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Production and Analysis of Soap using Locally Available Raw-Materials

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ABSTRACT

The use of locally available raw materials in soap production was carried out. The soap was prepared using sheabutter oil (SBO), palm kernel oil (PKO) and plantain peels. The physicochemical parameters of the oils were analysed. The saponification values of the oils 175.30±0.81mgKOH/g (SBO) and 249.18±1.40mgKOH/g (PKO), and the iodine values 65.99±1.27 I_2/100g (SBO) and 18.58±0.86 I_2/100g (PKO) agreed with those found in literature. The free fatty acid (FFA), acid value and Relative density were found to be 1.719±0.009, 3.60±0.06mgKOH/g and 0.90±0.02 for PKO and for SBO the corresponding values were 5.499±0.113, 11.78±0.56mgKOH/g and 0.91±0.07 respectively. The alkali was extracted from the plantain peels ash and used to saponify the oils for the production of soap. The soap produced was analysed by testing its hardness, moisture and foaming stability. The results indicated that the soap produced by SBO:PKO (50:50) showed a very good properties, hence regarded better compared to the soap produced by SBO and PKO separately.

Introduction

Soap is common cleansing agent well known to everyone. Many authors defined soap indifferent ways. Warra, [1], 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 hydrocarbon chain attached to the carboxylic group of the fatty acids [2]. 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 [3].

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 [5]. 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 [6].

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

$$C_3H_5(OOCR)_3 + 3KOH \longrightarrow 3KOOCR + C_3H_5(OH)_3$$

Fat Potassiumhydroxide Soap Glycerol

OR

$$C_3H_5(OOCR)_3 + 3NaOH \longrightarrow NaOOCR + C_3H_5(OH)_3$$

Fat Sodiumhydroxide Soap Glycerol

Where R represents the hydrocarbon chain or 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. Examples of such saturated fatty acid is palmitic acid (CH_3-$(CH_2)_{14}$-CO_2H), while unsaturated fatty acids is oleic acid, $C_{17}H_{33}COOH$.

The constituent component of fatty acids, are chiefly oleic ($C_{17}H_{33}COOH$), stearic ($C_{17}H_{35}COOH$), palmitic ($C_{15}H_{31}COOH$), lauric ($C_{11}H_{23}COOH$) and myristic ($C_{13}H_{27}COOH$) acids; 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 obtain as a by-product to the soap-making industry [1].

Shea butter is a white or milky colored fat extracted from the nut of the African shea tree (*Vitellaria paradoxa*). Shea butter is a triglyceride (fat) that is derived from mainly stearic acid and oleic acid [7].

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Shea butter extract is a complex fat that contains the following fatty acids: oleic acid (40-60%), stearic acid (20-50%), linoleic acid (3-11%), palmitic acid (2-9%), linolenic acid (<1%) and arachidic acid (<1%) [8].

Chemical analysis of Shea butter extracted from nuts sample in Nigeria shows that the extract contain 47% oleic acid [9].

Palm kernel oil is majorly lauric acid containing saturated fatty acids of C_6-C_{18} chain. It has a sharp melting point when heated. Higher quality soap is produced using 10-15% lauric acid [10].

Alkalis are water soluble base, usually hydroxide or oxide of potassium or sodium. Alkali can be produced locally from ashes as "potash" by extraction with water. It is generally believed that the highest soluble metal is potassiumA, though this depends on the species of the plant material and the type of soil where the plant grows [11].

The plantain is a crop from the genus Musa, scientifically named *Musa Paradisiaca* is a very starchy. It is a fast - growing plant 3-5m high with herbaceous stem. The fruits grow in bunches of up to 200 fingers each, edible and are process differently for consumption. it is different from the soft and sweet banana (which is often called dessert banana). Plantains are often firmer than dessert bananas; they also have less sugar. Dessert bananas are often eaten raw; plantains are usually processed before they are eaten. Plantains are among the staple food in tropical regions, treated similarly to potatoes. They also have a similar taste [12]. The plantain fruits are highly nutritious, containing large amounts of carbohydrates and minerals such as calcium, phosphorus, and potassium as well as vitamins A and C.

Several studies have been carried out on the potash content of some plant materials such as: cocoa husks [13], fresh plantain trunk [14], unripe plantain peel [11], ripe plantain peel, groundnut shell and sorghum chaff [15].

The used of ashes obtained from agricultural materials as source of industrial alkali have reported [16]. Research has shown that plantain peel ash has been used to produce soap of good quality.

The aim of the present studies is to prepare and analysed soap from locally available raw materials such as; shea butter, palm kernel and plantain peels.

Materials and Methods

Materials

The materials/reagents used in this work are; shea butter oil (SBO), palm kernel oil (PKO) and plantain peel which were sources randomly from Sokoto central Market, Sokoto state, Nigeria. Ethanol, ether, KOH, NaOH, anhydrous Na_2SO_4, iodine monochloride, glacial acetic acid, CCl_4, HCl, KI, Sodium thiosulphate, phenolphthalene were al obtained from BDH chemicals England. Distilled water was used throughout the period of experiment.

Methods

Sample Preparation

The samples were dried by adding anhydrous sodium sulphate for determinations in which result might be affected by moisture (e.g. iodine value). To retard rancidity the samples were kept in cool place and protected from light and air [17].

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;

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

Aiwizea and Achebob [18].

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 ^{0}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:

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

Where the weight of sample = (weight of cylinder + weight of content) - weight of cylinder Aiwizea and Achebob, [18].

Determination of Iodine value

0.3g of the oil sample was placed in a flask and 20 cm^3 of carbon tetrachloride was added to dissolve the oil followed by 25 cm^3 of Wij's iodine solution. The flask was covered, shaken and kept in the dark for 50 minutes at room temperature. Then 20 cm^3 of potassium iodide solution and 200 cm^3 of distilled water were added. 'The liberated iodine was slowly titrated against 0.IN 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) [17]. Iodine value was calculated by the formula below:

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

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

126.9= mole weight of Iodine

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 0.10N NaOH solution with constant shaking until a pink color was developed and persisted for 30seconds [19]. 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:

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

$$Acid\ value = \%FFA \times 1.99$$

Extraction of Alkali from Plantain Peel Ashes

Unripe plantain peels were collected and sun dried for 5 days. The dried peels were heated on a "combustion pan" until the peels ignited. To ensure uniform combustion, a metallic rod with a wooden handle was used to turn the burning peel during combustion. The ignited sample was ashed crushed, homogenized and sieved to remove large particles.

The sieved samples (150g) was placed in distilled water, agitated for 5 minutes and allowed to stand for 12 hours. The slurry was then decanted and the filtrate was heated for 10 hours at 60 ^{0}C and the bleached alkali was filtered using Whatman No 44 filter paper to obtain the extract. The molarity of the extracted alkali was determined by titrating against 0.1M hydrochloric acid using phenolphthalein indicator [20].

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

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

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)

Saponification Reactions Using Ash-extract and Sheabutter/Palm Kernel Oil.

The manufacture of soap involved the following processes: Saponification reaction; "salting out" and what is called "fitting" process to obtain a neat soap. 3250ml of the ashed plantain peel extract containing 419.3g of potassium hydroxide was concentrated to 50% KOH by evaporation. The saponification process adopted was semi-boiled method as described by Schumann and Siekman [21]. The procedure was modified with the exemption of NaOH. The oil was poured into a stainless steel container and heated to 60^{0}C. The purified alkali was added continuously with stirring until the mixture became sticky. 20ml of NaCl solutions was added for salting out and the soap was completely homogenized for 30 min.

Analysis of Soap

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 measured using a stopwatch. The hand feel hardness was determined relative to each other

Moisture content

Moisture content was determined by drying 10g of the sample to a constant weight at 105 ^{0}C according to AOAC [17]. It was allowed to cool and then reweighed. The % moisture content was calculated from the formula below;

$$\%Moisture\ content = \frac{W_1}{W_2} \times 100$$

Where

W_1=weight of soap after drying

W_2=weight of soap before dryings

Results and discussion

The results of the physico-chemical parameters of the shea butter and palm-kernel oils are shown in table 1. The data were presented as mean$\pm$ standard error of mean of triplicate analysis.

Discussion

The physicochemical parameters of both SBO and PKO (Table 1) reported in this work shows relative density agrees with FAO standard value and the values obtained by other researchers (0.860-0.873 g/ml) elsewhere [23]. The Relative densities of the two oils are almost the same. The saponification value for SBO oil is 175.30±0.81mgKOH/g which is also between the reported values of 178-198 in [23], while that of PKO is 249.18±1.40mgKOH/g which is in agreement with 249.90 for palm kernel oils reported by Aremu, [24]. The SV of the oils are in agreement with the finding of Kyari, [25]. The FFA of SBO is 5.499±0.113mgKOH/g while that of PKO is 1.719±0.009 mgKOH/g and the acid values are 11.76±0.56 mgKOH/g and 3.60±0.06 mgKOH/g respectively. The saponification value of the two oils indicated their suitability in soap making. The iodine values for SBO is 65.99±1.27I_2/100g which showed that SBO contained higher number of unsaturation compared with PKO whose iodine value is 18.74±0.86 I_2/100g. The Iodine value reported in literature for SBO is 61.00I_2/100g [25]. It is evident from the above that the saponification and iodine values of the oil are complementary. The oil with high saponification value has low iodine value and vice-versa. Therefore, we expect this blend to produce good quality soap with the combined properties of the two oils, particularly for the blend ratio in samples 50:50. Usually, oils with low iodine values produce hard soaps. For example, coconut oil and PKO give hard soaps with large bubbles which is short lived oils with medium iodine values e.g. palm oil (PO) and Beef tallow oil (BTO) give short lived bubbles [16]. Kuntom *et. al.*, [26] produced and studied the soap using blends of distilled fatty acids of palm oil (PO) and palm-kernel oil (PKO) and observed an increase in acid value and hardness of the soap, while the iodine value decreases as the ratio of PKO increases. It is not surprising therefore, that the soap from hundred percent PKO is the hardest in term of hand feel amongst the soaps produced from the blend studied. PKO is made up of over 80% saturated fatty acids by composition, hence the low iodine value recorded. It is however surprising that the remaining oil blends do not follow this pattern. For example SBO placed second in the order of hardness whereas it is expected to be the softest, because of the high iodine value of the SBO. This suggests that other factors other than unsaturation must be responsible for this behaviour. Possibly, a reaction at the double bond centers of the SBO occurs before saponification through thermal oxidation and hydrolysis when the oil was heated for filtration [27]. Acid value (AV) measured the quality of fatty acids in oil. 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 [28]. The AV obtained in this work is within the standard set by FAO [22].

Table 1. Physicochemical parameters of Sheabutter oil (SBO), palm-kernel oil (PKO) and FAO standard value.

Parameters	SBO	PKO	FAO [22] standard
Relative Density (g/ml)	*0.90±0.02*	*0.9* I±0.07	*0.89-0.910*
Saponification Value (mgKOH/g)	175.30±0.81	249.18±1.40	189-199
Iodine value (I_2/100g)	65.99±1.27	18.74±0.86	50-55
Free Fatty Acid (mgKOH/g)	5.499±0.113	1.719±0.009s	< 0.5
Acid Value (mgKOH/g)	11.78±0.56	3.59±0.06	≤ 30

Table 2. Properties of the Soap immediately after production.

Properties of Soap	SBO	PKO	SBO:PKO (50:50)
Foam Stability (min^{-1})	2.00±0.01	3.70±0.06	1.90±0.03
Hardness of soap	2±0.04	1±0.00	9±0.21
Moisture Content (%)	8.20±0.43	8.20±0.54	10.60±0.87

Table 3. Properties of the soap after 8 weeks of production.

Properties of Soap	SBO	PKO	SBO:PKO (50:50)
Form Stability (min^{-1})	2.45±0.02	4.15±0.09	3.20±0.07
Hardness of soap	2±0.01	1±0.03	9±0.09
Moisture content (%)	3.75±0.12	7.40±0.21	4.70±0.18

Tables 2 and 3 showed the properties of the soap immediately and after eight weeks of production respectively. The foam stability was determined by measuring the time it takes for the lather formed by the soap with pure water to collapse. Sample PKO has the longest time for lather collapse hence it has highest Foam stability value of about 3.70 minutes for the fresh soap and 4.15 minutes for the eight week old soaps, this observation corroborates moisture loss, that is, as the moisture content reduces, the foaming strength increases. There is great moisture loss also as the soap ages, for example, the moisture content of the soap is 8.20% when freshly prepared and 3.70% after eight weeks. However, if foam stability is considered the most desirable soap quality and then sample SBO: PKO emerges the most suitable soap in the present study.

Conclusion

The production of soap from shear butter and palm kernel with purified alkali made from plantain ash was successfully achieved using an improved conventional method adopted for black soap production. 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 effect on pollution that commonly associate with these synthetic chemicals. In addition, the heavy dependence on synthetic chemicals for soap production would drastically reduced if concerted effort is made on improving this locally source of raw material for soap making.

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