Quality Assessment of Palm Oil from Different Palm Oil Local Factories in Imo State, Nigeria

Enyoh Emmanuel Chinedu[1], **Enyoh Christian Ebere**[2,*]
and **Amaobi Collins Emeka**[2]

[1]Department of Food Technology, School of Industrial and Applied Sciences, Federal Polytechnic, Nekede, Owerri, Imo State, Nigeria

[2]Group Research in Analytical Chemistry, Environment and Climate Change, Department of Chemistry, Imo State University, Owerri, Imo State, Nigeria

*E-mail address: cenyoh@gmail.com

ABSTRACT

Palm oil is the most commonly used vegetable oil in Nigeria due to its numerous benefits. Therefore, it is very important to investigate the quality of palm oil. In this study, oil samples were collected from different oil mills in Imo state. Physical and chemical properties of the oil samples were evaluated using standard procedures. The result showed that the moisture content ranged from 0.26% to 0.33%, specific gravity ranged from 0.8900 to 0.9250 while the density ranged from 0.8700 g/ml to 0.9100 g/ml. The saponification value (SV), Free fatty acid and Acid value ranged from 192.49 mg KOH/g to 202.73 mg KOH/g, 10.38 mg KOH/g to 18.80 mg KOH/g and 20.76 mg/g to 37.59 mg/g respectively, while the Smoke point and Refractive index ranged from 114.0 °C to 116.2 °C and 1.4615°Bx to 1.4640°Bx respectively. The peroxide value, Iodine value and Ester value ranged from 14.10 mEq./g to 24.80 mEq./g, 0.48wij's to 2.84wij's and 160.86 to 172.86 respectively. All samples showed > 35% SV suggesting the palm oil will be good in soap production. It is recommended that oil palm factories in Imo state processing and storage method should be properly monitored to prevent major contamination or adulteration which might have an adverse effect on the future of oil palm industry in Imo state, Nigeria.

Keywords: Adulteration, Factory, Health, Impurity, Imo State, Palm oil, Storage

1. INTRODUCTION

Palm oil is the most commonly used vegetable oil in Nigeria; it is orange-red to brownish or yellowish-red in colour. The palm fruit, a tropical tree crop takes five to six month to mature from pollination and it is mainly grown for its industrial production of vegetable oil. It is cultivated over large uniform areas close to central oil mill to enable rapid industrial handling or processing after harvesting. After processing the palm fruit, oil is extracted from both the pulp of the fruit and the kernel (Agbaire et al, 2012). The various methods for palm oil processing have been complied in a bulletin by Food and Agriculture Organization (FAO, 2002) of the United Nations. The compilation explains that batch processes is often employed by small-scale facilities, which process two or less tones of fresh fruit bunch per hour. The small scale factories make use of manual skilled labourers. On the other hand, large-scale plants process more than ten and often up to sixty tones of fresh fruit bunches per hour (Kwaski, 2002). The level of oil extraction varies wildly, mainly due to the different methods. Although, non-polar solvents such as hexane, diethyl ether and carbon tetra chloride are commonly been used (Amaobi et al, 2017). In Imo state, in the traditional/local channel most of the palm oil is produced by women using manual traditional method namely mortar and pestle. Oil extracted usually reaches only 25% of the available oil in the fruit.

However, the different methods used in some local mills in Imo state, Nigeria leads to production of oil of different qualities. This practice may reduce the quality of the extracted palm oil. Therefore, the need to assess the quality of palm oil from different palm oil local factories in Imo state is of great importance as most people utilizes the palm oil direct without any further purification. Several studies have been reported on the quality of palm oil from various regions. Agbaire, 2012 reported on the quality assessment of palm oil sold in some major markets in Delta State, southern Nigeria. Result revealed that the investigated parameters where all within the SON/NIS standard, indicating that the palm oil is of good quality and there were no evidence of adulteration. Quality assessment of crude palm oil (CPO) and crude palm olein (CPOL) produced in the states of Bahia and Pará, Brazil were investigated by de Almeida et al 2013, result revealed that all samples produced in Bahia exhibited higher FFA (6.77-13.49%) and TPC (13.71-19.50%) levels than permitted in the international quality standards, unlike the samples produced in Pará. Factors influencing quality of palm oil produced at the cottage industry level in Ghana was investigated by Tagoe, et al, 2012. Results shows that low fatty acid (FFA) observed in good grade oils contain microbes, some of which have the potential of producing toxin. A direct relationship was observed between storage period of oil and fatty acid content, and microbial loads in oils. Enyoh et. al., 2017 performed a physicochemical analysis on palm oil produced locally from Ihube community, Okigwe LGA of Imo state. The author obtained in their result that all parameters analyzed were within limit except for moisture 0.32 % and the free fatty acid after the tenth-day. However, the study concluded that the palm oil is of good quality. The scope of this work is to determine the physical and chemical properties of palm oil samples obtained from different local oil palm processing factories in Imo state. In the present study, the physical and chemical properties determined includes the specific gravity, density, acid value, free fatty acid, iodine value, saponification value, peroxide value, ester value, moisture content, smoke point and refractive index. The information obtained from this work will be useful to food processors, palm oil consumers in Imo state and also the information will be adding to the database on the subject for optimization of the relevant industrial processes.

2. MATERIAL AND METHOD

2. 1. Study area

Four locations namely; Okigwe, Ngor-okpala, Mbaise and Umuagwo in Imo State, Nigeria were selected for this study. The study area lies between latitude 4°45' and 7°15' N and longitude 6°50' and 7°25' E and it occupies the area between the lower River Niger and the upper and middle Imo River. The chief occupation of the people is farming and their cash crops include oil palm, raffia palm, melon, maize etc. food crops such as yam, cassava, cocoyam and maize are also produced in large quantities.

2. 2. Samples collection

Four samples of palm oil were collected from different palm oil processing units at Okigwe, Mbaise, Ngorokpala and Umuagwo all in Imo state, Nigeria. The samples were collected in glass bottles that were previously cleaned. The palm oil was then stored in black polythene bag to prevent exposure to light and transferred to the laboratory for analysis.

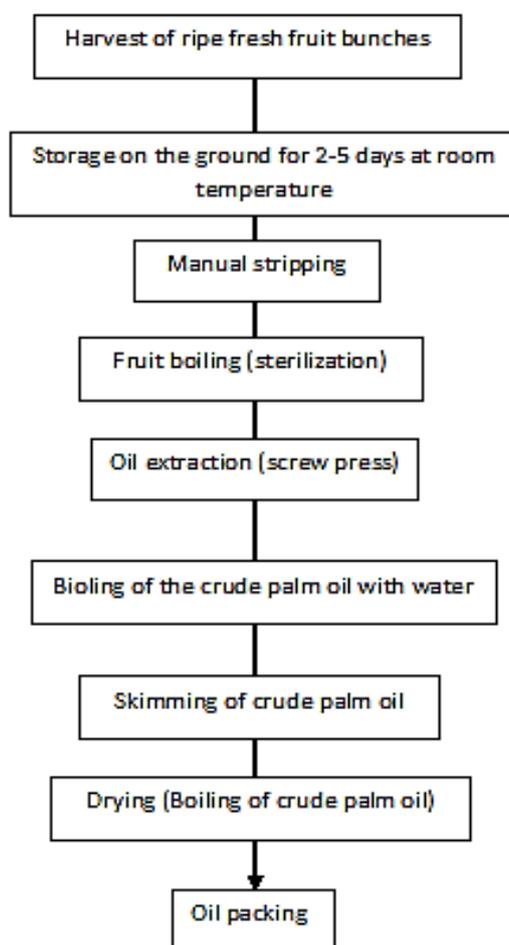### 2. 3. Production of palm oil at the units

Figure 1. Flow chart for the production of palm oil.

Ripe palm fruits bunches were harvested, stored on the ground for 2-5 days at room temperature before sterilization of the palm fruits was carried out by boiling and then the oil was extracted by screw pressing. Thereafter, the extracted crude palm oil was boiled with water and then skimmed for proper clarification of the oil before drying by boiling and finally, packaging in bottles.

The flow chart above is the semi-mechanized extraction method of palm oil from oil palm fruit bunches according to Frank et al. (2011).

2. 4. Physico-chemical analysis of palm oil.

The physico-chemical analysis which includes moisture content, peroxide value, smoke point, iodine value, free fatty acid content, acid value, specific gravity, density, saponification value and refractive index determination were carried out using different method of analysis.

2. 4. 1. Determination of specific gravity/ density.

The analysis was carried out according to the method reported by Morris (1999).

50 ml pycometer bottle was washed thoroughly with detergent, water and petroleum ether, then dried and weighed. The bottle was then filled with water and weighed before it was dried again.After the drying process, the bottle was filled with the oil sample and then weighed.

Calculation:

$$\text{SPECIFIC GRAVITY} = \frac{\text{Weight of Xml of oil}}{\text{Weight of Xml of water}}$$

$$\text{DENSITY} \left(\frac{g}{ml}\right) = \frac{Weight\ of\ oil}{Volume\ of\ oil}$$

2. 4. 2. Determination of refractive index.

According to the method reported by Onwuka (2005), the Abbes' refractometer was reset with a light compensator (water @ 20 °C), then the oil sample was smear on the lower prism of the instrument and closed. A light was passed by means of the angled mirror (the reflected light appears in form of a dark background). After which, the telescope tubes were moved using the fine adjustment until the black shadow appeared central in the cross wire indicator and then the refractive index was read.

2. 4. 3. Determination of smoke point.

The smoke point determination was done using the method reported by Onwuka (2005).

10 ml of the oil sample was poured into an evaporating dish. A thermometer was then suspended at the centre of the dish ensuring that the bulb just dips inside the oil without touching the bottom of the dish. After which, the temperature of the oil was raised gradually using a stove.

The temperature at which the oil sample gave off a thin bluish smoke continuously was noted as the smoke point.

2. 4. 4. Determination of acid value and free fatty acid content.

The method reported by Akinola et al. (2010) and Enyoh et. al., (2017) was used. The acid value is the number of milligrams of the potassium hydroxide necessary to neutralize the free aid in one gram sample. 10 ml of diethyl ether and 10 ml of n -propanol were mixed and 1ml of Phenolphthalein solution (1%) was added. 2 g of oil was dissolved in the Solvent and titrated with aqueous 0.1 M KOH, shaking constantly until a Pink colour which persists for 15sec. was obtained. The amount of KOH used was recorded.
The procedure was repeated for the blank.

Calculation:

$$\text{ACID VALUE (mg KOH/g)} = \frac{Titre\ value\ x\ 5.61}{weight\ of\ sample\ used}$$

$$\text{FREE FATTY ACID (mg KOH/g)} = \frac{Acid\ value}{2}$$

2. 4. 5. Determination of ester value

Ester value was obtained according to Akinola *et al.* (2010) by finding the difference between the saponification values and acid value.

2. 4. 6. Determination of peroxide value

The method reported by Akinola et al. (2010) in their work was used. One gram of oil sample was weighed and poured into a dry 250ml stopper conical flask, flushed with inert gas. 10ml of chloroform was added and the oil was dissolved by swirling. 15ml of glacial acetic acid and 1ml of fresh saturated aqueous potassium iodide solution were added. The flask with stopper, shaken for one minute and placed in the dark for one minute. Thereafter 75ml of water was added, mixed and the freed iodine was titrated with 0.002M sodium thiosuphate solution using soluble starch solution (1%) as an indicator. The titre value was recorded as V. Blank determination (V_0) was also recorded.

Calculation:

$$\text{PEROXIDE VALUE (mEq/kg)} = \frac{(V-V0)T}{M} x 10^3$$

where: T = exact molarity of sodium thiosulphate solution.

2. 4. 7. Determination of moisture content

According to Enyoh et. al. (2017), the aluminium dishes were washed thoroughly and dried in the oven, then cooled in the desicator before they were weighed. 2-5 g of the sample was put in the dish and the weight of the dish with the sample was taken every 30 minutes (Amaobi et al, 2017).

Thereafter, it was dried in the oven at 70-80 °C for 2 hours and at 100-135 °C for the next 4 hours and then cooled in the desicator, after which the dry weight of sample plus dish was taken.

Calculation:

$$\% \text{ MOISTURE } = \frac{W2 - W3}{W2 - W1} x \ 100$$

where: W_1 = Initial weight of empty crucible
$\qquad$ W_2 = Weight of crucible plus sample before drying
$\qquad$ W_3 = Final weight of crucible plus food after drying

2. 4. 8. Determination of saponification value

Two grammes of oil was weighed accurately and put into a conical flask containing 25 ml of 0.5 M alcoholic KOH. Reflux condenser was fitted to the flask containing the ionic solution and heated in a water bath for an hour swirling the flask frequently. Excess KOH was titrated hot with 0.5 M HCl using 1ml of phenolphthalein (1%) solution. The procedure was repeated for the blank.

Calculation:

$$\text{SAPONIFICATION VALUE } = \frac{(b - a) \ x \ 28.05}{weight \ of \ the \ sample}$$

where: b = titre value of blank
$\qquad$ a = titre value of sample
$\qquad$ 28.05 = mg of KOH equivalent to 1ml of 0.5 M HCl. (Akinola *et. al,* 2010).

2. 4. 9. Determination of iodine value

The iodine value of the oil sample was determined using the method reported by Akinola et. al, (2010) using the wijs' method.
Palm oil was added and suitably weighed in a dry glass stoppered bottle. The appropriate weight in gram of the palm oil to be used was calculated by dividing 20 by the highest expected iodine value, the stopper was inserted (previously moistened with potassium iodide solution) and allowed to stand in the dark for 30 minutes. Of potassium iodide (10%) 15 ml was added and mixed with 100 ml water. The solution was titrated with 0.1 M thiosulphate solution using starch indicator just before the end point (titration = a ml). Blank was treated at the same time commencing with 100 ml of carbon tetrachloride (titration = b ml).

Calculation:

$$\text{IODINE VALUE (wijs)} = \frac{(b - a) \ x \ 1.269}{weight \ of \ the \ sample}$$

2. 5. Statistical Analysis

The data obtained from the physico-chemical analysis of the palm oil were subjected to statistical treatment using mean, standard deviation, and analysis of variance (ANOVA). Graph and bar chart was also used to show the properties of various oils.

2. 6. Quality control

All instrument and chemicals used in this work were in good working condition, of analytical grade and were used according to manufacturer's instructions. Glass wares and plastic bottles were soaked separately in 10% HCl for 48 hours, washed and rinsed with deionized water and dried.

3. RESULTS AND DISCUSSION

The results for the physicochemical properties of the palm oil samples expressed as its mean and standard deviation for duplicate analysis are presented in table 3.0-3.8. One factor ANOVA were carried out for the four different samples obtained from the four different locations. There was no significant difference ($P>0.05$) in the values obtained for the four different samples. These suggest that the properties of palm oil obtained from the four palm oil samples from the different local oil mills in Imo state Nigeria are similar.

3. 1. Acid value and Free Fatty Acid

The acid and free fatty acid values were presented in table 1. The measure of the free fatty acids in oil is the acid value. Fatty acids are usually in the triglyceride form but during processing, they tend to get hydrolyzed into free fatty acids. Therefore, there is a direct relationship between acid value and the free fatty acid content. These mean that higher acid value will cause higher free fatty acid and thereby decreasing the oil quality. AOCS (2003) stated 0.6 mg KOH/g as the maximum accepted level for vegetable oil.

Table 1. Acid value and free fatty acid content of palm oil from the different local oil mills in Imo state

PROPERTIES	A (Okigwe)	B (Ngor-Okpala)	C (Mbaise)	D (Umuagwo)	Mean
AV (mg KOH/g)	29.88±1.39	20.76±1.18	24.97±1.19	37.59±6.36	28.3
FFA (mg KOH/g)	14.94±0.70	10.38±0.59	12.49±0.60	18.80±3.17	14.153

The acid value obtained ranges from 20.76 mg KOH/g to 37.59 mg KOH/g with palm oil from Ngor-okpala having the lowest value and palm oil from Umuagwo had the highest value. These acid values are higher than the 20.00 mg KOH/g reported by Birnin-Yauri et al. (2011). The free fatty acid obtained in the present work ranges from 10.38-18.80 mg KOH/g. Palm oil obtained from Umuagwo was found to have the highest FFA value this in relation with the high acid value obtained. SON's recommended a maximum value of 3.5 mg KOH/g (SON, 2000).

All values obtained from the present study were found to be higher than the recommended standard. Ekwenye, 2005 stated that high free fatty acid may be due to the fact that the palm oil samples were exposed to normal room temperatures at the processing mills. In addition, it may also be due to glycerides decomposition by fungi and microorganism (Hiol et al., 1999; Houria et al., 2002; Okechalu et al., 2011) and exposure to heat and sunlight (Enyoh et. al, 2017). Ranking the acid value and the free fatty acid content showed Umuagwo > Okigwe > Mbaise > Ngor-Okpala respectively.

3. 2. Iodine value

The iodine value results were presented in table 2. The iodine value which is the measure of the level of unsaturation in the oil samples (AOCS, 1993) ranges from 0.48wij's to 2.84wij's. Palm oil from Okigwe had the highest iodine value while palm oil from Ngor-okpala had the lowest iodine value. The values obtained from the analysis are lower than the 33.24wij's reported by Akinyeye et al. (2011).

Table 2. Iodine values of palm oil from the different local oil mills in Imo state

PROPERTIES	A (Okigwe)	B (Ngor-Okpala)	C (Mbaise)	D (Umuagwo)	Mean
IV (wijj's)	2.84±0.00	0.48±0.14	2.50±0.06	0.89±0.03	1.6775

The iodine values obtained in the present study were below the standard range of 45 – 53 Wij's as recommended by SON (2000) and NIS (1992). These low values suggest that the oil has low level of unsaturation and might not be susceptible to oxidation. When ranking the IVs in decreasing order of significance; Okigwe > Mbaise > Umuagwo > Ngor-Okpala.

3. 3. Smoke point

The smoke points for the palm oil samples ranged from 114.0 °C to 116.2 °C, with palm oil from Umuagwo having the lowest while palm oil from Ngor-okpala had the highest. The smoke point is an indication that the oil is good frying.

Table 3. Smoke point results of palm oil from the different local oil mills in Imo state

PROPERTIES	A (Okigwe)	B (Ngor-Okpala)	C (Mbaise)	D (Umuagwo)	Mean
SP (°C)	114.2±0.00	116.20±0.00	115.6±0.00	114.00±0.00	115

3. 4. Saponification value

Saponification value (SV) is an indication of the molecular weights of triglycerides of oils. High saponification value indicates high proportion of low fatty acids since saponification value is inversely proportional to the average molecular weight or length of

fatty acids (Muhammad et al., 2011). Therefore the shorter the average chain length (C4-C12), the higher the saponification value.

Table 4. Saponification value of palm oil from the different local oil mills in Imo state

PROPERTIES	A (Okigwe)	B (Ngor-Okpala)	C (Mbaise)	D (Umuagwo)	Mean
SV (mg KOH/g)	202.73±0.09	192.49±1.49	194.60±0.49	198.45±0.00	197.067

The saponification values obtained ranged from 192.49 mg KOH/g to 202.73 mg KOH/g. Palm oil from Ngor-okpala had the lowest value of saponification while palm oil from Okigwe had the highest value. These values are within the recommended range of 195-205 mg KOH/g for palm oil (SON, 2000; NIS, 1992). These values are close to the 222.90 mg KOH/g reported by Akinyeye et al. (2011) but higher than the 140.00 mg KOH/g reported by Birnin-Yauri et al. (2011). These values are indication that the oils are well suited for soap making (Agbaire, 2012).

3. 5. Ester value

The ester value ranged from 160.86 to 172.80 with palm oil from Okigwe having the highest, while palm oil from Umuagwo had the lowest ester value (table 5). These values obtained are lower than 196.07 reported by Akinola et al. (2010). Ester value is the number of milligrams of potassium hydroxide required to combine with fatty acids present in glyceride form in 1g sample of oil or fat.

Table 5. Result for ester values of palm oil from the different local oil mills in Imo state

PROPERTIES	A (Okigwe)	B (Ngor-Okpala)	C (Mbaise)	D (Umuagwo)	Mean
EV	172.86±1.49	171.74±2.67	169.63±0.49	160.86±6.35	168.773

3. 6. Moisture content

The moisture content results were presented in table 6. The moisture content of oils is an important parameter in assessing the quality of an oil sample. The moisture content of any food is an index of its water activity (aw) (Fraziar and Westoff, 1978). High moisture content is an indication of ease of spoilage and rancidity as well as short shelf-life.

Table 6. Moisture contents for the various palm oil samples

PROPERTIES	A (Okigwe)	B (Ngor-Okpala)	C (Mbaise)	D (Umuagwo)	Mean
MC (%)	0.30±0.01	0.33±0.11	0.86±0.94	0.26±0.06	0.437

The moisture content of samples ranged from 0.26% to 0.86%, Palm oil from Umuagwo had the lowest while palm oil from Mbaise had the highest moisture content. Values obtained for palm oil from Okigwe, Ngor-okpala and Umuagwo were within same range as the 0.29% recommended for fresh oil by SON (2000). The low moisture content obtained will encourage the storage stability of the palm oil samples. It has been stated that the moisture content of palm oil depended directly on the efficiency of the final extraction and clarification processes (Wolves, 1969; Johansson and Pehlergard, 1977; Poku, 2002; Orji, 2006; Mbata and Orji 2008). However, the 0.30% obtained for Okigwe was similar to value (0.32 %) obtained by Enyoh et. al., (2017) who reported that the values may be due to the fact that the local producers do not boil the pure oil to reduce the moisture content.

3. 7. Density

The results for the density and specific gravity (SG) are presented in table 7. The density obtained for the oil samples ranged from 0.8700 g/ml to 0.9100 g/ml with palm oil from Ngor-okpala having the lowest density while palm oil from Okigwe had the highest.

Table 7. Density and specific gravity (SG) of palm oil from different local oil mills in Imo state

PROPERTIES	A (Okigwe)	B (Ngor-Okpala)	C (Mbaise)	D (Umuagwo)	Mean
DENSITY (g/ml)	0.91±0.00	0.87±0.00	0.91±0.00	0.88±0.00	0.8913
SG	0.92±0.00	0.89±0.00	0.93±0.00	0.89±0.00	0.9063

The term Specific Gravity (SG) is used to define the weight or density of a liquid as compared to the density of an equal volume of water at a specified temperature. The values obtained for the specific gravity ranged from 0.8900 to 0.9250. Palm oil from Ngor-okpala had the lowest while palm oil from Mbaise had the highest. The values obtained for specific gravity of the oil samples are similar to 0.9003 reported by Akinyeye et al. (2011).

3. 8. Peroxide value

Peroxide value for the palm oil samples from the different local oil mills in Imo state is presented in table 8. The values obtained for the peroxide value ranged from 14.10 to 24.80 mEq./Kg with palm oil from Ngor-okpala having the highest peroxide value and palm oil from Umuagwo had the lowest. Agbaire et al, 2012 reported a much lower PV when compare to that obtained in the present study.

Table 8. Peroxide value for the palm oil samples from the different local oil mills

PROPERTIES	A (Okigwe)	B (Ngor-Okpala)	C (Mbaise)	D (Umuagwo)	Mean
PV (mEq./Kg)	16.50±0.42	24.80±0.85	15.60±0.57	14.10±0.14	17.75

The peroxide value is an indicator of the level of lipid peroxidation or oxidative degradation. It is a useful indicator of the early stages of rancidity occurring under mild conditions and a measure of primary lipid oxidation products (Onyeka et al., 2005). Palm oil from Mbaise and Umuagwo had the closest value to the 10 mEq./Kg standard specified by SON (2000) and NIS (1992) with other values exceeding the recommended value. This suggests a high level of unsaturation and susceptible to oxidative rancidity. The addition of antioxidant may be a good way to prolong the stability of the oil
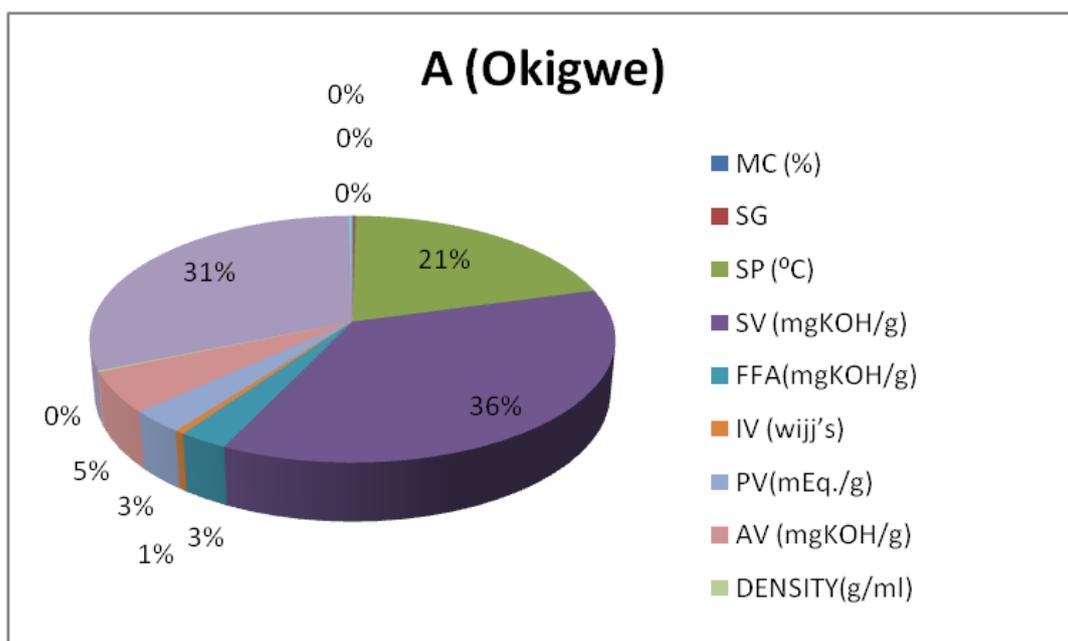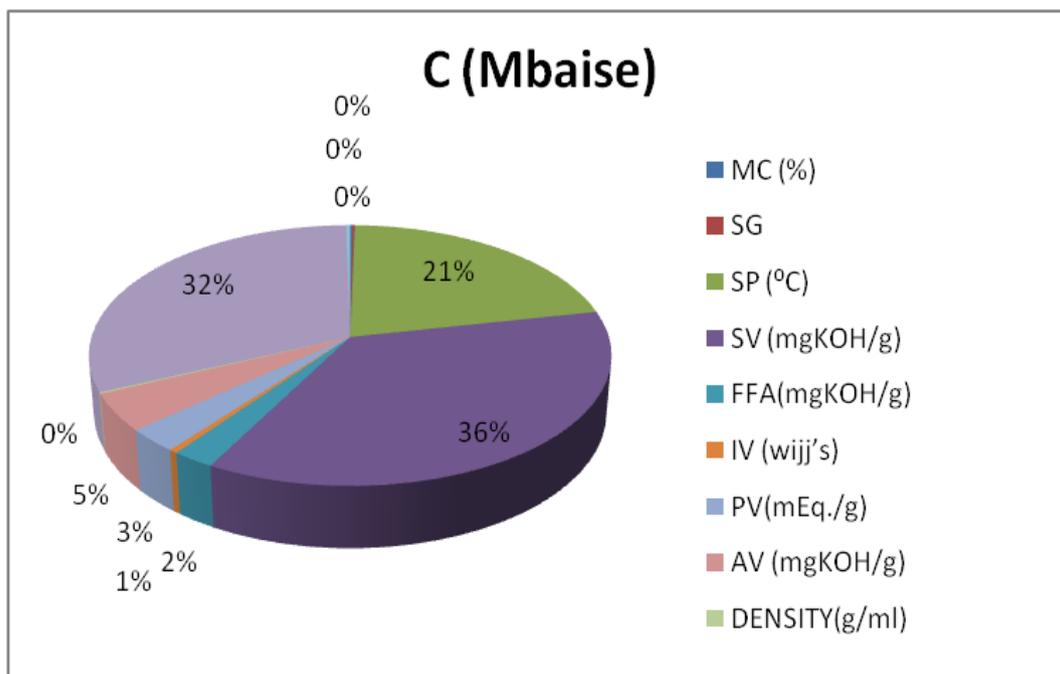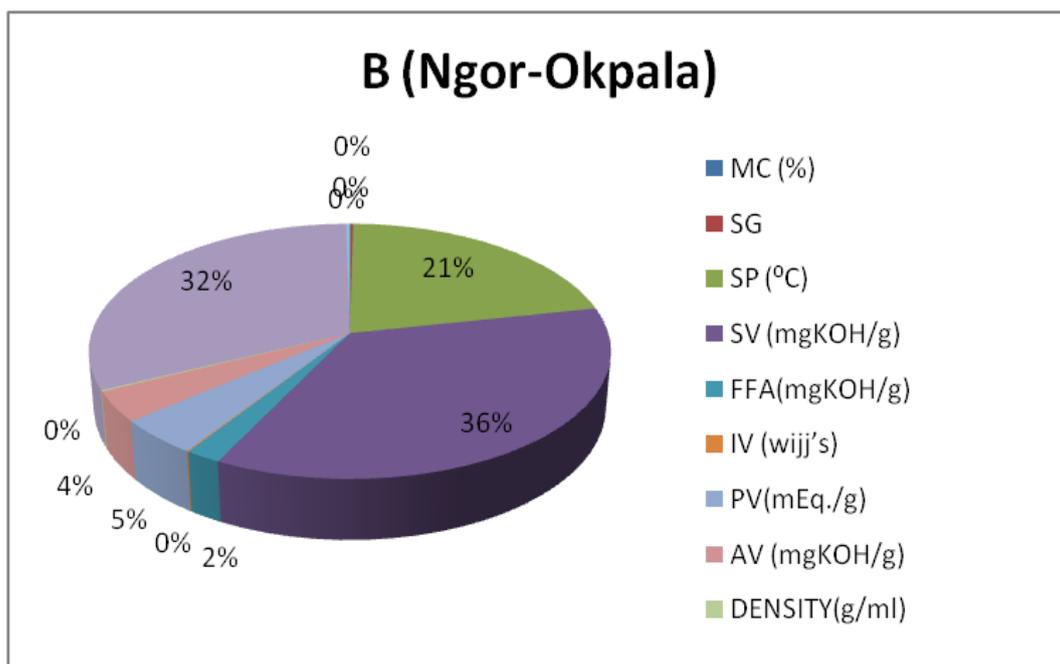
3. 9. Refractive Index

The results for the refractive index analysis on the different palm oil samples are presented in table 9. The index of refraction ranged from 1.4615°Bx to 1.4640°Bx. Palm oil from Okigwe had the lowest while palm oil from Ngor-okpala had the highest. These values obtained are close to the 1.4600°Bx obtained by Akinyeye et al. (2011).

Table 9. Refractive Index result for the palm oil samples from the different local oil mills

PROPERTIES	A (Okigwe)	B (Ngor-Okpala)	C (Mbaise)	D (Umuagwo)	Mean
RI (°Bx)	1.4615±0.00	1.4640±0.00	1.4635±0.00	1.4625±0.00	1.462

The RI is in the order; Ngor-okpala > Mbaise > Umuagwo > Okigwe. The refractive index measures of how much light bends when traveling through the oil. It also assesses the purity of a palm oil sample by comparing its refractive index to the value for the pure substance.
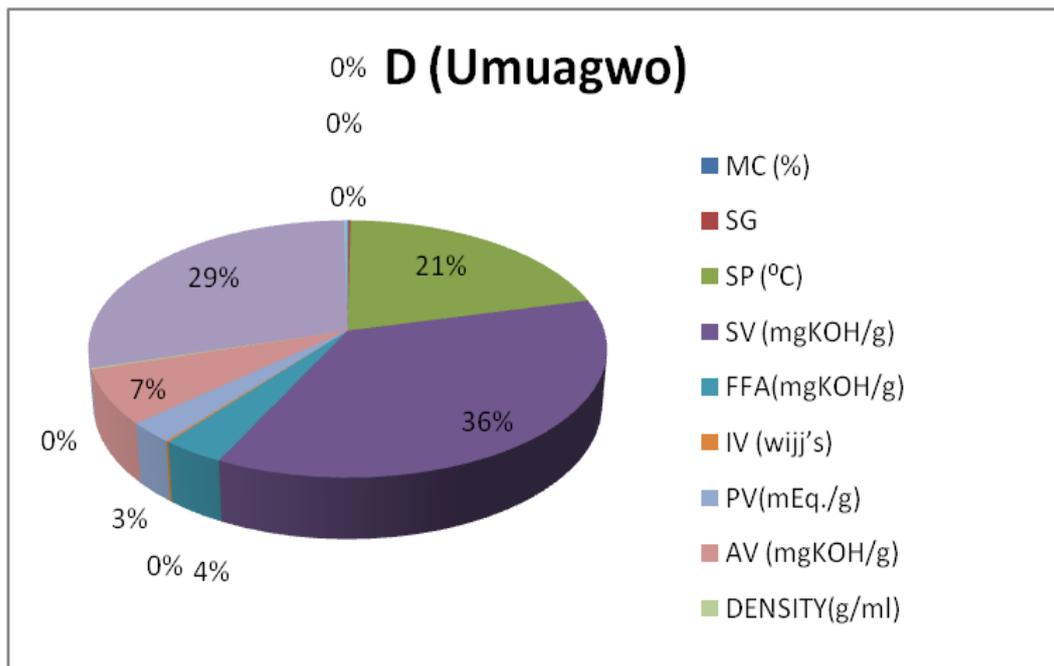
B (Ngor-Okpala)

0%
0%
0%
21%
32%
36%
0%
4%
5%
0%
2%

MC (%)
SG
SP (ᵒC)
SV (mgKOH/g)
FFA(mgKOH/g)
IV (wijj's)
PV(mEq./g)
AV (mgKOH/g)
DENSITY(g/ml)

C (Mbaise)

0%
0%
0%
21%
32%
36%
0%
5%
3%
1%
2%

MC (%)
SG
SP (ᵒC)
SV (mgKOH/g)
FFA(mgKOH/g)
IV (wijj's)
PV(mEq./g)
AV (mgKOH/g)
DENSITY(g/ml)

Figure 2. Pie-chart showing percentage compositions of different parameters analyzed

The pie chart generally showed that all palm oil samples have high percentage (>35%) for saponification value, thus making them good for soap making.

4. CONCLUSION AND RECOMMENDATION

4. 1. Conclusion

This study showed that palm oil produced at different local factories in Imo state, Nigeria display varied physical and chemical properties which tend to reflect the stability and quality of the palm oil. The palm oil sample from Okigwe and Umuagwo showed the best physical and chemical composition compared to other samples studied.

The study was limited to Imo state, therefore the outcome of the research cannot be said to be true representative of palm oil from all parts of Nigeria.

4. 2. Recommendation

Palm oil is the most commonly used vegetable oil in Imo state, Nigeria. From the study carried out on the physical and chemical composition of palm oil obtained from different local oil palm factories in Imo state, it is recommended that palm oil from Okigwe is most suitable for soap making since it had the highest saponification value. Although, all other palm oil samples under study indicated their suitability for different domestic and industrial applications as well as export trade.

It is also recommended that oil palm factories in Imo state processing and storage method should be properly monitored to prevent major contamination or adulteration which might have an adverse effect on the future of oil palm industry in Imo state, Nigeria.

References

[1] P. O. Agbaire. *African Journal of Food Science and Technology* 3(9) (2012) 223-226.

[2] F.F. Akinola, O.O. Oguntibeju, A.W. Adisa, & O.S. Owojuyigbe, *Journal of Food, Agriculture and Environment,* 8(3) (2010) 264-269.

[3] R.O. Akinyeye, E.I. Adeyeye, O. Fasakin, & A. Agboola, *Electronic Journal of Environmental, Agricultural and Food Chemistry*, 10(5) (2011) 2190-2198.

[4] D.T. de Almeida, I.L. Nunes, P.L. Conde, R.P.S. Rosa, W.F. Rogério & E.R. Machado, *grasas y aceites,* 64 (4) (2013) 387-394.

[5] E. Baryeh, *Journal of Food Engineering,* 48(6) (2001) 201-209.

[6] U.A. Birnin-yauri, & S. Garba, *Nigerian Journal of Basic and Applied Science*, 19 (2011) 64-67.

[7] R.H.V. Corley, *Environmental science and policy,* 12 (2009)134-139.

[8] I. Danso, B.N. Nuertey, E. Andoh-mensah, A. Osei-Bonsu, T.E.O. Asamoah, D.A Dwarko, G. Okyere-Boateng, E. Marfo-Ahenkora,& A. Opoku, *Journal of Ghana science Association,* 10(2) (2008) 93-101.

[9] G. Danyo, *International Research Journal of plant science,* 4(6) (2006) 158-167.

[10] C.E. Enyoh, E.A. Ihionu, A.W. Verla, & P.N. Ebosie, *International Letters of Natural Sciences,* 62 (2017) 35-43.

[11] U.N. Ekwenye, *Journal of Food Technology,* 4(3) (2006) 172-173.

[12] U.N. Ekwenye, & Ijeomah, *Mongkut's Institute of Technology Ladkrabang Science Journal,* 5(2) (2005) 319- 341.

[13] Frank,N.E.G; Albert,M.E; Laverdure,D.E.E & Paul,K, *Journal of stored products and post harvest research,* 2(3) (2011) 52-58.

[14] G. Johannson, P.O. Pehlergard, *Society of Planters Malaysia* (1977) 203-220.

[15] N.O. Juliet, M.D. Michael, M.L. Patricia, O. Brains, & G. Tongriyang, *J. Microbiol. Biotech. Res.* 1(2) (2011) 107-112.

[16] P. Kwaski, *FAO Agricultural Services Bulletin,* 148(3) (2002) 274-280.

[17] C.E. Amaobi, I.J. Geogianna, A.W. Verla, E.N. Verla. *Einstein International Journal of Scientific Studies,* 1(1) (2017) 66-69.

[18] K. Loh soh, M. Choo Yuen, F. Cheng sit & N. Ma Ah, *Journal of palm oil research,* 307(6) (2006) 10-12.

[19] R.P. Mensink, P.L. Zock, A.D.M. Kester, & M. B. Katan, *American Journal of clinical Nutrition,* 77 (2003) 1146-1155.

[20] U.R. Nagendran,Y. M. Unnithan, Y.M. Choo, & K. Sundram, *Food and Nut. Bull.,* 21(2) (2000) 189-194.

[21] A. Hiol, L.C. Comeau, D. Druet, M. D. Jonzo, N. Rugani,& L. Sarda, *Enzyme Microb. Tech.* 26 (1999) 421-430

[22] A. Houria, L. Comeau, V. Deyris, & A. Hiol, *Enzyme Microb. Tech.* 31(9) (2002) 68-975.

[23] J.N. Okechalu, M.M. Dashen, P.M. Lar, B. Okechalu , T. Gushop, *J. Microb. Tech. Res.* 1(2) (2011) 107-112

[24] M.U. Orji, *Afr. J. Biochem. Res.* 2(9) (2006) 192-196.

[25] M.U. Orji & T.I. Mbata, *Afri. J. Biochem. Res*. 2(9) (2008) 192-196.

[26] C. Rona, F. Vailati, E. Berardesca, *Journal of cosmetic dermatology,* 3 (2004) 26-34.

[27] K. Sundram, T. Thiaharajan, A. Gapor, & Y. Basiron, *Palm tocotrienols: new antioxidants for the new mellinium,* 13 (2002) 634- 641.

[28] M. Sutapa, & M. Analava, *J. Hum. Ecol,* 26(3) (2009) 197-203.

[29] W. Verheye, *EOLSS,* 2 (2005) 117-219.

[30] S.M.A Tagoe, M. J. Dickinson, & M.M Apetorgbor, *International Food Research Journal* 19(1) (2012) 271-278.

[31] B. Wicke, R. Sikkema, V. Dornburg, & A. Faaij, *Land use policy,* 28 (2011) 193-206.

[32] A. Wolves-Perges A, *The Society of Planters, Malasia,* (1969) 42-52.

[33] W.C. Fraziar, D.C. Westoff, Food Microbiology, 3rd Ed. Tata Mcgraw-Hill Publishing Company Ltd, New York. 170 (1979).

[34] B.J. Morris, The chemical analysis of food products, (3rd ed.), New Delhi: CBS Publishers (1999).

[35] AOCS, Official Methods and Recommended Practice of the American oil Chemist Society, 5thedition. Champain (1993).

[36] NIS, Nigerian Industrial Standards. Standard for edible vegetable oil, (1997) 5-12.

[37] G.I. Onwuka, Food analysis and Instrumentation, theory and practice, Lagos, Nigeria: Naphtali Print (2005).

[38] AOCS, Official Methods and Recommended Practice of American Oil Chemist Society. 5thed. Champaign (2003).

[39] FAO, Food and Agricultural Organization of United Nations publications, Rome (2002).

[40] WHO, World Health Organization, WHO Technical Report, 916 (2003) 82-88.

[41] SON, Standard Organization of Nigeria. Standards for edible refined palm oil and its processed form, (2002) 2-5.