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Physio-Chemical Characteristics and Dietary Metal Levels of Oil from *Elaeis guineensis* Species

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Abstract: Three Species of local palm oil (*Elaeis guineensis*) were harvested and some of their physio-chemical and dietary metal components were analyzed using standard test methods such as Spectrophotometry, Titrametry and Gravimetry. The three species of *E. guineensis* studied were *Elaeis pisifera, Elaeis dura* and *Elaeis tenera*. Determination of the antioxidants as total carotenoids (Vitamin A) and Vitamin E showed that Vitamin A content in *E. pisifera*, *E. dura* and *E. tenera* were 8677.17, 8927.65 and 880.80 ug/g respectively, while Vitamin E obtained for the species were 476.88, 443.52 and 181.92 mg/100 g for Pisifera, Dura and Tenera species respectively. The protein content in the three species (with proximate) also gave 2.21, 2.30 and 2.70% for Pisifera, Dura and Tenera respectively while the iodine values which were determined using Wijis method gave results to be 44.38, 46.93 and 44.05 for Pisifera, Dura and Tenera in that order. The acid value and the saponification values were determined (by titrametric method) in the three species which gave acid value results to be 0.65, 0.67 and 0.57 mgkOH/g for Pisifera, Dura and Tenera respectively while the saponification values where 191.45, 185.77 and 188.48 mgKoH/g for Pisifera, Dura and Tenera in that order. Also the percentage moisture content gave 0.05, 0.04 and 0.05 for the three species in same order above. The dietary magnesium for the Pisifera, Dura and Tenera in that order were 0.95, 1.13 and 0.37 mg/dm^3 and 0.08, 0.24 and 0.05 mg/dm^3 for dietary zinc. The Dietary calcium level were 0.46, 0.41 and 0.34 mg/dm^3 and the potassium 0.46, 0.39 and 0.48 mg/dm^3 for Pisifera, Dura and Tenera respectively. The iron concentration levels were 38.30, 67.70 and 78.30 mg/dm^3 for the three in the same order above.

Key words: *Elaeis guineensis*, physio-chemical, dietary metal, oil,

INTRODUCTION

Palm oil (*Elaeis guineensis*) is a form of edible vegetable oil obtained from the mesocarp of the oil palm fruits. Previously the second most widely produced vegetable oil after Soya bean oil, it may have now surpassed Soya bean oil as the most widely produced vegetable oil in the world today.

Palm oil itself is reddish in colour because of its rich in beta carotene (a provitamin responsible for pigmentation of most fruits and vegetables and the precusor of vitamin A also an antioxidant that destroys singlet oxygen and free radicals in the body). (Ellan Johannesen, 2005).

It is used as cooking oil and also in the processing of other foods.

Red palm oil, besides providing calorie density to the diets is also the largest natural source of tocotrienol and tocopherol (vitamin E family). (Manorama and Rukmini, 1991).

Chemical analysis of the fatty acids composition of the red palm oil indicates that it has about 50% saturated, 40% mono unsaturated and 10% poly unsaturated fatty acids. (Manorama and Rukmini, 1991).

Previously, (Njoku, 2006; Njoku and Ejele, 2004) have done some work on the isolation characterization and a physiochemical property survey of *Elaeis guineensis* at varying temperature regimes just like other works in *Elaeis guineensis* compositional checks but emphasis on their antioxidative potentials and dietary metal levels were not captured, so that formed the basis and scope of this work. Obetta (2000) also worked on palm kernel physio-chemistry.

A study by a group of researchers in China comparing palm, soyabean, peanut oils and lard showed that palm oil actually increased the levels of good cholesterol and reduced the levels of bad cholesterols (LDL) in the blood (Zhang *et al.*, 1995; 1997; cited by Koh, 2006).

A study by Hornstra in 1990 also showed similar results.

The composition of palm oil: Palm oil consists mainly of glycerides made up of a range of fatty acids. Triglycerides constitute the major components, with small proportion of diglycerides and monoglyceride. (Tan and FCH, 1981).

The 2 most predominant fatty acids in palm oil are C16:O (saturated) palmitic acid and C18:1 (Unsaturated) Oleic acid. Typical fatty acid composition of palm oil is given as: ie Malaysian palm oil (Tan and FCH, 1981).

Other major constituents of palm oil are mono and diglycerides. Free fatty acids, moisture, diet and minor component of non oil fatty matter referred to collectively an unsaponifiable matter (Goh *et al.*, 1985).

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Table 1: Fatty acid composition of Malaysian oil

ACID	Name	% Range	% Mean
C12: 0	Lauric	0.1-1.0	0.2
C14:0	Myrstic	0.9-1.5	1.1
C16:0	Palmitic	41.8-46.8	44.0
C16:1		0.1-0.3	0.1
C18:0	Stearic	4.2-5. 1	4.5
C18:1	Oleic	37.3-40.8	39.2
C18:2	Linoleic	9.1-11.0	10.1
Others	Others	0.0-1.8	0.9

Minor components: These are classified into one category because they are fatty in nature but are not really oils. They are referred to as unsaponifiable matter and they include the following:
(1) Carotenoids (2) Tocopherols and tocotrienols (3) Sterols (4) Phospholipids (5) Triterpene alcohol (6) Methyl Sterols (7) Squalenes etc. (Goh *et al.*, 1985).

Carotenoids: The carotenoids, whose name is derived from the fact that they constitute the major pigment in the carrot root, *Daucus carota*, are undoubtedly among the most widespread and important pigments in living organisms. Carotenoids are a group of more than 700 compounds (eg alpha-carotene, beta-carotene). The human body uses carotenoids as Vitamin A which enhances eye health. Carotenoids also play an important potential role by acting as biological antioxidants protecting cells and tissues from the damaging effects of free radicals, which could also cause cancer (Koh, 2006).
Studies also suggest that carotenoids enhance immune function by a variety of mechanisms and improve cardiovascular health. Carotenoids are present in numerous vegetable oils, including yellow maize (corn) oil, groundnut oil, soya-bean oil, rape seed oil, linseed oil, olive oil, barley oil, sunflower oil and cotton seed oil. The concentration of carotenoids in these vegetable oils is generally low, less than 100 ppm (Ong and Tee, 1992).
Of the vegetable oils that are widely consumed palm oil contains the highest known concentration of agriculturally derived carotenoids. In fact, crude palm oil is the world's richest natural plant source of carotenes in terms of retinal (pro vitamin A). Palm oil contains about 15-300 times as many retinal equivalent as carrot, leafy green vegetables and tomatoes (Tan, 1989).

MATERIALS AND METHODS

The physiochemical parameters used in the evaluation of the three palm oil species composition were determined using standard analytical method such as spectrophoto-metric, titimetric and gravimetric etc.

- Metallic measurements-Unicam solar 32 AAS
- Total Carotenoid-Genesys 10 uv spectrophotometer
- Vitamin E Content-Genesys 10 uv spectrophotometer
- Protein content-Titration
- Iodine value-Titration
- Acid value-Titration
- Saponification value-Titration
- Moisture content-Gravimetric

The three palm oil samples were collected from their respective bunches and processed by heating (boiling) the nuts, pounding and pressing the pounded fibre to obtain the palm oil while the nuts were removed. The palm oil samples were collected in plastic containers and later stored in smaller glass containers with good cork.

Sample collection: The three palm oil species were extracted by the traditional method of boiling the palm nuts, pounding them in motar and pressing the pounded mesocarp while the palm kernels were isolated.
These samples were collected in Amaawom-Oboro village near Umudike Umuahia in Abia State, Nigeria. The 3 species, which has their characteristic physical properties, were identified and isolated based on those properties. Examples of their physical properties:

- Okpuruka (*E. dura*): This specie is usually red when ripe and has a thick-hard kernel which cannot be broken with ease with the teeth. Preferable for PKO yield.
- Osukwu (*E. pisifera*): This specie is very much like the Elaeis Dura but differs in its yield and thicker endosperm. Pisifera has higher palm oil yield with little or no kernel. The kernels are usually soft and can be broken with teeth.
- Obia (*E. tenera*): This specie usually has a characteristic green seed when unripe but equally red when ripe. It has a mixture of both small and large kernels. It's palm oil yield is higher than that of Dura but less than Pisifera.

Determination of metals: 2.0 g of the homogenized palm oil sample was weighed in a beaker on a mettler balance and 2 cm^3 of concentrated sulphuric acid was added to it.
The beaker was heated on the hot plate for 10 min to digest the oil sample in the acid. The digested sample was then transferred to an electric furnace and ashed at 550°C for 30 min. After the ashing and cooling of the sample, 6 cm^3 of HCL was used to wash the sample into another beaker. The beaker was further washed with 25 cm^3 of distilled water and resultant solution filtered with a 125 mm whatman filter paper.
The filtered sample solution was then assayed using the Atomic Absorption Spectrophotometer (AAS) combusting and atomizing the sample using air-acetylene oxide [Unicam Solar 32 AAS].

Standard solutions of Calcium, Magnesium, Zinc, Iron and potassium were prepared according to ASTM standard: Carotenoid content was determined by the screening method developed by Kimura Meiko (2004)

Table 2: Composition of minor component in Malaysian crude palm oil

Names	ppm Concentration
Carotenoids	500-700
Tocopherel and Tocotrienels	600-1,000
Sterols	326-527
Phospholipids	5-130
Triterpene alcohol	40-80
Methyl Sterol	40-80
Squalene	200-500
Aliphatic alcohols	100-200
Aliphatic hydrocarbon	50

Courtesy of Malaysian food and nutrition bulletin, volume 15 (1993/1994)

Table 3: Retinol equivalent (RE) of red palm oil compared with other foods

	RE
Fish liver oils (preformed retinol)	
Halibut	900,000
Shark	180,000
Cod	18,000
Fruits and vegetables (carotene derived)	
Red palm oil	30,000
Carrot	2,000
Leafy vegetables	685
Apricots	250
Tomatoes	100
Bananas	30
Orange juice	8

Courtesy of American oil chemical society (Tan, 1989)

following the guidelines of Rodriguez-Amaya (1999) while the Vitamin E content was determined by the method described by Pearson (1976) and the protein by Kjeldahl method described by James (1995). The Iodine value was also determined by the Wijis method while the, Acid value and saponification number were determined by titrametry.

The moisture content was determined by the gravimetric method (James, 1995). 5.0 g of samples were weighed into clean, dry crucibles of known weight. The crucibles containing the samples were then transferred into an oven and heated to dryness at 105°C for 3 h.

The crucibles were removed, cooled in a desiccator and reweighed repeatedly until constant weights were obtained.

The % moisture content were determined by the calculation below:

$$\%\text{Moisture} = \frac{W_2 - W_3\,x100}{W_2 - W_1}$$

Where:

W_1 = Weight of empty crucible

W_2 = Weight of crucible + sample before drying

W_3 = Weight of crucible + sample after drying to a constant weight

RESULTS AND DISCUSSION

Metal components: The analysis results obtained from the three palm oil species showed that *Elaeis tenera* (obia) which is a cross of the *Dura* and *Pisifera* species had highest concentration of dietary metal composition for iron and potassium. For example its iron and potassium concentrations were 78.30 mg/dm^3 and 0.48 mg/dm^3 while, *E. dura* and *E. pisifera* had 67.70 and 38.30 for iron and 0.39 and 0.46 for potassium respectively.

Tenera had lower concentration in Zinc (0.05 mg/dm^3), Magnesium (0.37 mg/dm^3) and Calcium (0.34 mg/dm^3) compared to *Pisifera* and *Dura* which had 0.08 mg/dm^3 Zinc, 0.95 mg/dm^3 Magnesium, 0.46 mg/dm^3 Calcium and 0.24 mg/dm^3 zinc, 1.13 mg/dm^3 Magnesium, 0.41 mg/dm^3 Calcium respectively.

Summarily, the *Elaeis tenera* has the highest concentration of dietary metal components analyzed.

Carotenoid: The results showed that the cross breed specie (*Elaeis tenera*) had the least concentration of vitamin A (880.80 mg/g). The other species analyzed for example, *E. dura* and *E. pisifera* had 8927.65 ug/g and 8677.17 ug/g respectively.

The *E. tenera* showed a general lower concentration of vitamins than the other species.

Vitamin E: The analysis results obtained from the three palm oil species also indicated that the *E. tenera* which is the cross of *E. dura* and *E. pisifera* had the least concentration of Vitamin E., which was 181.92 mg/100 g. While *E. dura* and *E. pisifera* had 443.52 and 476.88 mg/100 g respectively. The results above depicts a steady lower concentration of vitamins in the *Elaeis tenera* specie.

Protein: The three species of palm oil analyzed indicated a close and almost equal concentration of dietary protein content. The *E. tenera* was 2.75% while the *E. dura* and *E. pisifera* had 2.30% and 2.21% respectively. The result also showed that the cross (*E. tenera*) had the highest concentration of protein among the 3 species.

Iodine value: The result obtained on the iodine value of the palm oil samples also indicated a very close value in their iodine values includes the values which gave 44.05 for *E. tenera* while the *E. dura* and *E. pisifera* had 46.93 and 44.38 respectively. The result depicts the degree of unsaturation of the fatty acids in the species hence, *E. tenera* has the least contents of the unsaturated fatty acids among the 3 species.

Acid value: There is equally a close relationship in the acid value obtained from the three palm oil species. The *E. tenera* also had the least value of 0.57 mg kOH/g while the *E. dura* and *E. pisifera* had (mgkOH/g) 0.67 and 0.65 respectively. Though the values were close but the *E. tenera* still had the least acid value.

Table 4: Analysis result summary

Metal Content		Mg/dm^3		
Parameter	Method	Obia (*E. tenera*)	Okpuru (*E. dura*)	Osukwu (*E. pisifera*)
Zinc (Zn)	ASTM D1691	0.05	0.24	0.08
Magnesium (Mg)	ASTM D511	0.37	1.13	0.95
Calcium (Ca)	ASTM D511	0.34	0.41	0.46
Potassium (K)	ASTM D3561	0.48	0.39	0.46
Iron (Fe)	ASTM D1058	78.30	67.70	38.30
Careteniods (mg/g)				
Carotenoids	E/E	888.80	8927.65	8677.17
Vitamin E (mg/100 g)				
Vitamin E	E/E	181.92	443.52	476.88
Protein (%)				
Protein	E/E	2.75	2.30	2.21
Iodine value				
Iodine Value	E/E	44.05	46.93	44.38
Acid value (mgKOH/g)				
Acid Value	E/E	0.57	0.67	0.65
Saponification value (mgKOH/g)				
Saponification value	E/E	188.48	185.77	191.45
Moisture content (%)				
Moisture Content	E/E	0.05	0.04	0.05

E/E = Explained Earlier

Since the acid value measures the extent to which the glycerides in the oil have been decomposed by lipase action and depicts the tendency of rancidity, it means then that the *E. tenera* would be the most stable on the shelf (Manorama and Rukmini, 1991).

Saponification value: The analysis results of the three palm oil species indicated that the Elaeis Dura had the least saponification value (185.77 mg/KOH/g) while the *E. pisifera* had the highest value among the three (191.45 mgKOH/g). The cross (*E. tenera*) had 188.48 mgKOH/g.

Since S.V. measures the volume of KOH required to neutralize the fatty acids produced by hydrolysis of 1 g of sample, the results above therefore depicts that the *E. dura* has the least value of both free and combined fatty acids.

Moisture content: The three (3) species had almost an equal moisture content as indicated in the results of samples analyzed.

The *E. tenera* was 0.05%, *E. pisifera* was 0.05% while the *E. dura* gave a slightly lower value of 0.04%.

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