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Quality Evaluation of Some Laundry Soaps Sold in Markets of Port Harcourt, Rivers State, Nigeria

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Abstract

Ten commercial laundry soaps labeled A to J, purchased from some markets in Port Harcourt, Rivers State, Nigeria were evaluated for their physicochemical properties, including declared and actual weight, hardness, perfume level, colour, staining and cracking test, foam stability, rate of ware, pH, moisture and volatile matter (M&V), Free alkali (FA), Total fatty matter (TFM), and chloride content (Cl) using Standard methods. Results showed that pH ranged from 9.5 to 11.0, moisture content varied from 15.2 to 23.6%, free caustic, total fatty matter, and chloride ranged from 0.04 to 0.26%, 42.3 to 52.0%, and 0.8 to 3.2 %, respectively. Similarly, alcohol insoluble matter and water insoluble varied from 1.5 to 3.0% and 0.8 to 1.5 %, respectively. Foam value and stability ranged from 69 to 82, while the rate of wear varied from 8 to 25%. All the samples failed in the declared and actual tests. The study revealed that many of the laundry soaps sold in the markets do not conform to the minimum standard recommended by the Nigerian Institute of Standards (NIS). It is, therefore, recommended that regular quality checks should be carried out by regulatory agencies to ensure that the quality of laundry soaps sold in the markets meets the minimum obligatory standard.

Keywords: Commercial, Standard, Recommended, Test, Physicochemical.

Introduction

Soap is formed by reacting vegetable/animal fats or oils with potassium or sodium hydroxide. The process is termed saponification. This involves the hydrolysis of triglycerides by a base (NaOH or KOH) to produce soap and glycerol. In the saponification reaction, triglyceride fats are hydrolyzed at the beginning to give free fatty acids, which later react with the aqueous alkali to produce soap [1]. Soap is generally referred to as the salt product of a fatty acid, as seen in Scheme 1[2].

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

Fat alkali Soap Glycerol

Scheme 1: Saponification reaction

The hydrocarbon chain known as the soap molecule has a carboxylic acid group at one end that is bonded to a metal ion, normally sodium or potassium, through an ionic bond. The organic end is hydrophobic while the carboxylate end is hydrophilic. The ionic end is soluble in water, but the hydrocarbon end is non-polar and highly soluble in non-polar substances. The ability of soaps to emulsify or distribute water-insoluble compounds and keep them in the suspension of water is what gives them their cleaning properties. Soap molecules crystallize in various ways, depending on the alkali used. KOH is usually used to make soft soaps, while NaOH generates hard bars [3].

Valuable soaps have hydrophilic carbon chains of 12 to 18 for detergency. Any soap with fewer than 12 hydrophobic carbon atoms cannot remove oil, but can function as a detergent if it has more than 18 hydrophilic carbon atoms. The soap is a detergent, but detergent has been used loosely to refer to only synthetic detergent [4, 5]. Fat is a valuable constituent for washing. Sodium carbonate is added to harden them. It also aids the cleansing effects of the soap and acts as a softening agent. Sodium silicate or water glass is used as filler. Laundry and toilet soaps are the same in terms of major raw materials, animal oil, vegetable oil, and caustic soda, and the principle of production is saponification. Toilet soap is made for cleaning skin so they are added with ingredients that are beneficial to the skin like anti-bacterial, moisturizing, deep cleaning, and protection substances, etc, while laundry soap is made for cleaning clothes and shoes, so it is made to have more alkaline properties than toilet soaps [6]. In terms of foam value & stability**,** good soap must possess good lathering and cleaning properties, and the foam created when stirred in water should be stable for some time.

A good soap should be free from objectionable odors. When colored laundry soap is used in washing any white fabric, it should not leave any visible stains after washing and thorough rinsing with water. When immersed in water for one hour at 25 30 °C, good laundry soap should not disintegrate, and when dried at room temperature for 25 hours thereafter, it shall not crumble, crack, or break.

Good quality soap for cleansing purposes strikes a balance in all the physicochemical parameters [7]. Investigation of the levels of the physicochemical properties in Kenya bar soaps that are used for cleansing purposes, manufactured and sold in Kenya markets, has been carried out, and the researchers reported that the soaps were similar in their levels of physicochemical parameters [8]. An assessment of the physicochemical properties of liquid soaps in Port Harcourt, Rivers State was carried out and the researchers reported that the inorganic salt content and pH levels of the soaps were not within standard, and this may be responsible for the skin irritation experienced by people after the use of such detergents [9]. There is, therefore, a need for constant quality assessment of soaps and detergents sold in the markets.

Other important soap parameters include:

pH:-The pH level of soap can vary with the brand and with the function of the soap. Soaps with pH values below 5 and those with pH above 10 are associated with harshness on the hands and skin. Soap is alkaline in aqueous solution; as a result, soap is generally expected to have a pH above 7. A high pH value is an indication of incomplete alkali hydrolysis resulting from the saponification process.

Moisture Content - This is a measure of the amount of free water present in the soap. It is an important parameter used to determine the shelf life of soap. Excess water in soap reacts with any unreacted triglycerides (Fats/Oils) that might be present in soap (hydrolysis) to form fatty acids and glycerol on storage. High moisture content in soap increases the solubility of the soap, which leads to waste. The foaming strength increases as the moisture content reduces [10].

Free Caustic Alkali (FCA) – This is defined as the free sodium hydroxide or free alkali used in making soap. Free Caustic Alkaline content determines the abrasiveness of the soap. Superior soap should contain little or no free alkali [11]. Soap with an excess amount of FCA irritates the skin and wears out clothes. Alkaline soaps are characterized by a high content of FCA, leading to skin dryness and scaling, which cause the skin to become susceptible to fungal attacks. This is because the excess alkali saponifies the fats and oils that are normally found on the skin as a protective coat to form soluble soap and therefore get washed away, thereby rendering the skin dry.

Total Fatty Matter (TFM) – This is the total amount of fatty matter, mostly fatty acids, which results from the presence of unreacted alkali in the soap. Low TFM is normally associated with lower soap quality that results in limited removal of grease and other fatty matter from clothes during laundering [12. 13].

Matter insoluble in alcohol – This depends on the level of fillers in soap. The higher the level of matter insoluble in alcohol,the lower the quality of soap.

Water insoluble matter is a property that describes how insoluble soap is.

Good quality soap must conform to the Nigerian Institute Standard (NIS). Hence, this study is focused on evaluating the quality of some laundry soaps sold in Port Harcourt, River State, Nigeria, through the measurements of soap parameters like declared and actual weight, hardness, perfume level, color, staining and cracking test, foam stability, rate of ware, pH, moisture and volatile matter (M &V), Free alkali (FA), Total fatty matter (TFM), and chloride content.

Materials and methods

Sample Collection

Ten different laundry samples labeled A to J were purchased from some markets in Port Harcourt, Rivers State, Nigeria, and taken to the Chemistry Department laboratory, Rivers State University, Port Harcourt, for analysis.

Equipment and Reagents

Analytical balance (Ohaus. scout pro SPU202), pyknometer (Orison base 20), oven (Memmert model 500, Japan), distilled water, petroleum ether, sodium hydroxide (0.5 N), methyl orange indicator, phenolphthalein indicator, nitric acid (0.5 N), oxalic acid (0.25 M), Sulphuric: acid (0.05 N), sodium carbonate (0.05 N), anhydrous sodium sulfate, pH buffers (4, 7 and 9) and distilled ethanol (95 %w/w) were used for this study. All chemicals were of analytical grade and were obtained from Joechem Chemicals, Choba, Port Harcourt, Rivers State.

Methods

Sample Preparation

The soap samples were removed from their covers and weighed to ascertain declared and actual weights. They were reduced into smaller pieces with the aid of a grater for further analysis. Grated samples were kept in airtight plastic containers. The samples were stored at ambient temperature until required for laboratory analysis.

Determination of Soap Weight

The procedures described by AOAC (2019) for the determination of weight were followed [14]. The soaps were weighed in a digital Balance (Mettler PE160, Switzerland). The analysis was conducted, and the average value was taken.

Determination of Soap Hardness (Penetration Value)

A hardness test on the soap was done by piercing a needle through the surface of the soap. The distance at which the needle pierced through the bar of soap determined its hardness. Generally, hard soaps penetrate less, while soft soaps penetrate more. Soap hardness is recorded as soft, hard, or brittle. The more the penetration, the softer the soap, and vice versa

Rate of Ware

As described in Standard (NIS) 005 (2006) [15], the soap samples were weighed first and then washed 30 times under running water. After, it was damped and re-weighed. The rate of waste was calculated using Equation 1.0.

$$\text{Rate of ware} = \frac{W_1 - W_1}{W_1} \times 100 \quad 1.0$$

Where,

W_1 = weight of soap before washing

W_2 = weight of soap after washing

Fragrance test

The soap was analyzed for the presence of fragrance using the sense of smell

Staining Test

Using the method described in NIS, 004 (2006) [16], the soap samples were used in washing white fabric to determine if any visible stains on the fabrics would be left after washing and thorough rinsing with water. It is reported as a passed or failed staining test.

Soap Cracking Test

Soap samples were immersed in distilled water for one hour at 25-30℃°C, and dried at room temperature for 25 hours to check if, thereafter, they would crumble, crack, or break. The number of cracks was recorded. It was reported as crumbed or not crumbled, as described by East African Standard (2011) [17].

Foam Stability

One percent (1%) of the soap sample was prepared, and an equal amount of the soap solution was measured into test tubes. The solution was shaken vigorously for 1 minute and allowed to stand for five min.; the height of the foam was observed and recorded.

Cleaning Properties

A drop of used oil was placed on strips of filter paper. The strips were placed into test tubes containing the 1% soap. The soap solutions were then shaken vigorously and allowed to stay for 2 min, the filler paper was removed, and rinsed with water. The cleansing power was observed and recorded,

pH determination

A 10% soap solution was prepared by weighing 10 g of the chopped soap into a 250 mL conical flask and dissolved in 100 mL distilled water with slight warming over a water bath. The pH of the soap solution was determined using a pH meter (Hanna pH 211 microprocessor pH meter) as described by AOAC (2017) [18]. Before reading pH, each sample was agitated (using a magnetic stirrer) until a stable reading was assessed. Between readings, the electrode was rinsed with distilled water for the accuracy of the measurement. Each test was made in triplicate.

Moisture Content Determination

Five (5g) grams of the chopped soap samples were accurately weighed using an analytical balance of sensitivity 0.1 mg into a dried petri dish and placed in an air oven for 2 h at a temperature of 105℃°C. At the end of 2 Hr, the sample was removed from the oven, cooled in a desiccator, and re-weighed to a constant weight. Moisture was calculated using the formula below as described in AOAC (2019) [14].

$$\% \text{ Moisture} = \frac{w_1 - w_2}{W_1 - W_o} \qquad 2.0$$

Where:

W_o = Weight of empty Petri dish

W_1 = Weight of Petri dish + sample before drying

W_2 = Weight of Petri dish + sample after drying.

Determination of Free Caustic Alkaline (FCA)

According to the method described by AOCS (2017) [19], five (5g) grams of chopped soap samples were weighed and dissolved by warming in 30 mL of neutralized ethanol. A few drops of phenolphthalein indicator and 10 cm^3 of 10% Barium chloride ($BaCl_2$) solution were added. The whole content was titrated against O.1N H_2SO_4 until the solution became colorless. The free caustic alkali obtained was calculated using the formula:

$$FCA = \frac{0.31}{W} \times V_A \qquad 3.0$$

Where V_A = Volume of acid used, W = Weight of soap.

Determination of Chloride Content

Ten (10g) grams of the soap samples were weighed, and 100 mL of distilled water was added and heated over a water bath to dissolve with occasional agitation. 2-3 drops of methyl red indicator were added, followed by the addition of a few drops of $H_2SO_{4(aq)}$. This is acid hydrolysis. The solution was then filtered, and the resulting solution was titrated against 0.1 $AgNO_3$ using K_2CrO_7 as an indicator till a brick-red color was obtained. Chloride content was calculated as described by AOAC (2019) [14].

$$\%\ \text{Chloride content} = \frac{\text{Titre volume}}{\text{Weight of soap}} \times 0.585 \qquad 4.0$$

Matter Insoluble in Alcohol

Matter insoluble in alcohol was determined by the method described in AOCS (2017) [19], with slight modifications. Five (5 g) grams of soap sample was dissolved in 50 mL hot ethanol and quantitatively transferred to a pre-weighed filter paper. The residue was dried in the oven at 105°C for 1 Hr, cooled, and re-weighed again. Matter insoluble in alcohol was calculated using the following formula.

$$\%\text{Matter insoluble in alcohol} = \frac{Ws-FP}{W} \times 100 \qquad 5.0$$

Where;

W_s = Weight of sample + filter paper, FP = Weight of filter paper, W = Weight of the sample.

Matter Insoluble in Water

The matter insoluble in water was determined by the method described in AOCS (2017) [19], with slight modifications. Five (5 g) grams of soap sample was dissolved in 50 mL hot water and quantitatively transferred to a pre-weighed filter paper. The residue was dried in the oven at 105°C for 1 Hr, cooled, and re-weighed again. Matter insoluble in water was calculated using the formula below.

Matter insoluble in water (%) = $\frac{Ws-FP}{W} \times 100$

6.0

Where:

Ws = Weight of sample + filter paper

FP = Weight of filter paper

W = Weight of the sample

Total Fatty Matter Determination (TFM)

With slight modifications, the method described in AOCS (2017) [19] was followed. About 10 grams of flaked soap was weighed, and 150 mL of distilled water was added and heated to dissolve. To the dissolved solution was added a few drops of methyl orange indicator, followed by the addition of concentrated H_2SO_4 (acid hydrolysis). The solution was cooled and transferred to a separatory funnel before adding 50 mL diethyl ether and extracting the fatty matter from the residue three times. The extracted fatty matter was transferred to a weighed empty flask, and the solvent was evaporated.

The residual solvent in the extracted fat was further dried in an air oven, cooled in a desiccator, and weighed. The total fatty matter was obtained using the formula.

$$\% \text{ TFM} = \frac{\text{Difference in wt}}{\text{Weight of Sample}} \times 100$$

7.0

Where: Difference in weight = weight of oil - the weight of the empty flask

Weight of sample = weight before analysis

Results and Discussion

The results of the physicochemical properties of the laundry soaps are presented in Tables and Figures below

Table 1: Some physical properties of the soap samples

Soap Sample	Hardness	Perfume	Color	Staining test	Cracking
A	Hard	Okay	White	Passed	Nil
B	Hard	Good	White	Passed	Nil
C	Hard	Good	White	Passed	Nil
D	Hard	Good	White	Passed	Nil
E	Hard	Okay	White	Passed	Nil
F	Hard	Okay	Cream	Passed	Nil
G	Hard	Good	Yellow	Passed	Nil
H	Hard	Good	Pink	Passed	Nil
I	Hard	Good	White	Passed	Nil
J	Hard	Okay	White	Passed	Nil

Table 2: Declared and Actual weights of the soap samples

Soap Sample	Declared weight (g)	Actual weight (g)
A	70	66
B	75	70
C	75	72
D	75	72
E	70	66
F	70	65
G	75	70
H	75	66
I	75	65
J	75	72

Table 3: Foam value and stability of the soap samples

Soap Sample	Foam & Stability (mL)	Nigerian industrial standard (NIS) (mL)
A	69	200 max
B	80	-
C	70	-
D	76	-
E	80	-
F	79	-
G	70	-
H	81	-
I	82	-
J	71	-

Table 4: Rate of wear of the soap samples

Soap Sample	Rate of ware% %	Nigerian industrial standard (NIS) (mL)
A	25	5 % max
B	10	-
C	10	-
D	12	-
E	10	-
F	15	-
G	20	-
H	12	-
I	8	-
J	9	-

Table 5: Physicochemical properties of the soap samples

Parameters	A	B	C	D	E	F	G	H	I	J	NIS
pH	10.00	10.00	11.00	10.0	11.00	9.50	10.5	11.00	10.50	10.00	7-10
MC (%)	22.80	22.30	23.60	22.8	25.00	21.50	18.6	19.30	20.40	15.20	10-30
FCA (%)	0.25	0.15	0.26	0.15	0.04	0.18	0.22	0.16	0.20	0.25	0.20
AIM (%)	3.00	2.50	3.20	2.80	1.70	1.50	2.8	2.80	3.00	1.20	2.50
WIM (%)	1.50	0.80	0.70	0.40	0.70	0.80	1.00	1.10	1.12	0.80	0.50
TFM (%)	42.30	48.00	45.00	48.00	46.0	50.0	44.7	45.00	41.85	52.0	62.0
CL (%)	2.00	1.20	2.80	2.40	3.20	1.20	2.00	1.60	2.35	0.80	1.50

Key: NIS = Nigeria Industrial Standard, MC = Moisture content, Free caustic alkali, AIM = Alcohol Insoluble Matter, WIM = Water Insoluble Matter,
TFM = Total Fatty Matter, Cl = Chloride content

Results of the physicochemical properties of the laundry soaps presented in Tables 1-5 show that the soap weight of all the soap brands differed from the actual and declared weight.

Hardness: It was observed that all the soap brands are hard. According to the East African Standards Committee (EAS 31:2011) [17], laundry soap should be of firm texture, not brittle.

pH: The pH values for the soap samples are within the range, except for C, E, and G samples, which had a pH of 11.0. Soap solutions with a basic pH may hurt human skin after washing clothes.

The moisture content of the laundry soaps ranged between 15.2 and 25.0 %. This indicates that most of the soaps analyzed will not favor the growth of microbes. The moisture content is lower than the 29.05% obtained by some earlier researchers for black soap [20]. Moisture content is a parameter that is used in assessing the shelf life of a product [21].

Free caustic content: The Nigerian Industrial Standards (NIS) requirement for free caustic content in laundry soap is 0.2 percent maximum. All the brands had values lower than the maximum limit except for samples B, D, and F. The free caustic alkali is the amount of alkali-free to counter and avert the soap from becoming oily. Excess-free caustic alkali causes skin itching.

Alcohol-insoluble matter: The values for all the soap brands conformed to the specification. High value contributes to the mushiness of soap and reduces its quality. Also, high Water Insoluble Matter in soaps results in high mushiness.

Total fatty matter (TFM): High TFM in the soap means good quality. According to NIS standards, laundry soap should have at least 62 percent minimum; however, all the brands failed to comply with the minimum requirement of total fatty matter, and this decreases soap quality. TFM values are due to moisture, low fat, and the presence of unreacted alkali in the soap. Similar reports have been made by earlier researchers [7, 13, 22].
Low TFM is linked to excess fillers. This lowers the effective removal of dirt and grease from clothes during laundry.

Chloride: Sodium chloride is used in the soap industry for soap precipitation. The standard requirement is 1.50 percent maximum. The values obtained for samples A, C, D, E, and J were all above the maximum permissible limit.

Conclusions

The results of this study have provided some information on the quality of some laundry soaps sold in Port Harcourt markets. All the brands of soap analyzed failed in declared and actual weight. Most of the soap samples are highly filled with insoluble matter in alcohol and water (over 2.5% and 0.50% respectively), resulting in mushiness and low total fatty matter. This is the reason for the decrease in the quality of soap samples. All the brands complied with the minimum requirement for total fatty matter. Samples A, C, D, E, and J were all above the maximum permissible limit for chloride content. There is need to regularly check on the quality of laundry soaps sold in the markets.

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