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Effect of Oil Blending on the Physicochemical Properties of Locally Produced Bar-Soaps

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ABSTRACT

The quality, efficiency and cleansing abilities of soap can be deduced from their physiochemical properties. This study was conducted to investigate the effect of pure and mixed oil blends on the synthesis and characterization of locally produced bar soap in comparison to locally available commercial soaps. The colour, functional groups and bulk density of groundnut oil (GO) and palm kernel oil (PKO) were analysed. The pure oils (PO:S1, GKO:S7) and oil blends in different ratios (S2-S6) were applied in the synthesis of bar soaps. The colour, texture, hardness, moisture content, solubility, specific gravity, foaming, washing and cleansing abilities of the produced bar soaps were also studied. The results revealed that both oils were liquids at room temperature, had yellow colour variations, and bulk densities of 0.90g/cm3 and 0.92 g/cm3 respectively. The Fourier transform infra-red analysis (FT-IR) showed the presence of C-C (alkane), C=O (Carboxyl), O-H(hydroxyl) and C-N (amine) functional groups. Soap production using both pure oils and oil blends were successful. However, soaps produced from oil blends had better physicochemical properties such as, specific gravity, foamability, texture, moisture content, pH and penetrating power when compared to soaps synthesized from pure oils. All soaps produced had no significant variation when compared with the physiochemical properties of commercially available soaps. This study highlights that both pure oils and oil blend produced soap of good quality nevertheless, soaps from oil blends displayed higher standards

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1.0 INTRODUCTION

Soaps are definitely one of the oldest products synthesized for man's use as an anionic surfactant and till this day continues to be an integral commodity. The history of soap making dates back to around 2800BC in ancient Babylon. Romans sources claim it dates back to at least 600 BC, when Phoenicians prepared it from goats tallow and wood ash (Woodllatt, 1985; Butler, 1997; Hunt, 1999; Nangbes et al 2014). Soaps are synthesized through the process of saponification; a chemical reaction between various form of fats and oil (fatty acids) and strong alkali (NaOH or KOH) to produce soap, water and glycerol. Soaps can be manufactured in distinct forms and types depending on the make, finishing and packaging some example include the toilet, bar and liquid soaps. Each fat or oil is made up of a of several types of triglycerides, each consisting of its own particular combination of fatty acids (Hunt, 1999; Nangbes et al 2014). Several investigations have shown the importance of soap in personal hygiene for preventing variousdiseases and infections (Boyce et al, 2002; Nouira et al, 2008; Pettet et al,2009; Nangbes et al, 2014). Majority of health specialists agree to the fact that personal and environmental hygiene is one of the simplest and most effective way to prevent transmission of micro-organisms. This notion has further been reinforced in the outbreak of COVID-19 pandemic where awareness of personal and environmental hygiene through the frequent washing of hands and contaminated surfaces has been consistently emphasized as an important preventive measure.

The quality of a soap depends on its ability to satisfy the specific needs of a consumer despite its numerous features, characteristics and physiochemical properties. However, soaps sold to consumers are usually made to manufacturers own formulations and specifications, rather than to any official quality specifications, as long as such specifications generates satisfactionand economic value to the consumers. The purchasing attitude depends on the physicochemical properties - the appearance and texture, the effect on skin, hand and clothes, quantity of suds produced, odour, high solubilization of dirt and clarity of the solution (Abulude *et al*.,2017). In chemistry, the quality of a good bar soap is usually dependent on several physicochemical parameters: strength and purity of alkali, the kind of oil used and completeness of saponification,moisture content, hardness, colour, foaming ability pH, washing and cleansing abilities etc.(Roila *et al.*, 2001). A soap of good cleansing and washing abilities strikes a balance in all its indicated physiochemical properties (Habib *et al.*, 2016). Thus, the need for constant quality surveillance on the commercially available toilet soaps sold in the open markets is important.

The type of lipids utilized in soap making has a significant and direct impact on the characteristics and properties of soap product. Fats and oils normally used for local soap making process include neem, coconut, palm kernel, palm, groundnut/peanut, shea butter, tallow and shea butter oils (Ekpa and Ekpe, 1995:Osei-ampong, 2003). The palm kernel and coconut oils are good for soapy bubbles, while the neem oil is good for making antiseptic soaps. Palm kernel oil is obtained from the oil-rich seed of the oil palm (*Elaeis guineensis*) and a good source of lauric acid in the world (Atasie and Akinhanmi, 2009). Palm kernel oil is mainly composed of saturated fatty acid of C_6-C_8 chains with lauric acid having a high percentage, with a sharp melting point when heated. Higher quality soap is produced using 10-15% lauric acid (Berger and Ong, 1985). In Nigeria, oil blends of palm kernel and shea butter oil possess antimicrobial properties which have been applied in the production of medicated traditional soaps (Ekwenye and Ijeomah, 2005; Aliyu *et al.*, 2012).

Groundnut oil (*Arachis hypogea*) also called peanut oils is obtained from the processing of groundnut seeds which appearspale yellow in colour with distinctive nutty taste and odour. However, refining may result in the production of odourless oil (Sanders, 2002). Groundnut oil (GO) is rich in oleic acids that is known for its good oxidative and freezing stabilities. Groundnut oil contains a well-balanced fatty acid and antioxidant profile that provides protection against harmful substances especially free radicals. Major fatty acid in GO includes palmitic,oleic and linoleic acids. It is also composed of stearicacid,arachidic,eicosenoic,behenic, lignoceric acids and Linolic fatty acids which are present in minute quantities (Akhtar, 2013).Various researches have revealed that GO contain both macro and micro nutritional components such as potassium, phosphorus, sodium, magnesium, zinc, calcium, vitamin E, selenium, thiamine, selenium, arginine (Sulaiman *et al.*, 2012).It has been documented by Akhtar, 2013that GO also help prevent chronic diseases including heart disease, diabetes, and cancer.

This aim this research is to investigate the effect of pure oils and mixed oils (oil blends) on selected physicochemical properties of locally produced soap and comparing these properties with those of a commercially available soap. The data generated could be used as a tool to determine the economic viability and usage of the produced bar soap as a basic tool for maintenance of personal and environmental hygiene.

2. MATERIALS AND METHOD

2.1*Procurement of Palm Kernel Oil and Groundnut Oil*

Cold pressed groundnut (GO) and palm kernel oils (PKO) were obtained from stainless chemicals in Auchi Edo State, Nigeria. A locally available commercial soap was also procured for use in this study.

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2.2 Characterization and mixture of oils

2.2.1 *FTIR Analysis of Palm Kernel and Groundnut Oil*

The functional group of the GO and PKO oil samples were analyzed using FTIR (84005) Shimadzu Japan. The matrix used was potassium Bromide (KBr) in a spectra range of 500 – 4000 cm^{-1}. The spectra was recorded on a computer using the software spectrum for windows, Parkin-Elmer.

2.2.2 *Physical State and Colour of Oil*

At room temperature, GO and PKO were poured into a 500mL beaker to determine its colour and physical state of the oils.

2.2.3 *Bulk Density*

To determine the bulk density, 20mL of the oil was measured and transferred into a measuring cylinder and weighed. The difference in mass was noted and the bulk density was calculated as

Bulk density = $\frac{W2-W1}{Volume}$..(1)

W_2 = weight of measuring cylinder + oil

W_1 = weight of measuring cylinder

2.2.4 *Mixture of Oil Blends*

The oil blends were mixed in seven different combinations which were according to the following ratios 0:100, 20:80, 40:60, 50:50, 60:40, 80:20 and 100:0 respectively. The ratio of PKO:GO are seen in Table 1

Table 1: Names of PKO-GO soap samples

Soap	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8
Oil ratio (PKO: GO)	100:0	80:20	60:40	50:50	40:60	20:80	0:100	0:0

Footnote: S_1 and S_7:Pure oils soap, S_2-S_6: Oil blends soap,S_8: Commercial soap

2.3 Soap Making Process (Cold Process)

The soaps were synthesized with modifications according to Ameh et al, (2013) method. Using PKO: GO (100:0), 200g of slightly heated oil was poured inside a bowl after which 100mL of 40.00 wt% NaOH solution, followed by 100mL of 50.50 wt% soda ash solution and stirred in one direction. Afterwards, 50.44g of sodium sulphate, 26.00mL of sodium silicate, 5mL of pine oil, and 5mL of perfume were added successively to the mixture and stirred continuously until a mixture trace (visible thick lines seen in a properly stirred soap mixture) is observed. The properly stirred mixture is poured into the soap mould. This process was repeated for each oil combination.

2.4 Characterization of Bar Soap

2.4.1 *Colour*

To determine the colour of the soap, the optical eye contact was employed.

2.4.2 *Texture*

The texture of the soap sample was observed using the thumb and the index finger.

2.4.3 *Solubility*

To determine the solubility, 2gram of the produced soap was dropped in 50mL of distilled water and allowed to stand for about 10 mins.

2.4.4 *Hardness*

To determine the hardness, a needle (64cm in length; 1mm in diameter) attached to a 42.6g square wood wasdropped into the soap.The depth of penetration by the needle after 30s, was recorded as a measure of its hardness. This was repeated thrice for each soap sample and the mean and standard deviation calculated.

2.4.5 *Specific Gravity*

To determine specific gravity, 2gram of the soap was measured and transferred into a measuring cylinder that contained 50mL of water, the differences in volume was noted and the specific gravity was calculated as:

$$\text{Specific gravity} = \frac{\text{soap mass}}{V2-V1} \quad \text{.......................................} \quad (2)$$

where V_1 = initial volume of water in cylinder, V_2 = final volume of water after same was transferred

2.4.6 *Moisture Contents*

To determine the moisture content, 2g of the sample was accurately weighed into an empty 250mL beaker, placed in an oven for about 2hours at a temperature of 105°C. The processes of drying, cooling and weighing were repeated at interval of 30 min until constant weight was obtained. Then the moisture content of the samples was calculated from the following expression:

$$\% \text{ moisture} = \frac{W2-W3}{W2-W1} \times 100 \text{.......................................} (3)$$

whereW$_1$ = weight of beaker, W_2 = weight of beaker + soap before drying, W_3 = weight of beaker + soap after drying

2.4.7 *Formability Test*

To determine the foam height, 2g of the soap was dissolved in 50 mL of distilled water in a 100mL measuring cylinder, well-shaken and allowed to stand for 5 min before measurement. This procedure was repeated thrice and the mean values computed.

2.4.8 *pH Analysis*

The pH was determined by dissolving 2.0g of the produced soap in 50mL of distilled water in a 100mL measuring cylinder. This was done thrice for each sample and the mean calculated. This parameter was analyzed using a pH meter (Kent 7055 model).

2.4.9 *Cleansing Ability*

A drop of used brake oil was placed on two separate thin strips of filter paper. One filter paper with oil spot was placed in the test tube containing soap and water. A second strip was placed in the tube containing only water. Each one was well shaken while ensuring the filter paper was properly immersed in the solution. After 2 min the filter paper was removed and rinsed with tap water. The cleaning power of water versus the soap was compared. This reaction was carried out for all the soap samples prepared.

2.4.10 *Washing Properties*

A small amount of the dry soap was used to wash hand using distilled water. The lathering properties and "teel" were taken (very supper, greasy, or about normal).

3. RESULTS AND DISCUSSIONS

3.1 FT – IR analysis

The table 2 depicts the functional groups identified in the oils. In the PKO spectrum, the peaks at 3456.55, 2924.18, 1747.57, and 1161.19 corresponds to the functional groups of O-H, C–H, C=O, and C-N. In the GO spectrum, the peaks at 3471.98, 2926.11, 1747.59, and 1161.19 corresponds to the functional groups of O-H, C – H, C=O, and C-N (Pavia et al., 2001). The functional groups O-H, C–H, and C=O identified in the spectra of the oil samples are typical of plant extracted oils. The above result is in accordance with Ameh *et al.*, (2013) who reported on the synthesis and characterization antiseptic soaps using neem and shea butteroils.

Table 2: FT-IR analysis of groundnut oil and palm kernel oil

GO	PKO	Functional group
3471.98	3456.55	O – H
2926.11	2924.18	C – H
2854.74	2854.74	C – H
1747.59	1747.57	C = O
1161.19	1161.19	C – N

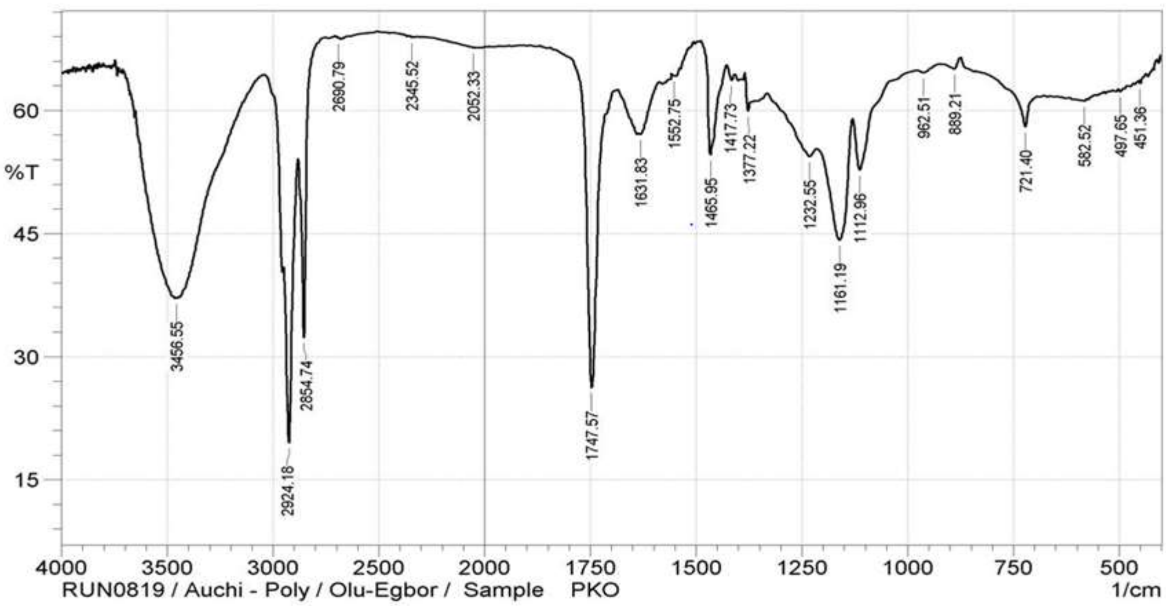

Figure 1: FT-IR spectrum of PKO

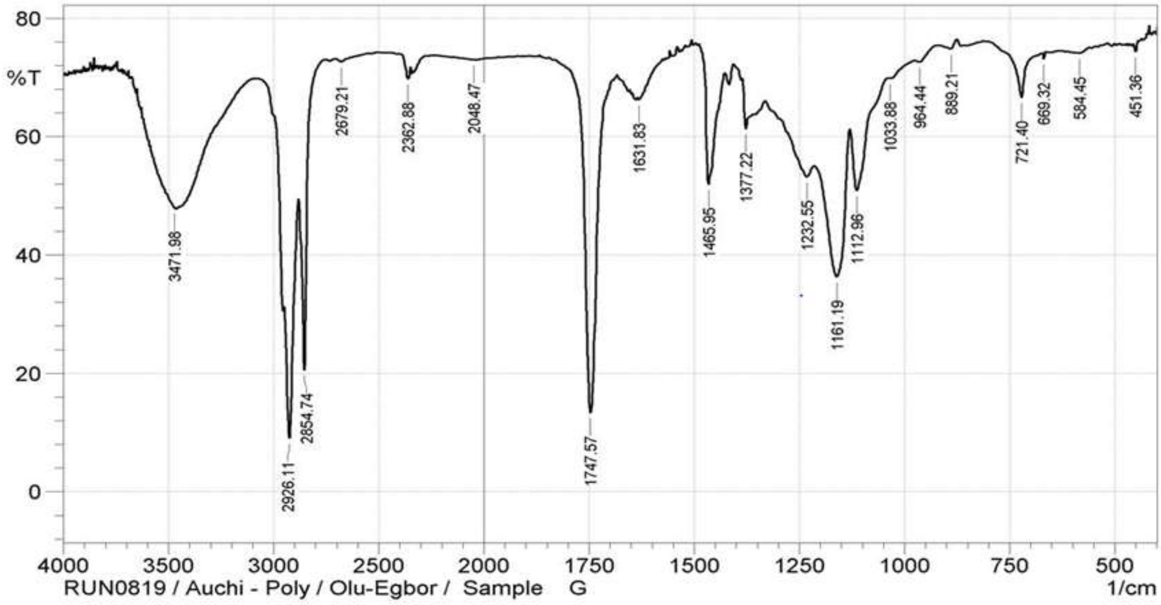

Figure 2: FT-IR spectrum of GO

3.2 Physical State, Colour, Bulk Density

From the Table 3, it was observed that both PKO and GO are liquid at room temperature which implies that both lipids are of plant origin. It should be noted that oil extracted from plant are usually liquid at room temperature. The oil also showed similarities in the colour which were variations of yellow. PKO and GO had bulk densities of 0.90 and 0.91g/cm^3 respectively. This implies that both oils are less dense than water which explains why they are found in the first layer when mixed with water. The densities of both oils concur with the recommended FAO standard values (0.89-0.91 g/cm^3).

Table 3: Physical State, Colour, Bulk Density of PKO and GO

	PKO	GO
Physical state	Liquid	Liquid
Bulk density	0.90g/cm^3	0.91g/cm^3
Colour	Dark yellow	Yellow

3.3 Characterization of Soap

3.3.1 *Colour, Hardness, Specific Gravity and Foamability*

From table 4, all synthesized soaps produced had colour variation from white to yellow. This implies that oil blends had little or no impact in the colour of the bar soap produced when compared with the commercial soap.

Results from table 4, denotes that soaps produced had average specific gravities ranging from 1.0g/ml to 1.53g/ml when compared with the commercial soap of whose specific gravity was 1.2g/ml. it was also observed that all soaps with the exception of S_2 and S_5 had approximately similar specific gravity when compared to the commercial soap.

The results from the foamability tests showed that S_2 exhibited the highest foam height of 3.00cm when compared to other locally produced soap with commercial soap having an almost similar value of 2.50cm.

The penetrating hardness of the commercial soap which had an average value of 0.50cm was lower when compared with the produced soap sample. It can also be observed that S_3 had the lowest penetrating values of 1.50cm when compared with other synthesized soap. This result indicates that soaps with lower penetrating values are harder than soaps of higher values.

Table 4: Colour and mean values of hardness, specific gravity and foamability of all antiseptic soaps

Soap	Colour	Hardness	Specific gravity	Foamability
S_1	Milky	2.00±0.01cm	1.21g/ml	1.50cm
S_2	Light yellow	2.50±0.05cm	1.53g/ml	3.00cm
S_3	Cream	1.50±0.11cm	1.21g/ml	1.00cm
S_4	Milk	4.50±0.29cm	1.27g/ml	1.50cm
S_5	White	4.25±0.15cm	1.50g/ml	0.70cm
S_6	White	1.90±0.02cm	1.15g/ml	1.60cm
S_7	White	2.30±0.21cm	1.00g/ml	1.60cm
S_8	Yellow	0.50±0.13cm	1.21g/ml	2.50cm

3.3.2 *Texture*

From table 5, all soap produced had texture varying from oily to hard. After 2 weeks of production, S_5 and S_4 where mostly similar in texture to the commercial soap however all soaps had the same textures 8 weeks after production. The results from the texture shows that the soap made from oil blends had a better impact on the soap texture than the soaps synthesized from pure oils. It should be noted that the texture of a soap changes as the soap ages which accounts for the changes in texture after 8 weeks.

Table 5: Textures of soap

Soap	Texture after 2 weeks	texture after 8 weeks
S_1	Partially hard and dry	hard and dry
S_2	Soft and oily	hard and dry
S_3	Soft and dry	hard and dry
S_4	Partially hard and sticky	hard and dry
S_5	Very hard and dry	hard and dry
S_6	Partially hard and sticky	hard and dry
S_7	Hard and oily	hard and dry
S_8	Hard and dry	hard and dry

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3.3.3 *Solubility, pH Analysis, Moisture Content*

One criterion utilized for the shelf-life evaluation of a product is moisture content (Oyango*et al.*,2014). It should be noted that moisture content of freshly synthesized soaps reduces wee (Zauro *et al.*,2014). From table 6 result, soaps produced had moisture contents ranging from 30.58% to 46.43% and these values were higher when compared with the commercial soap. This indicates that most of the soaps synthesized will favour the growth of microbes since they are not within the recommended value of 10-20% (Joselany *et al.*,2011: Idoko *et al.*, 2018). The high moisture values recorded may also be as a result of the method of preparation of the soaps. Another implication is that high moisture content of a soap when stored, causes reaction between the excess water and un-saponified fats leading to formation of free fatty acids and glycerol in a process called hydrolysis (Oyango*et al.*,2014) .The results did not conform to the values gotten by Onyango *et al.*, (2014) that reported on locally manufactured soaps in Kenya which recorded values of moisture content ranging from10.91 to 22.69% and also not in accordance with the standards recommended by the encyclopedia of the industrial chemical analysis (10-15%).

Table6, also revealed that the pH soap produced ranged from 9.3 to 10.4, however S_1 and S_7both have the highest pH of 10.4 each when compared to the commercial soap. The result from the pH implies that soap produced from pure oils would have a harsher effect on the skin when compared to soaps produced from oil blends and the commercially available soap. Furthermore, all soaps synthesized from pure and mixed oils aligned with the approved standards (9-11) of a good bathing soap (Mark-Mensah and Firempong, 2011). This result is in accordance with Abulude et al, 2017 who reported on physicochemical properties of soaps, detergents and water samples originated from Nigeria. The pH of the produced soaps also indicates that the prepared soap is slightly alkaline and could be more suitable for laundry purposes than bathing due to potential damage it has on the skin (Hassan and Wawata, 2018). The pH of a healthy skin ranges between 5.4 to 5.9 (Habib et al, 2016) but alkalinity of soaps neutralizes the protective acid layer that serves as barrier against viruses and bacteria (Hassan and Wawata, 2018).

Table 6: solubility, mean pH and moisture content of synthesized soaps

Soap	Solubility	pH	Moisture Content
S_1	Slightly soluble	10.4	46.43%
S_2	Slightly soluble	9.3	36.00%
S_3	Slightly soluble	9.5	37.00%
S_4	Slightly soluble	9.7	37.50%
S_5	Slightly soluble	10.1	36.58%
S_6	Slightly soluble	9.4	30.95%
S_7	Slightly soluble	10.4	35.29%
S_8	Slightly soluble	9.0	10.00%

3.3.4 *Washing and Cleansing Abilities*

The other physical analysis carried out on the soaps shows that all the soaps analyzed possessed very good cleansing properties, normal washing properties and very stable lathering properties.

CONCLUSION:

From this study, it can be established that soaps synthesized from oil blends had better physiochemical properties when compared with soaps produced from pure oils. In comparison to the commercial soaps, soaps synthesized from oil blends had favourable similarities in terms of texture, hardness, foamability, and pH than soaps from pure oils.

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