty acids by composition, hence the low iodine value recorded. Low acid value in oil indicates that the oil will be stable over a long period of time and protect against rancidity and its suitability in soap making [12]. The acid value obtained in this work is within the standard set by FAO [9].

Conclusion and Recommendation

Conclusion

Palm bunch ashes can be used to produce neat soap which is of almost the same properties as pure potassium hydroxide soap. Instead of importing alkalis for soap production, palm bunch ashes, especially those of *Elaeis guineensis* should be used as alkali sources. The ashes can be locally sourced because the specie grows abundantly in the eastern part of Nigeria (Anambra State). This will help reduce the cost of raw materials, improve production and the economy of the region. When sourcing for raw materials for soap production, *Elaeis guineensis* should be used as it contains high percentage of potassium carbonate alkali. Production of soap with purified alkali made from palm bunch ash is an improvement over the conventional method adopted for black soap. The qualities of soaps thus produced clearly indicated that exploitation of vegetable matter to generate alkali for soap production is worthwhile. Apart from the fact that our environment would be free of those agricultural wastes that often render them untidy, it will save the environment from the potential harmful effects of pollution that commonly associate with these synthetic chemicals. In addition, the heavy dependence on synthetic chemicals for soap production would drastically reduce if concerted effort is made on improving this source of raw material for soap making.

Recommendation

Considering the environmentally friendly nature of local alkali sourced from *Elaeis guineensis*, we therefore recommend the use of the local alkali in soap making.

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