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Food Quality Parameters of Crude Palm oil extracted from three varieties of Palm fruits from Nigeria

Sunday Peter Ukwo and Emem Michael Akpan
Department of Food Science and Technology, University of Uyo, Akwa Ibom State, Nigeria.
E-mail: sundayukwo@uniuyo.edu.ng

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Abstract
This study was conducted to assess some food quality parameters of crude palm oil extracted from three varieties of palm fruits (Dura, Pisifera and Tenera). Crude palm oil obtained through traditional extraction process were subjected to physicochemical analysis, mineral and vitamin content using standard methods of analysis. Results of physicochemical properties indicated values of specific gravity and refractive index did not show significant different at ($p > 0.05$) slip melting point varied from 36 to 38°C, acid value ranged from 6.679 to 10.942%. Free fatty acid ranged from 3.048 to 4.993% with the Tenera palm oil as the lowest. Peroxide value ranged from 1.349 to 1.868 meqO_2/kg with Tenera palm oil having the highest value while the iodine value varied from 50.724 to 52.429wij's with the Tenera palm oil having the highest value. Moisture and volatile matter content ranged from 0.196 to 0.343% with the Dura palm oil having the highest value while Pisifera palm oil had the lowest. Mineral content indicated low phosphorus, sodium and potassium content while calcium ranged from 12 to 28 mg/100g and magnesium ranged from 26.73 to 43.74 mg/100g for Dura and Tenera palm oil respectively. Vitamin A content indicated Dura (464 mg/g), Pisifera (335 mg/g) and Tenera (178 mg/g).. Tenera palm oil recorded the highest value of Vitamin E content while Tenera was the lowest These quality indicators are important parameters for choosing oil palm fruits variety for industrial and domestic oil production

Key words: *Palm oil, Physiochemical properties, Food quality, Varieties, Nigeria*

INTRODUCTION

Palm oil is the world's largest source of edible oil, accounting for over 78 million tons or 36% of global edible oil and fat production in 2023 with Indonesia and Malaysia being the principal global producers followed by Thailand, Colombia, and Nigeria (USDA 2024). Palm oil is extracted from the fleshy orange-red mesocarp fruit of oil palm with a characteristic red colour. *Elaeis guineensis* is the primary source of palm oil in West Africa and Southwest Africa. It is an important part of human diet, providing an essential raw material in some pharmaceutical and food industries (Ndife et al 2019; Frank, 2011). The distinctive colour of the oil is due to fat soluble carotenoids that are also responsible for the high vitamin content (Ngando, 2011). It is one of the major oils and fats produced and traded in the world today with numerous applications in the manufacture of

industrial products such as margarines, shortenings, cooking oils, confectionery fats and has been useful for other food applications. (Tagoe *et al*., 2012). Crude palm oil contains approximately 1% of minor components: carotenoids, vitamin E (tocopherols and tocotrienols), sterols, phospholipids, glycolipids, terpenes and aliphatic hydrocarbons, and other trace impurities (Goh *et al*., 1985). The most important are carotenoids and vitamin E, both of which possess important physiological properties. It also contains minor compounds such as diacylglycerol, mono glycerol and free fatty acids (FFA) issued from the biosynthesis and/or hydrolysis of triacylglycerols, sterol, tocopherol, pigments and metal ions are also represented while majority of fatty acids are palmitic acid followed by oleic acid (Mancini *et al*., 2015). The importance of palm oil are many and at the same time it present organoleptic and health implications from use of poor quality palm oil. Certain properties make it prone to rapid deterioration which may constitute a poor quality and health problem when consumed. Palm oil has been used in food preparation for years due to some inherent quality parameters such as good resistance to oxidative deterioration and its better ability to withstand high temperatures rendering it a useful in frying than most alternative oils In addition, it is rich in antioxidant such as carotenoids, tocopherols and tocotrienol which when consumed enhance immune function by a variety of mechanisms, and can improve cardiovascular health (Imoisi *et al*., 2015).

It is believed that low quality of palm oil may be as a result of the palm fruit variety, methods of processing and storage. It is a known fact that quality of palm oil to a large extent determines its usefulness in both domestic and industrial applications (Enyoh *et al*., 2017). The acceptability of palm oil in the international market is largely dependent on the physiochemical properties of the oil at the time of purchase. Some of the properties or parameters usually considered include free fatty acids (FFA), iodine value (IV), peroxide value (PV), moisture, impurities content, colour, taste, aroma, melting point, cloud point, tocophenol and tocotrienol contents (Edem, 2002). The variety of oil palm fruit used to produce palm oil has a significant impact on the quality of the oil as well as the physicochemical properties of oil palm fruits from the three varieties vary significantly. This is important to consider when selecting oil palm fruits for processing, as the physicochemical properties of the fruits can affect the quality and shelf life of the palm oil produced (Oluwole *et al*., 2017). The objective of this study is to determine some food quality parameters of crude palm oil extracted from three varieties of palm fruits (Dura, Pisifera and Tenera) and assess the impact of variety on those parameters.

MATERIALS AND METHODS

Sources of Raw Materials

The palm fruits *Elaeis guineensis* which were used for the production of palm oil were gotten from Ibono Okporo village, Ini Local Government Area, Akwa Ibom State. The ripe palm fruits were harvested by hand plucking and transported to the laboratory in cleaned polythene bags for analysis. All reagents used for laboratory analysis were of analytical grade and were purchased from a certified reagent store at Ago, Lagos state. Other materials and equipment used were gotten from Food Science and Technology laboratory, University of Uyo, Akwa Ibom State.

Sample Preparation and Oil Extraction

For improved oil extraction, the harvested palm fruits were first sorted to remove foreign materials, unripe, and infected palm fruits, thereafter cleaned and weighed. The palm oil samples were extracted from three varieties namely Dura palm fruit, Pisifera palm fruit and Tenera palm fruit according to the method described by Ekwenye (2006). The crude palm oil extracted was boiled in smaller vessels where any fibre still present sank to the bottom. The oil was again skimmed to further remove traces of water. The oil was finally filtered and stored in an air-tight plastic container

Physicochemical Analysis of Crude Palm Oil samples

Determination of Free Fatty Acid

Free fatty acid content was determined using the method described by AOCS (1997). 5g of the oil sample was accurately weighed into a 250ml conical flask. 50ml of neutralized ethanol was added to the weighed oil sample, thereafter few drops of phenolphthalein indicator was added. The solution was then warmed on the hot plate to 40^{o} C for 2 minutes. The solution was stirred while warming for uniformity. The solution was titrated against standardized 0.1N Sodium Hydroxide, shaking vigorously, to the first permanent pink color of the same intensity as that of the neutralized ethanol. The color persisted for 30 seconds.

Calculations:

$$\text{Free Fatty Acids (as Palmitic Acid), \%} = \frac{K \times V \times N}{W}$$

Where,

K = 25.6 (for palmitic acid)

V = average titre value (ml)

N = normality of NaOH used

W = weight of sample (g)

Determination of peroxide value

Peroxide value was determined using the method described by AOCS (1997). 5g of the oil sample was weighed into a 250ml conical flask with a glass stopper. 30ml of the 3:2 acetic acid-chloroform solution was added to the weighed oil sample. The flask was swirled continuously to dissolve the sample, thereafter 0.5ml of saturated Potassium iodide solution was added. The solution was allowed to stand in the dark for exactly 1 minute, then 30ml of distilled water was added immediately. Few drops of starch solution was added to the solution and titrated against 0.1N Sodium Thiosulphate until a colourless endpoint was attained. Blank determination of the reagents without using the oil was conducted alongside.

Calculations:

$$\text{Peroxide Value (meq/kg)} = \frac{(S-B) \times N \times 1000}{W}$$

Where,

S = Titration of Sample (ml)

B = Titration of Blank (ml)
N = Normality of Sodium Thiosulphate
W = weight of sample (g)

Determination of Iodine Value

Iodine Value was determined using the method described by AOCS (1997). 0.2g of the oil sample was weighed accurately into a 250ml collected neck stoppered conical flask. 25ml of Wijs solution was pipetted into the weighed oil sample followed by 15ml of chloroform with continuous swirling for proper mixing. The solution was allowed to stand in the dark for 30 minutes and a blank was carried out simultaneously. The solution was brought out and 10ml of 15% potassium iodide was added followed by 100ml of hot water. The solution was titrated against 0.1N Sodium thiosulphate until the colour changed to pale yellow. 1ml of starch solution was added and a black colouration was observed. Titration continued until a colourless endpoint was achieved.

Calculations:

$$\text{Iodine value} = \frac{12.69\,(B - S)\,N}{W}$$

Where,

B = Volume in ml of standardized sodium thiosulphate solution required for the blank.
S = Volume in ml of standardized sodium thiosulphate solution required for the sample.
N = Normality of the standardized sodium thiosulphate solution
W = Weight in g of the sample.

Determination of Moisture and Volatile matter

Moisture and volatile matter was determined using the air oven method described by AOCS (1997). A petri dish was oven-dried, cooled and the weight taken. The oil sample was thoroughly mixed to distribute the water uniformly. 10g of the oil sample was accurately weighed into the petri dish of a known weight. The weighed sample was placed in an air oven at 105^{o}C for 1 hour. The dried oil sample was removed from the oven and placed in a desiccator to cool to room temperature. The weight of the dried sample was taken after cooling.

Calculations:

$$\% \text{ Moisture and volatile} = = \frac{W_2 - W_1}{W} \times 100$$

Where,

W= weight of sample before drying
W_1= Initial weight of empty dish
W_2= Final weight of dish+ sample after drying.

Determination of colour

Colour was determined using the method described by AOCS (1997). The Lovibond tintometer model F was used to carry out the analysis. The cleaned cell was filled with the filtered oil sample and placed inside the sample holder. The lid was closed and the red, yellow, blue, and neutral filters were adjusted to match with the sample colour while observing through the eyepiece. The cleaned eyepiece was adjusted to a suitable focal length. The colour units of the corresponding filters applied were recorded.

Determination of Slip melting point

Slip melting point was determined using the open tube capillary slip method described by AOCS (1997). The oil sample was melted and filtered through a filter paper to remove any impurities and traces of moisture. The sample was thoroughly mixed and a clean melting point tube was inserted into the sample to force about 10mm of the sample in it.

Determination of Cloud Point

Cloud point was determined using the method described by AOCS (1997). 50ml of the oil sample was taken in a 100ml beaker and heated to 130^{o}C. The beaker was placed in a cold water bath under slow but continuous stirring. The water level of the water bath was higher than the level of oil in the beaker and the rate of cooling was maintained at 1^{o}C per min. A thermometer was used for uniform mixing and was not taken out of the beaker to avoid entrance of air bubbles. The cloud point was attained at the temperature at which the thermometer became invisible when placed at the center of the beaker and observed horizontally though the sample.

Determination of Specific Gravity

Specific gravity was determined using the method described by AOCS (1997). The oil sample was drawn into a sampling container. A stainless steel cylinder was filled to the brim with the oil sample. The hydrometer was dipped in the sample filled cylinder, then the reading was taken as the hydrometer became stable.

Mineral Content Determination

The minerals, sodium, calcium, magnesium, potassium, and phosphorus were determined using the method described by AOAC (2016). The extract was prepared by weighing 1mL of the oil sample into a crucible and placed in the muffle furnace to ash at 450^{o}C for 4 hours. After ashing, 5ml of 20% hydrochloric acid was added to the dried sample and stirred evenly. Minerals in the acid digested samples were analyzed with atomic adsorption spectrophotometer (AAS). Standard stock solution of the element to be analysed were prepared, diluted to the corresponding working standard solution for recovery experiment according to the methods as outlined by Onwuka (2018).

Statistical Analysis

The experiment was conducted in triplicate and data obtained from analysis were subjected to Analysis of Variance (ANOVA) using statistical package for social sciences (SPSS) version 22.0. Duncan Multiple Range Test (DMRT) was be used to compare the treatment means. All the determination was carried out in triplicates and data were expressed as mean ± standard deviation

RESULTS AND DISCUSSION

Physicochemical Analysis of crude palm oil samples

The results obtained from the physicochemical analysis of the crude palm oil extracted from three varieties of palm fruits are presented in Table 1.

The results obtained from the physicochemical analysis of the crude palm oil extracted from three varieties of palm fruits shows that the free fatty acid content of the crude palm oil samples were significantly ($p<0.05$) different ranging from 3.048% to 4.993% with the highest value found in oil from Dura palm fruit and the lowest value in oil from Tenera palm fruit. The results of iodine value of the crude palm oil samples increased significantly from 50.117 wij's in the Pisifera palm oil to 52.429 wij's in the Tenera palm oil. The results of acid value of the crude palm oil samples increased significantly ($p<0.05$) with the highest value found in the Dura palm oil (10.942%) and the lowest found in the Tenera palm oil (6.679%). The results of peroxide value of the crude palm oil samples recorded a decrease with the values ranging from 1.349 meqO_2/kg to 1.868 meqO_2/kg with the highest value found in the Pisifera oil while the Dura palm oil and Tenera palm oil were statistically not significant ($p > 0.05$) in their peroxide content. The results of the moisture and volatile matter of the crude palm oil samples were significantly low with the values ranging from 0.196 to 0.343 % with the lowest value found in the Pisifera palm oil, while the Dura palm oil and Tenera palm oil did not show significant difference statistically ($p0 >.05$). The results of the hexane insoluble content of the crude palm oil samples recorded significant ($p<0.05$) difference with the values ranging from 0.14% to 0.17% with the highest value found in the Tenera palm oil and the lowest found in the Dura palm oil. The Dura palm oil recorded the least slip melting point with a value of 36^{o}C while the Pisifera and Tenera palm oil were statistically ($p<0.05$) similar. The results of the specific gravity of the crude palm oil samples recorded no significance with the values ranging from 0.915 to 0.916. The results of the refractive index of the crude oil samples were statistically ($p<0.05$) similar with the values ranging from 1.455 to 1.458.

Table 1: Physicochemical composition of crude palm oil samples extracted from three varieties of palm fruits

Parameters	Dura palm oil	Pisifera palm oil	Tenera palm oil
Free fatty acid (%)	4.993±0.02^a	3.962±0.03^b	3.048±0.05^c
Iodine value (wij's)	50.724±0.03^b	50.117±0.02^c	52.429±0.04^a
Acid value (%)	10.942±0.03^a	8.682±0.06^b	6.679±0.08^c

Peroxide value (meqO_2/kg)	1.477±0.03^{b}	1.868±0.07^{a}	1.349±0.05^{bc}
Moisture and volatile matter (%)	0.343±0.02^{a}	0.196±0.03^{c}	0.289±0.05^{ab}
Slip melting point (^{o}C)	36.0±0.07^{c}	38.0±0.06^{ab}	38.0±0.04^{a}
Specific gravity	0.915±0.13^{a}	0.915±0.02^{a}	0.916±0.04^{a}
Refractive Index (nD40^{o}C)	1.455±0.03^{a}	1.455±0.02^{a}	1.458±0.04^{a}

Values are represented as means ± standard deviation of triplicate (3) replication. Data in the same row bearing different superscript significantly different at $p<0.05$.

The result of Physicochemical composition of crude palm oil samples extracted from three varieties of palm fruits indicated a free fatty acid values were in the order 4.993±0.02% (Dura), 3.962±0.03% (Pisifera) and 3.048±0.05% (Tenera). These values are comparatively low when compared to the value (16.38-16.54%) reported for crude palm oils by Akinyeye *et al*. (2014) but in agreement with Ekpa and Ekpa (1996) that stated that the palm oil from the Dura variety has higher levels of unsaturated fatty acids than that obtained from the corresponding Tenera and Pisifera. However, the free fatty acid content of the three oil samples were within the 5% standard category for edible oils by NAFDAC (2019). With the low free fatty acid content it shows that the oil would not easily go rancid when properly stored. Moreover, since the refining loss is twice the percentage free fatty acid of any vegetable oil, palm oil from the Dura variety will suffer a higher refining loss during the refining process in view of its high free fatty acids (Ekpa and Ekpa, 1996). Deterioration of fat leads to the liberation of free fatty acids (FFA) from triglycerides. The amount of free fatty acid (FFA) in a fat or oil is indicative of its level of spoilage (Constant *et al*., 2017). The free fatty acid content could serve as a quality indicator for a good harvest and processing. Their presence in palm oil indicates the level of oil degradation during processing. If the free fatty acid content is high, this shows that the fruits were damaged between harvest and extraction or harvested fruits were rotten, leading to the release of free fatty acids from triacylglycerol (Constant *et al*., 2017). Without refining, such oil may be unsuitable for human consumption.

The acid value is also a factor that significantly affects the use of oil for industrial applications or domestic uses. The acid value is an indirect method of deterring the free fatty acid (FFA) contents of oil as it is twice the amount of free fatty acid. It is an index of freshness. Exposure of oil to humidity and temperature results in increased acid value due to hydrolysis of glycerides. Higher acid value gives indication of increased susceptibility of oils to rancidity (Akinyeye *et al*., 2011). The acid values were determined to be 10.942±0.03%, 8.682±0.06%, and 6.679±0.08% for the Dura, Pisifera and Tenera varieties respectively. Palm oil from the Pisifera and Tenera varieties were within the 10% standard by FAO (1984). Iodine value is the quantity of iodine absorbed by one gram of the oil to saturate the sigma bond. It is an indication of the level of unsaturation and susceptibility of oil to oxidation and rancidity (Agbaire, 2012). Iodine value determines the stability and shelf life of oil. High iodine value makes the oil to be unstable thereby affecting other downstream application beside food. The iodine values for the crude oil samples were 50.724±0.03wij's, 50.117±0.02wij's and 52.429±0.04wij's for the Dura, Pisifera and Tenera

varieties respectively. The iodine values obtained in this study were at the standard range of 45 to 53wij's as recommended by NAFDAC (2019) These values suggest that the palm oil samples had low level of unsaturation and might not be susceptible to oxidation. Oils with unsaturated fatty acids are merely absorbed and comparably easier to decompose into calories than saturated fatty acids. Thus, the higher iodine value of palm oil from the Tenera variety is an indication of decline in stability and more susceptibility to oxidative rancidity compared to palm oil from the Dura and pisifera varieties (Olanrewaju and Moriyike, 2013). The peroxide value is an indicator of the level of lipid peroxidation or oxidative degradation. Hence, it is a useful indicator of the early stages of rancidity occurring under mild conditions and a measure of primary lipid oxidation products (Enyoh *et al*., 2017). The peroxide values obtained were 1.477±0.03, 1.868±0.07 and 1.349±0.05 meqO_2/kg for the Dura, Pisifera and Tenera varieties respectively. In this study, all the oil samples used were relatively fresh and had not undergone marked oxidative deterioration as indicated by their peroxide values. The peroxide values recorded in this study were within the 10 meqO_2/kg limit recommended by NAFDAC (2019)

The results obtained for refractive index of the crude palm oil samples from the three varieties of palm fruits ranged from 1.455±0.03 to 1.458±0.04. The high refractive indices of these oil varieties is attributable to the high number of carbon atoms in their fatty acid composition (Falade *et al*., 2008). Refractive index of an oil is the ratio of speed of light at a defined wavelength to its speed in the oil/fat itself. This value varies with wavelength and temperature, the degree and type of unsaturation, the type of substitutions of component fatty acids and with accompanying substances. Refractive index is widely used in quality control to check for the purity of materials and to follow hydrogenation and isomerization. When vegetable oils are contaminated with particulate matters and chemical adulterants such as potassium hydroxide, a chemical reaction takes place. This reaction takes place between fatty acids of vegetable oils and potassium hydroxide produces soap (carboxylic acid ester). This alters the optical activity of the vegetable oils and increases the susceptibility of the vegetable oils to become rancid or spoiled (Williams, 1990). This is a physical constant frequently used in determination of the identity and the purity of fats and oils and many other food and pharmaceutical products. In many cases, it may be used to determine quantitatively the strength and purity of solution or the proportion at which liquids are mixed.

The moisture and volatile matter values obtained were 0.343±0.02%, 0.196±0.03% and 0.289±0.05% for the Dura, Pisifera and Tenera varieties respectively. Palm oil from the Pisifera and Tenera varieties were within the Standard Organization of Nigeria 0.29% limit while palm oil from the Dura variety was slightly above the limit. It has been established that the moisture content of palm oil depends directly on the final extraction and clarification processes (Orji and Mbata, 2008). In a similar study, a value of 0.32% was obtained by Enyoh *et al*. (2017) who reported that the values might be because the local producers do not boil the crude palm oil long enough to reduce the moisture content, which might also be a reason for high moisture content obtained in the Dura variety in this present study. The high moisture content in the Dura variety could also be attributed to the method of processing used for the oil extraction. The moisture content of oils is an important parameter in assessing the quality of an oil sample. The moisture content level of any food is an index of its water activity which means high moisture content is an indication of ease

of deterioration, microbial growth and rancidity as well as short shelf-life. Water is an unusual component of oil and fat, as the two are non-miscible and the presence of water can be compatible only at very low proportions (Enemuor *et al*., 2021).This implies that the sample showing higher values is susceptible to short shelf life due to microbial degradation and endogenous enzymes activities. To this end, such palm oil samples must be given short storage period.

The results for slip melting points of the crude palm samples from the various palm fruits studied were in the range 36.0±0.07°C to 38.0±0.04°C. The values obtained for the melting points are within the regulatory limits of Standards Organization of Nigeria (SON, 2000). Therefore deemed fit for use as food and for industrial application. The results were comparable to results (41 to 48°C) obtained in a study conducted by Akinola *et al*. (2010) on the physicochemical parameters of palm oils in the South-Western part of Nigeria. The determination of melting point is crucial in the study of palm oils as it is used in identifying the level of purity of the crude palm oils. This significant increase in melting point could be the presence of various components in the palm oil especially free fatty acids (Zaeroomali *et al*., 2014), and also the redistribution of the fatty acid chains within the triacylglycerol molecules.

The specific gravity of the oils are 0.915±0.13, 0.915±0.02 and 0.916±0.04 for the Dura, Pisifera and Tenera varieties respectively. These results are quite close showing that the three samples are having comparable densities. According to Yahaya *et al*. (2012), specific gravity is commonly used in conjunction with other figures in assessing the purity of oil. This is a dimensionless unit defined as the ratio of density of the substance to the density of water at a specified temperature. It is a physical quality parameter of edible oils. Edible oils have characteristic specific gravities which are used for their identification (Ichu and Nwakama, 2019).

Mineral content of crude palm oil samples

The results obtained from the analysis of mineral content analysis of the crude palm oil extracted from three varieties of palm fruits are presented in Table 2. below.

The crude palm oil samples recorded a decrease in the potassium content with the Tenera palm oil having significantly ($p<0.05$) higher value of 5.19 mg/100g and the Dura palm oil having the least value of 1.87 mg/100g. Sodium content decreased significantly with the values ranging from 1.98mg/100g to 2.99 mg/100g. The phosphorus content of the crude palm oil samples decreased significantly with the Pisifera palm oil having higher content (0.4 mg/100g) and the tenera palm oil having the least content with a value of 0.1 mg/100g. The values for calcium content were significantly ($p<0.05$) high ranging from 12 mg/100g in the Tenera palm oil to 28 mg/100g in the Dura palm oil. The magnesium content of the crude palm oil samples increased with the values ranging from 26.73 mg/100g to 43.74 mg/100g with the highest content found in the Dura and Tenera palm oil. However the Dura and Tenera palm oil recorded no significant difference in their magnesium content.

The mineral content of crude palm oil samples indicated that Phosphorus was the least detectable mineral while magnesium and calcium were found to be the most abundant minerals. The mineral composition of the oil samples differed significantly ($p>0.05$) in their mineral contents, except for magnesium that showed statistical ($p<0.05$) similarity in the Dura and Tenera varieties. The

presence of magnesium in crude oils affects the process of refining. The result obtained for the magnesium content (26.73 to 43.74mg/100g) of the oil samples in the present study were higher than the values reported by Petraru *et al*. (2021) for sunflower seed oil.

Table 2: Mineral composition of crude palm oil samples extracted from three varieties of palm fruit (mg/100g).

Parameters	Dura palm oil	Pisifera palm oil	Tenera palm oil
Potassium	1.87 ± 0.00^{c}	2.03 ± 0.00^{b}	5.19 ± 0.00^{a}
Sodium	1.98 ± 0.00^{c}	2.09 ± 0.00^{b}	2.99 ± 0.00^{a}
Phosphorus	0.20 ± 0.02^{b}	0.04 ± 0.03^{a}	0.10 ± 0.02^{c}
Calcium	28 ± 0.01^{a}	24 ± 0.02^{bc}	12 ± 0.01^{c}
Magnesium	43.74 ± 0.02^{a}	26.73 ± 0.01^{c}	40.24 ± 0.03^{b}

Values are represented as means ± standard deviation of triplicate (3) replication. Values in the same row bearing different superscript differed significantly ($p<0.05$).

The similarities in the magnesium content of the oil samples despite the different varieties of palm fruits used for oil extraction might be attributed to the refining process. The use of appropriate technology in oil production effectively removes excessive concentrations of minerals present in the raw material (Szyczewski *et al*., 2016). The calcium content of the oil samples ranged from 12 to 28mg/100g. The calcium content of the oil samples are lower than 17.72mg/kg reported by Lamas *et al*. (2014). Calcium has an important role in formation of bone and regulation of heart beat and muscle action. High content of calcium in crude vegetable oils suppressive effects on the hydration of phospholipids thereby reducing the efficiency of degumming and refining processes. Potassium is the most intracellular electrolyte solution and plays a role in fluid balance and osmotic pressure (Balos *et al*., 2016). The potassium content was higher in the Tenera palm oil variety compared to the Dura and Pisifera varieties. The value of sodium in the oil samples ranged from 1.98 to 2.99mg/100g. These values were lower than the value (5.0 mg/100g) reported by Akpabio (2012) for almond seed oil, but in agreement with the value (1.96 mg/100g) obtained for cocoa bean oil. The dietary allowance for sodium is 110mg - 3300mg for adults,. The values obtained for the oil samples are very low and so cannot serve as dietary supplement for sodium. The values obtained for phosphorus were very low compared to the 10mg/100g reported by Akpabio (2012) for almond seed oil. Minerals are essential for the maintenance of the overall mental physical wellbeing and are important constituents for the development and maintenance of bones, teeth, tissues, muscles, blood, and nerve cells. They aid acid base balance, response of the nerves to physiological stimulation and blood clotting (Wardlaw and Kessel, 2002). Since they cannot be synthesized in the body, they must be taken daily from foods or other supplements. Excessive or insufficient intake of minerals, which are important in daily recommended amounts, causes disruptions in body functions and diseases (Nosratpour and Jafari, 2019). Thus assessing the

mineral composition of vegetable oils is important due to their metabolic role in human diet as well as for detecting adulteration and oil characterization .

Vitamin A and E composition of the crude palm oil samples

The results obtained from the vitamin A and E analysis of the crude palm oil extracted from three varieties of palm fruits are presented in Table .3 below. The crude palm oil samples recorded a decrease in the vitamin E content with the dura palm oil having the highest value (10.55 mg) and the Tenera palm oil having the least value (3.01 mg). The results showed significant ($p<0.05$) difference among the samples. The vitamin A content increased significantly with the Dura palm oil having the highest value (464 mg) and the Tenera palm oil having the least value (178 mg).

Table 3: Vitamin composition of crude palm oil samples extracted from three varieties of palm fruit (mg/g).

Vitamin	Dura palm oil	Pisifera palm oil	Tenera palm oil
Vitamin A	464 ± 0.03^{a}	335 ± 0.07^{b}	178 ± 0.05^{c}
Vitamin E	10.55 ± 0.04^{a}	5.96 ± 0.02^{b}	3.01 ± 0.03^{c}

Values are represented as means ± standard deviation of triplicate (3) replication. Values in the same row bearing different superscript differed significantly ($p<0.05$).

The vitamin E content of palm oil extracted from the dura, pisifera and tenera varieties of palm fruits were significantly different ($p>0.05$). Vitamin E, a fat soluble vitamin is known to be predominant in nuts and oily foods, which possesses neuro protective, anticancer and cholesterol lowering properties (Colombo, 2010). The vitamin E content observed in this study is in agreement with the vitamin E content of crude palm oil from the three palm fruit varieties reported by Ezenwaka and Ezeonu (2018). The vitamin A content observed in this study was relatively high.

Conclusion

Crude palm oil from the three varieties of palm fruits exhibited exceptional physicochemical properties and superior quality, hence it is suitable for industrial and domestic food applications. The study showed that the different varieties of palm fruits can be used for oil extraction; however the Pisifera and Tenera variety had higher oil yield than the Dura variety. The result of the physicochemical properties and mineral composition of the oil samples showed that palm oil extracted from different palm fruit variety had an effect on the fatty acid composition, colour intensity, acid values, and moisture content of the oil samples. The study also revealed that the Dura variety had the highest vitamin A and E content whereas Tenera variety had the least. Tenera variety was observed to have the highest degree of unsaturation from the result of the iodine value while Pisifera and Tenera variety had lower values. The study has revealed that varietal differences in palm fruits affect the quality of the palm oil. However, with appropriate processing methods, quality oil can be produced from the three varieties of palm fruits studied.

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