

Physicochemical Parameter of Palm Oil and Soil from Ihube Community, Okigwe, Imo State Nigeria

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Keywords: Physicochemical, palm oil, soil, heavy metals.

Abstract. This study assessed the quality of palm oil and soil from Ihube community, Okigwe L.G.A of Imo state in October 2015. The soil samples were collected from the top soil and the palm oil were collected immediately after extraction. Palm oil and soil were analyzed using standard analytical methods and the results obtained were compared to standards. The physicochemical analysis of the soil samples showed that ranges of EC (323.33 ± 0.57 - 480.33 ± 1.53 us/cm); Moisture Content (MC) ranged from 20.9 ± 0.80 to 40.8 ± 0.10 ; %SOM (1.92 ± 0.61 - 4.85 ± 0.01) which were within the acceptable limits while CEC, iron content and lead were not significant. Palm oil samples had MC ($0.32 \pm 0.09\%$) which was above the acceptable limit. The oil was acidic and free fatty acid (FFA) result for 10days showed even much acidic ranges from (2.15 ± 0.01 to 6.07 ± 0.05 mgNaOH/g) with Fe, (2.00 ± 0.01 to 5.43 ± 0.51 mgNaOH/g) with Pb and (1.27 ± 0.03 to 5.04 ± 0.03 mgNaOH/g) without contamination. This was tested using anova at $p < 0.05$ respectively and there was a significant difference between the results. However, the result obtained from these areas shows good quality soil for palm tree cultivation.

1.0 Introduction

The oil palm is a monocotyledon belonging to the genus "*Elaeis*". It is a perennial tree crop and the highest oil producing plant. The crop is unique in that it produces two types of oil. The fleshy mesocarp produces palm oil, which is used mainly for its edible properties and the kernel produces palm kernel oil, which has wide application in the oleochemical industry. The genus "*Elaeis*" comprises two species namely *E. guineensis* and *E. oleifera* [1]. *E. guineensis* originates from West Africa and indigenous to Nigeria. It is an economic crop and from the earliest times its product have played a very important role in the socio-economic and political life of the people of Nigeria [2].

Like all oils, triglycerides (TGs) are the major constituents of palm oil. Over 95% of palm oil consists of mixtures of triglycerides (TGs), that is, glycerol molecules, each esterified with three fatty acids. During oil extraction from the mesocarp, the hydrophobic TGs attract other fat or oil-soluble cellular components. These are the minor components of palm oil such as phosphatides, sterols, pigments, tocopherols, tocotrienols and trace metals. Other components in palm oil are the metabolites in the biosynthesis of TGs and products from lipolytic activity. These include the monoglycerols (MGs), diglycerols (DGs) and free fatty acid (FFA).

The fatty acids are any of a class of aliphatic acids, such as palmitic (16:0), stearic (18:0) and oleic (18:1) in animal and vegetable fats and oils. The major fatty acids in palm oil are myristic (14:0), palmitic, stearic, oleic and linoleic (18:2) [3] palm oils have saturated and unsaturated fatty acids in approximately equal amounts.

Most fatty acids are present as TGs. The different placement of fatty acids and fatty acid type on the glycerol molecule produces a number of different TGs. There are 7 to 10% of saturated TGs, predominantly tripalmitin [4]. The fully unsaturated TGs constitute 6 to 12%. The triacylglycerols in palm oil partially define most of the physical characteristics of palm oil such as melting point and crystallization behavior etc.

Palm oil has a high resistance to oxidation and therefore a long shelf life. These properties make it particularly suitable for use in hot climates and as a frying fat in the snack and fast food industry and the fatty acid derivatives of palm oil are used in the production of bactericides, cosmetics, pharmaceuticals and water-treatment products.

Palm oil quality could be affected by improper post harvest handling, processing and storage techniques [5]. Proper packaging and storage is known to slow down chemical deterioration. However, in Nigeria, poor storage in our locality causes the use of poor quality palm oil in cooking. The effect of packaging materials on storage stability of crude palm oil has been conducted [6, 7]. The poor storage causes increase in deterioration of the palm oil. Furthermore, some of the ways in which palm oil are stored in Nigeria are in lacquered metal cans, tanks, plastics, bottles etc [6]. Some of these containers are made up of materials which enable deterioration such as lead additives used in plastics as well as iron in metal cans etc. A study however has shown that crude palm oil packaged in plastic bottles recorded high oxidations values [6].

Soil, the loose material that covers the land surfaces of earth and supports growth of plants. Crop production involves a complex relationship between the environment, soil parameters, and nutrients dynamics. Because of this fact, studies on soil are important in the terms of their productive potentials or capabilities. Failure to understand these complexities has resulted in lack of good crop production and management technique: hence agricultural production has tended to be low.

Soil fertility decline is considered as an important cause for low productivity of many soils. It hasn't received the same research attention as soil erosion, probably because as soil fertility decline is invisible and less spectacular, and more difficult to assess. Assessing soil fertility is difficult because most soil chemical properties either change very slowly or have large seasonal fluctuations. This decline includes: nutrient depletion, nutrient mining, acidification (decline in pH and/or an increase in exchangeable aluminium), loss of organic matter and increase in toxic elements such as Cadmium and Manganese [8].

No study however, has been reported on soils and palm oil from Ihube Autonomous Community. Therefore, this study is aimed at accessing the quality of palm oil and soil from Ihube community, Okigwe, Imo State, Nigeria and also to determine the possible effect of iron and lead rich materials under normal room temperature on the storage stability of palm oil from Ihube community, Okigwe, Imo State, Nigeria. Additionally, the information obtained from this work will be useful to food processors, palm oil consumers in Imo state and also the information from the soil will be useful to farmers from the study area.

In the present study, the physicochemical parameter of the soil and palm oil namely pH, temperature, viscosity, texture, soil organic matter (SOM), moisture content, electrical conductivity, cation exchange capacity (CEC), heavy metals, acid value and free fatty acids were determined from the soil and palm oil from Ihube community, Okigwe L.G.A of Imo State. The specific objectives include; (1) to characterize the soil from Ihube and examine the impact on palm oil quality from the area, (2) to characterize the palm oil (3) to evaluate the effect of iron (Fe) and lead (Pb) rich storage material on the quality of palm oil.

2.0 Materials and method

2.0.1 Chemical and Reagents:

All instrument used in this work were in good working condition and were used according to manufacturer's instructions. Aqua-Regia, Hydrochloric acid (HCl), Nitric acid(HNO₃), Ethanol, Sodium hydroxide(NaOH) (0.1N), Phenolphthalein indicator, Distilled water.

2.1 Study Area

Geographically Ihube lies with latitude of 5° 52' 0" North, and longitude 7° 22' 0" East. The district is located in the boundary of Imo-Enugu state in the South-East of Nigeria. The soil is predominantly partly red clay and black or dark brown. The major crops grown in the district on its hilly farmlands are palm tree (palm oil and palm wine), cassava, vegetables.

2.2 Sample Collection and Pretreatment

The soil and palm oil used for this work were collected from Ihube Autonomous Community, Okigwe L.G.A, of Imo State. The palm oil is of the “*elaies guineensis*” and was collected immediately after extraction at a local palm oil processing unit in the study area. The soil samples were collected at 5 different sample locations in Ihube.

Five villages in Ihube Autonomous Community, Okigwe L.G.A of Imo state were selected for testing the quality of the soil. Twenty five samples were collected from the five different sites. At each site a W shaped line was drawn on a 2x2m surface along which five samples were collected from each sample field area and mixed homogeneously to form one sample. The sampling locations are rural places and the sample sites are palm plantations. The soil samples were collected at a depth of 0-15cm of the soil, which is the top soil (TS) into polythene bag which were previously cleaned. The palm oil sample was collected immediately after extraction into polythene bag which was previously cleaned. The palm oil and soil samples were then transferred to the chemical laboratory at Imo State University for analysis.

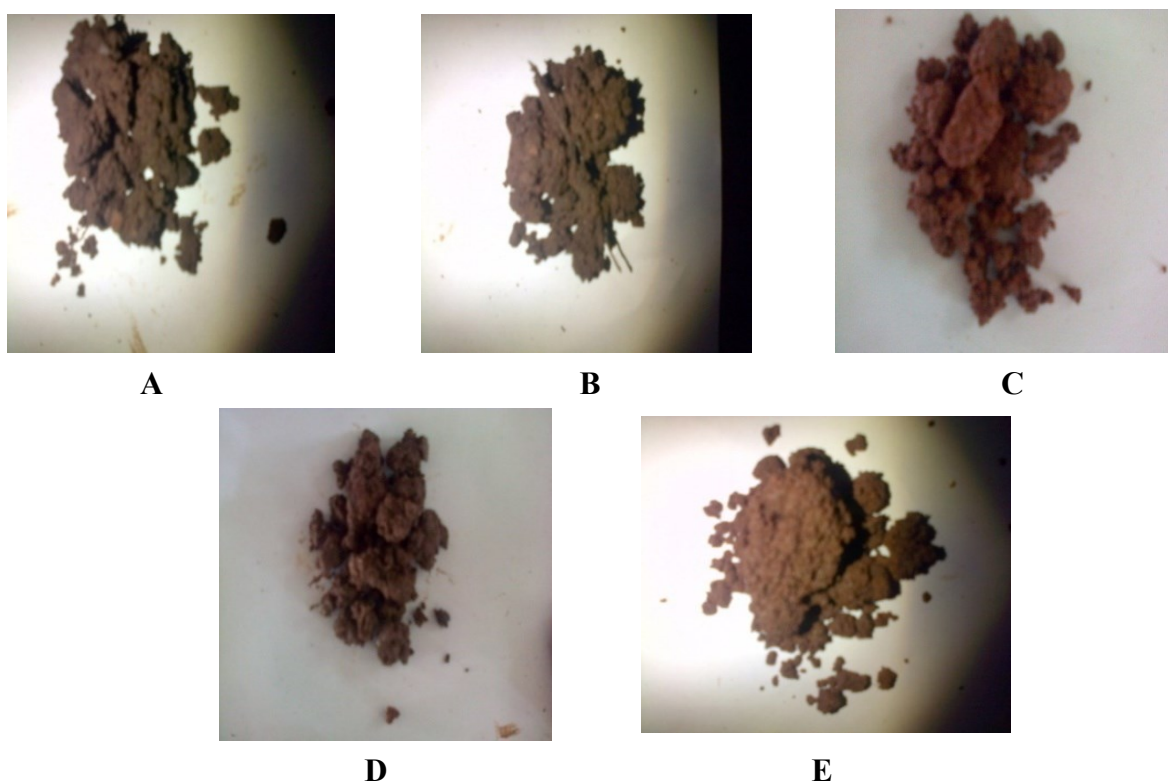


Figure 1. Photographs of soil samples A to E.

2.3. Visual Soil Field Classification

The color was determined with the aid of a munsell color chart. The moisture description was determined by collecting some soil sample from the field, and then places it on a paper. Then it is observed for moist, dry or wet. The size gradation was determined with the use of a hand lens. The odor was determined by direct smelling with the nose. This was done with the use of a muslin cloth to check the soil for staining. Dilute hydrochloric acid was added drop-wise to the soil sample and observe for either strong, weak or no reaction.

2.4. Physico-Chemical Analysis of Soil

2.4.1. Electrical Conductivity (EC)

The electrical conductivity was measured using HANNA HI8733 EC METER in $\mu\text{S}/\text{cm}$. Calibrated using KCl.50 gram of soil was weighed into a beaker and 100ml of water was added. Then, it was stirred gently and allows standing for 30mins. The EC probe is then introduced into the soil-water suspension for 60seconds and readings is taken.

2.4.2. pH

The pH was determined using JENWAY 3510pH METER which was calibrated using buffer 4 and buffer 7 by dissolving one capsule each in 100ml of distilled water respectively. The pH was determined also with the same method used for the EC measurement.

2.4.3. Temperature

The soil temperature was determined using the Gardner's Soil Thermometer. The thermometer was inserted to about 3cm depth of the soil for 3-6mins. The soil temperature was determined for 3days consecutively in the morning.

2.4.4. Determination Of Texture

100g of the soil was weighed into a quart bottle, and was filled with water to the neck of the bottle. The bottle was shaken vigorously to separate the soil. Then allow standing for 2-3 days. Different layers were formed (i.e. sand, silt, and clay) and the percentage was calculated and named using the USDA Soil Texture Triangle. The percentage of sand, silt, and clay was calculated using the formula below:

$$\frac{x}{y} \times 100 \quad (1)$$

where X= clay, silt, and sand thickness, Y = total thickness

2.4.5. Moisture Content Determination

The moisture content was determined using the gravimetric method.

10g of the soil was weighed into a porcelain dish (which was previously weighed, W_D). Then placed in an oven at 105°C for 2hours until all the water is driven off (i.e. constant weight) (Y_2). The difference in weight is the amount of moisture in the soil. The moisture in the soil is calculated using the formula below.

$$\% \text{ Moisture Content} = \frac{\text{Initial weight} - \text{Final dryweight}}{\text{Initialweight}} \times 100 \quad (2)$$

2.4.6. Soil Organic Matter Content (SOM)

The SOM was determined using the weight Loss on Ignition (LOI) method.

From the moisture content determination, the entire oven-dried test soil sample with the porcelain dish was placed into the muffle furnace at 440 °C for more than 8 hours. Then it was removed carefully from the furnace using the tongs and allows cooling to room temperature. Determine and record the mass of the dish containing the ash (burned soil) (M_{PA}).

Calculations were done as follows

Determine the mass of the dry soil (M_D) from the moisture determination

$$M_D = Y_2 - W_D$$

Determine the mass of the ashed (burned) soil (M_A)

$$M_A = M_{PA} - W_D$$

Determine the mass of organic matter (M_o)

$$M_o = M_D - M_A$$

$$\% \text{ SOM} = \frac{M_o}{M_D} \times 100 \quad (3)$$

2.4.7. Determination of Cations Exchange Capacity (CEC) and Heavy Metals

The cation exchange capacity and heavy metals of the soil was determined using Varian AA240 Series Atomic Absorption Spectrophotometer (AAS) measured in ppm. To provide element specific wavelengths, a light beam from a lamp whose cathode is made of the element being determined is passed through the flame. A device such as photon multiplier can detect the amount of reduction of the light intensity due to absorption by the analyte and this can be directly related to the amount of the element in the sample.

The soil sample was digested using aqua-regia. 1g of the soil was weighed into a test tube and was digested with 24mls of aqua-regia for 3days. The supernatant is then filtered using a sieve and was subjected to AAS for the cations and heavy metals. The summation of the cations present is the cation exchange capacity (CEC) measured in ppm or mg/kg.

2.5 Physico-Chemical Analysis of Palm Oil

2.5.1. Temperature

The temperature was determined using a thermometer. The thermometer is inserted in the oil and reading is taken.

2.5.2. pH

The pH was determined using JENWAY 3510 pH METER which was calibrated using buffer 4 and buffer 7 by dissolving one capsule each in 100ml of distilled water respectively. The pH electrode is inserted into the oil and the reading is taken.

2.5.3. Viscosity

The viscosity was determined using NDJ-5S DIGITAL VISCOMETER at various temperatures ranging from 20°C – 50°C. The rotary part of the viscometer was inserted in the palm oil and readings were taken from 0-90% in mPas.

2.5.4. Determination of Acid Value (Av) and Free Fatty Acid Content (FFA) Of Palm Oil

The acid value and FFA were determined using titrimetry method. 5g of palm oil was weighed in a dry conical flask. 25mls of absolute ethanol and 2-3 drops of phenolphthalein was added. Then it was heated with continuous shaking in a water bath till the content of the flask starts boiling. Allowed cooling and then it was titrated with 0.1N NaOH until pink color appears. Record the volume NaOH used and calculate the AV and %FFA of the palm oil using the formula below

$$AV = \frac{\text{ml of NaOH} \times N \times 56}{\text{weight of sample}} \times 100 \quad (4)$$

$$\%FFA = AV \times 0.503$$

2.5.5. Moisture Content Determination

The moisture content was determined using the gravimetric method. 10 g of the palm oil was weighed into a porcelain dish (which was previously weighed, W_D). Then placed in an oven at 105°C for 2hours until all the water is driven off (i.e. constant weight) (Y_2). The difference in weight is the amount of moisture in the palm oil. The moisture in the palm oil is calculated using the formula below

$$\% \text{ Moisture Content} = \frac{\text{Initial weight} - \text{Final dry weight}}{\text{Initial weight}} \times 100 \quad (5)$$

2.6. 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 was also used to show the variation of free fatty acid in 10 days.

3.0. Results

Table 1. The visual characteristics of the soil.

Parameter	Soil Samples				
	A (Ozara)	B (Amagu)	C (Nkoto)	D (Ogwube)	E (Akpugo)
Color	Dark brown	Dark brown	Light reddish-brown	Dark brown	Light brown
Moisture description	Moist	Moist	Moist	Moist	Moist
Size gradation	Clay	Clay	Clay	Clay	Clay
Evidence of contamination	Stains	Stains	Stains	Stains	Stains
Reaction with HCL	Strong	Strong	Weak	Strong	Weak
Other comment	Present of debris and living organism	Present of debris and living organism	Present of debris	Present of debris and living organism	Present of debris

Table 1 shows the result for the visual soil classification of soil sample fields. The dark brown color exhibited by samples (A, B, and D) indicates that there is presence of organic matter. However, the light brown, light-reddish brown colours shown by samples E and C indicates that there is presence of little quantity of organic matter. Samples E and C could be said to show the presence of free iron and the soil is poorly oxidized. The moist nature from the five samples gives an insight on the groundwater conditions and the clayey gradation indicates that the soil exhibit puffy-like (plasticity) within a range of water contents, and so the soil is most likely to exhibit considerable strength when air-dried. The odor and the reactions of the soil samples with HCl indicate significant organic material in the soil.

Table 2. Characteristics of the soil samples.

Samples	EC (μS/cm)	pH		MC (%)	SOM (%)	Particle size distribution (%)		
		Temp.(°C)				Sand	Silt	Clay
A	358.4±0.57	6.63±0.01	29.1±0.2	33.1±0.20	4.52±0.23	13.6±0.49	4.6±0.51	51±0.02
B	323.33±0.57	6.71±0.0	28±0.26	38.8±0.10	4.85±0.01	21.9±0.40	10±0.0	53.8±0.4
C	413.67±3.21	6.77±0.06	27.8±0.12	20.9±0.80	1.92±0.61	19.3±2.07	8.8±0.69	67.1±1.38
D	343.33±1.15	6.70±0.01	29.1±0.20	40.8±0.10	4.22±0.0	16.2±1.61	8.5±1.45	75.2±8.49
E	480.33±1.53	6.54±0.04	28.1±0.20	21.9±0.10	3.29±0.0	18.1±2.00	8.9±0.98	64.4±1.90

*mean \pm SD reported for triplicate analysis, A= Ozara, B= Amagu, C= Nkoto, D= Ogwube, E= Akpugo

The electrical conductivity, temperature and the pH of the soil samples analyzed ranges from (323.33 \pm 0.57-480.33 \pm 1.53), (27.8 \pm 0.12-29.1 \pm 0.20) and (6.54 \pm 0.04-6.77 \pm 0.06) respectively (Table 2), which falls within the range of international standard. The electrical conductivity is a measurement of the dissolved material in an aqueous solution, which relates to the ability of the material to conduct electrical current through it. Temperature indirectly affects the soil biota by affecting physico-chemical properties such as diffusion & solubility of nutrients, mineral weathering and evaporation rates. The pH is weakly acidic and plays an important role in the metal bioavailability to plant, toxicity and leaching capacity of soil to surrounding areas [9].

The moisture content of the soil samples analyzed shown in table 2 ranges from (20.9 \pm 0.80-40.8 \pm 0.10%). This indicates the amount of water present in the soil. The soil water dissolves salts and makes up the soil solution, which is important as medium for supply of nutrients to growing plants. The results obtained for moisture could have been due to the textural class of the soil samples shown in table 2 and the compactness of the soils may have also been a contributor.

The soil organic matter result (table 2) showed that the soil samples fall within the normal range (1-6%) [10] The organic matter is a reservoir of nutrients that can release to the soil and it improves soil structure.

Table 3. Heavy metals and cation analysis of the soil.

Sampling sites	Cations and heavy metals (mg/kg)						CEC (mg/kg)
	Ca	Mg	K	Pb	Fe	Na	
A(Ozara)	2.664	1.673	1.0063	ND	0.731	0.445	5.7883
B (Amagu)	3.563	3.275	0.8068	ND	0.317	0.462	8.1063
C (Nkoto)	3.512	0.655	1.0019	0.004	0.428	0.674	5.8429
D (Ogwube)	3.545	ND	2.0046	ND	0.311	0.216	5.7656
E (Afikpo)	4.308	0.155	0.956	0.054	0.515	0.052	5.471

Trace metals are known to form complexes with organic matter and this influences their mobility in the soil [7]. The result of the concentration of the heavy metals and estimated cation exchange capacity (CEC) (ppm) (table 3) is below the NESREA standard for soil quality [11]. The CEC shows the capacity of the soil to hold cations. This could have been due to the downward leaching of nutrients in the soil by the consistent rainfall experienced in these areas; because at this pH it is expected that the soil has maximum availability of all the essential plant nutrients.

Table 4. Physico-chemical characteristics of the palm oil.

Temp. °C	pH	Viscosity (mPas)	%MC
20	4.74±0.01	106.23±0.55	0.32±0.09
25	4.74±0.01	77.48±0.53	0.32±0.09
30	4.73±0.00	57.54±0.31	0.32±0.09
40	4.71±0.01	35.54±0.15	0.32±0.09
50	4.71±0.01	23.41±0.44	0.32±0.09

*mean±SD reported for triplicate analysis * MC = moisture content

The maximum acceptable limit for FFA is 5% [12, 13]. The palm oil obtained was shared in two extra containers and a material rich in iron (Fe) was added in one the sample by introducing a nail in the oil and lead (Pb) into the other through PVC pipes. The variation of the FFA content with days under normal storage condition and as they were influenced by these metals was shown in Table 5. There is a perceived increase in the FFA contents of the two palm oil samples as influenced by these metals compared to sample without metal contamination. The rate at which the oil deteriorated with days is greatly influenced by Fe compared to Pb as shown in Table 5.

Table 5. Variation of free fatty acid values in 10 days under normal storage condition and as influenced by iron and lead.

Days	FFA (mg NaOH/g) as influenced by iron	FFA (mg NaOH/g) as influenced by lead	FFA (mg NaOH/g) under normal storage without contamination
1	2.15±0.01	2.00±0.01	1.27±0.03
2	2.79±0.01	2.06±0.04	1.84±0.02
3	3.36±0.04	2.70±0.02	2.06±0.04
4	3.69±0.04	3.07±0.04	2.46±0.04
5	3.94±0.06	3.38±0.02	2.82±0.03
6	3.97±0.02	3.85±0.04	3.36±0.04
7	4.07±0.04	3.91±0.03	3.86±0.04
8	4.51±0.06	4.13±0.01	4.05±0.04
9	5.54±0.03	4.64±0.03	4.52±0.02
10	6.07±0.05	5.43±0.51	5.04±0.03

*mean±SD reported for triplicate analysis

Table 6. Analysis of variance for the free fatty acid (FFA) in 10 days as influenced by iron (Fe) and lead (Pb) at 5%, 1% and 10%.

	Sum of squares		df	Mean squares	F-ratio	F _{0.05}	F _{0.01}	F _{0.001}	Sig.
With iron	Between	25.54	1	25.54	102.15	4.49	8.29	15.4	0.0000**
	Within	4.48	18	0.25					
	Total	30.02	19						
With lead	Between	24.27	1	24.27	21.23	4.49	8.29	15.4	0.0002**
	Within	20.58	18	1.14					
	Total	44.85	19						

** Highly Significant

Statistical analysis of data using analysis of variance (ANOVA) (Table 6) indicates that there is a significant difference in the FFA's of the two palm oil samples as influenced by Fe and Pb at $p < 0.05$, 0.01, 0.001 respectively. However, there is also a significance differences as influenced by Fe ($p=0.00000001$) compared to Pb ($p=0.00021857$) and it could be said that Fe has a greater effect on the quality of the palm oil compared to Pb. This could be that the rate at which iron (Fe) enables lipolytic activities which brings about deterioration in the palm oil is greater than lead (Pb). (i.e. Fe > Pb) and may also be due to decomposition of glycerides by lipase or other actions such as heat and light. Trace metals is known to enable oxidative deterioration of oils.

The moisture content (MC) of the palm oil sample was higher than the international standard for edible palm oil. The moisture content obtained from this study is similar to those obtained by Orji and Mbata [14] who reported that the high values of moisture of the oil produced through traditional methods may be due to the fact that the local producers do not boil the pure oil to reduce the moisture content. The pH and viscosity of the palm oil were determined at different temperature as shown in table 4. Though pH of oil was acidic probably due to the presence of free fatty acid (FFA), the viscosity had values comparable to the international standard. This variation has been reported for may seed oils [15].

Conclusion

In conclusion, from the result obtained from this study, it could be said that soil from these areas has enough nutrients even though the region is faced with pollution from human activities and that the quality of palm oil from these areas is affected by secondary factors which might be the time of harvest etc. and also from the present study iron and lead can be detrimental to the shelf-life of palm oil.

References

- [1] A.R. Rees, Evidence of the African Origin of the oil palm, Principles. 9 (1965) 30-36.
- [2] G.K. Helleiner, Peasant Agriculture and Economic Growth in Nigeria, Irwin Inc, 1966, p. 67.
- [3] W.L. Siew, Analysis of palm and palm kernel oils, in: Y. Bashiron, B.S. Jalani, K.W. Chan (ed.), Advances in Oil Palm Research. Malaysian Palm Oil Board, Kuala Lumpur, Malaysia, 2000, pp. 968-1035.
- [4] H. Kifi, Studies on palm oil with special reference to interesterification, PhD Thesis, University of St. Andrews, United Kingdom, 1981, pp. 6-8.
- [5] E.A. Udensi, F.C. Iroegbu, Quality assessment of palm oil sold in major markets in Abia State, Nigeria, Agro-science. 6(2) (2007) 25-27.
- [6] N.N. Nnadozie, F.C. Osanu, T.A. Arowolo, Effect of packaging materials on stability of crude palm oil, Journal of the American Oil Chemists' Society. 67(4) (1990) 259-263.

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- [7] R. Raitio, V. Orlien, L. Skibsted, Effects of palm oil quality and packaging on the storage stability of dry vegetable bouillon paste, *Journal of Food Chemistry*. 132(3) (2012) 1324-1332.
- [8] P.A. Sanchez, Soil fertility and hunger in Africa, *Science*. 295 (2002) 2019-2020.
- [9] A.E. Hartemink, Soil fertility decline: definitions and assessment, *Encyclopedia of Soil Science*. 2 (2006) 1618-1621.
- [10] T.R. Frederick, M.T. Louis, *Soils and soil fertility*, 6th ed. Ames, Iowa, Blackwell Publication, 2005, pp. 123-125.
- [11] NESREA. Federal Republic of Nigeria official Gazette, 2011, p. 40.
- [12] E.G.F. Ngando et al., Assessment of the quality of crude palm oil from smallholders in Cameroon, *Journal of Stored Products and Postharvest Research*. 2(3) (2011) 52-58.
- [13] E.I. Ohimain et al., Assessment of quality of crude palm oil, produced by small holder processes in River state, *Nigerian Journal of Agriculture, Food and Environment*. 8(2) (2012) 20-24.
- [14] M.U. Orji, T.I. Mbata, Effect of extraction methods on the quality and spoilage of Nigerian palm oil, *African Journal of Biochemistry Research*. 2(9) (2008) 192–196.
- [15] A.W. Verla. C.O.B. Okoye, Chemistry compositions and nutritional values of two local condiments: *Monodora tenuifolia* and *Monodora myristica* seeds, *Bio-Research*. 4(2) (2006) 111–115.