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Production and Physicochemical Analysis of Palm Kernel Oil

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ABSTRACT

This study is a comparative analysis on the physicochemical properties and chemical composition of palm kernel oil. The extraction of the oils and determination of physicochemical properties were done employing established methods. The chemical compositions for both oils were ascertained with a Gas chromatography-mass spectrometry (GC-MS). The results from the physicochemical properties for palm oil from Ezeioboand palm oil from Naze are specific gravity range of (0.890 - 0.902), refractive index range of (1.4497- 1.4620), acid value range of (1.354 mgKOH/g, 3.815mgKOH/g), iodine value range (47.84g/100g, 50.31 g/100g), peroxide value (4.94meq/kg, 9.14meq/kg) and saponification value (185.85mgKOH/g - 204.77mgKOH/g) respectively. The GC-MS revealed 10 and 12 chemical compounds in palm kernel oil, typically dominated by fatty acids. The results attest to its usefulness in food and in manufacturing industry.

***Keywords*:** Palm oil, Palm kernel Oil, Oil extraction, Saponification, Physiochemical Properties.

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1. INTRODUCTION

Palm oil is orange-red to brownish or yellowish in color and is extracted from the rind of the oil palm (Elaeisguineensis) fruit. The fruit of the oil palm tree, an oblong spherical nut, varies in length from 20 to 50 mm and can reach 25 mm in diameter. It is found in clusters attached to the top of a tree by a stem. (Orji, M.U, et al., 2008). The pod consists of three layers, namely the outer shell (skin), the mesocarp (the outer pulp containing palm oil) and the endosperm (the hard shell surrounding the nucleus (endosperm) that stores oil and carbohydrates for the embryo. Fruit development begins about two weeks after bloom (WAA). Oil deposition in the endosperm begins at about 12 WAA and is almost complete at 16 WAA. (Idris, A.I., et al., 2000). It has been shown that during 12 WAA, the endosperm and endosperm harden slowly, and at 16 WAA, the endosperm is a hard shell surrounding a hard white (nucleus). Oil deposition in the mesocarp is thought to begin at about 15 WAA and continue until the fruit ripens at about 20 WAA. The fruits in the cluster did not ripen at the same time due to the slight variation in the time of pollination. The fruits at the end of each flower ripen first and those at the base last. The outer fruits are large and dark orange when ripe while the inner ones are smaller and lighter in color. (Corley, 1976).

Humans have been using oil palm for 5,000 years. In the late 1800s, archaeologists discovered a substance they believe to be the source of palm oil in a tomb in Abydos dating back to 3000 BC. (Farombi, E.O. 2003). Palm oil from Elaeisguineensis has long been recognized in West and Central African countries and is widely used as a cooking oil. European traders trading with West Africa occasionally bought palm oil to use as cooking oil in Europe.

Palm oil formed the basis of soap products, such as the soap "Sunlight" by Lever Brothers (now Unilever) and the American brand Palmolive. (Oguntibeju, O.O., et al., 2009). By 1870, palm oil was the main export of several West African countries, although it was overtaken by cocoa in the 1880s with the advent of cocoa plantations in colonial Europe. (Petrauskaite, V., et al., 1999).

Norizzah, A. R., et al., (2014), performed a study in which the objective of the study was to determine the physicochemical properties of the olein and stearin fractions obtained from the non-chemical process (NIE), chemical interest (CIE) and enzymatic interest. (EIE) A 50/50 blend of palm oil and palm kernel oil. Potential applications of olein and stearin fractions have also been identified. The stearin and olein fractions were obtained by the one-step dry fractionation method at 25°C. The physicochemical properties analyzed included percent yield, fatty acid composition (FAC), iodine value (VI), smoke point, cloud point, melting point (SMP) and sugar content of the substance solid fat. The results indicated that the percentage of olein yield was higher in the EIE blend (85%) and NIE (82.2%), compared with the CIE blend (41.8%). The EIE blend produced the liquid fraction with the highest amount of unsaturated fatty acids (~50%). Therefore, the olein portion of the EIE blend that best meets the requirement to be used as a frying oil is based on the highest smoke point (265.1°C) and the lowest smoking point. On the other hand, the stearin portion of the CIE blend may be suitable for use in margarine formulations because it has an SMP close to body temperature.

In the study conducted by Niamketchi, G. L., et al., (2021), the obtained results show that the values of physicochemical parameters of palm kernel oil from the three parts are similar and within the range of the Codex Alimentarius 2019 standard. However, the physicochemical parameters are statistically different ($P<0.05$) between the departments. The yields of oils extracted fluctuated between 39.64 ± 2.14 % and 52.26 ± 1.16 %. The refractive index ranges between 1.453 ± 0.01 and 1.454 ± 0.002.

The relative density varies between 0.90 and 0.91. The level of insoluble impurities ranged from 0.06 to 0.09 %. The moisture and volatile matter content varied between 0.62 ± 0.05 to 1.94 ± 0.07 %.

The acid value and free fat acid percentage varies from 6.37 ± 0.65 to 8.54 ± 0.57 mg KOH/g and 3.20 ± 0.31 to 4.29 ± 0.28 %, the saponification value ranges between 216.02 ± 8.96 mg KOH/g and 248.16 ± 2.40 mgKOH/g, iodine value varies from 17.52 ± 0.43and 19.05 ± 0.95 g of iodine per 100 g of fat and peroxide value range between 6.02 ± 1.13 to 8.38 ± 1.00meq O2 kg of fat. The study of the lipid composition of these fats showed significant presence of fatty acid and unsaponifiable. The major fatty acids are lauric acid (50.50 - 51.00 %), myristic acid (18.35 - 18.80 %) and oleic acid (12.80 - 13.92 %).

The study is therefore aimed at investigating the physiochemical characteristics of palm kernel oil, the chemical component of the palm kernel oil in order to ascertain the suitability in consumption, ability to meet local and international market demands.

2. MATERIALS & METHODS

2.1. Materials

Potassium Hydroxide (KOH), Tricylglycerol, 0.5M alcoholic KOH, Reflux, Condenser, Volumetric flask, Water bath, 0.5M HCL, Diethyl ether, n-propanol, 1ml, phenolphthalein, Aqueous 0.1M KOH,Distilled water, Weighing balance, Dry glass stoppered bottle, Potassium iodide, 0.1ml thiosulphate, Starch indicator, Separation funnel, Chloroform, Anhydrous Na2SO4, Conical flask, Acetic acid, Sodium thiosulphate.

2.2. Sample Collection

Samples of palm oil was collected from palm tree planation in Ezeiobo and NazeOwerri west and Owerri North Local Government of Imo state Eastern region of Nigeria respectively. All chemicals and solvents used were of Chemistry Department University of Abuja.

2.3. Determination of Saponification Value

Saponification value is the amount of alkali necessary to saponify a definite quantity of the sample (oil). It is expressed as the number of milligrams of potassium hydroxide (KOH) required for saponifying 1 g of the sample. The smaller the saponification number, the larger the average molecular weight of the tricylglycerol present in the oil. (Petrauskaite, V., et al., 1999)

Triacylglycerol + 3KOH (Glycerol + 3 fatty acids + 3 molecule of KOH)

C3 H0 (C17H35COO)3 + 3KOH C3 H5 (OH)3 + 3C17H35COOK

Two grams of oil were precisely weighed and added to a conical flask that already contained 25 milliliters of 0.5 M alcoholic KOH. The flask containing the ionic solution had a reflux condenser attached to it, and it was heated in a water bath for an hour while being frequently swirled. A hot titration of excess KOH with 0.5 M HCI was performed using 1 ml of phenolphthalein (1%) solution. The saponification value was calculated from the difference between the blank and the sample titration. Saponification value = (b – a) x 28.05/Weight of sample, where b = titre value of blank; a = titre value of sample; 28.05 = mg of KOH equivalent to 1 ml of 0.5 M HCI.

2.4. Determination of Acid Value and Free Acid Content

The acid value is the number of milligrams of the potassium hydroxide necessary to neutralize the free acid in 1 g sample. The breakdown of triacylglycerol into free fatty acids, which has a negative impact on the quality of many fats, can frequently be measured by the acid value. Ten milliliters of diethyl ether and n-propanol were combined, and one milliliter of phenolphthalein solution (1% concentration) was added.

A pink color that lasts for 15 s was obtained after two grams of oil were dissolved in the solvent and titrated with aqueous 0.1 M KOH while vigorously shaking the mixture. The quantity of KOH used was noted. Repetition of the process was done for the blank. % Free fatty-acid = Acid value/2

2.5. Determination of Ester Value

Ester value is obtained through the determination of the difference between the saponification value (SV) and acid value (AV).

2.6. Determination of Viscosity

Specific gravity was used to calculate viscosity for this study. The mass of a given volume divided by the mass of an equivalent volume of water is known as specific gravity. For similar compositions, the specific gravity drops slightly as viscosity drops and rises slightly as temperature rises. On a weighing balance, ten milliliters of distilled water were weighed and the result was recorded as W1. Ten ml of the oil sample was also weighed on the weighing balance, and the weight was recorded as W2.

2.7. Determination of Iodine Value

The amount of iodine that is absorbed by 100 grams of an oil or fat is referred to as the oil or fat's iodine value. Because the glycerides of unsaturated fatty acids, particularly those in the oleic acid series, combine with a specific amount of halogen, the iodine value can be used to determine the degree of unsaturation. Although it is constant for a specific oil or fat, the precise figure obtained depends on the technique used. The likelihood that the oil or fat will oxidize and turn rancid increases with the degree of unsaturation (i.e., higher iodine value). Wijs' method was used to determine the iodine value.

A dry glass bottle with a stopper was filled with palm oil and weighed appropriately. By multiplying 20 by the highest expected iodine value, the proper weight in grams of palm oil was determined. After inserting the stopper, which had previously been moistened with potassium iodide solution, it was left to stand in the dark for 30 minutes. 15 ml of potassium iodide (10%) was added, and 100 ml of water was combined with it. Just before the endpoint, the solution was titrated with 0.1 ml of thiosulphate solution using starch indicator (titration = a ml). In order to treat Blank simultaneously, 100 ml of carbon tetrachloride were used (titration = b ml).

Iodine value = (b – a) x 1.269

Weight of sample

2.8. Determination of Beta-Carotene

Each oil sample was weighed at two grams to create a paste in the refine flask. 25 ml of the alcoholic KOH solution was added, and the mixture was heated for one hour while being frequently shaken in a boiling water bath. After the mixture had quickly cooled, 30 ml of water was added.

The obtained product was then poured into a separation funnel. Three separate 25 ml extractions of the solution were performed. To get rid of any remaining water, two grams of anhydrous Na2 SO4 were added to the extract. The mixture was then filtered into a 100 ml volumetric flask and chloroformed to the proper strength. By dissolving 0.003 of standard beta-carotene in 100 ml of chloroform, a standard solution of beta-carotene, vitamin A, of 0–50 Ug/ml was created. In order to calculate vitamin A from beta-carotene (Ug/100g), the gradient of various standard preparations was determined with reference to absorbance. At a wavelength of 440 nm, the absorbance of the sample and the standard were measured spectrophotometrically.

$$\text{Beta-carotene equivalent (Ug/100g)} = \frac{\left(\frac{Ug}{100g}\right) Absorbance\ x\ Gradient\ x\ Dilution\ factor\ xl}{Weight\ of\ sample}$$

2.9. Determination of Refractive Index

At room temperature, 40°C, and 60°C, the refractive index of oil samples was calculated in triplicates using the Abbe refractometer. Calculating the peroxide value: A 250 ml dry stoppered conical flask was filled with a weighed one g of oil sample after being flushed with inert gas. After adding 10 ml of chloroform, the oil was dissolved by swirling. 1 ml of freshly saturated aqueous potassium iodide solution and 15 ml of glacial acetic acid were added. The flask was sealed, shaken for one minute, and then left in the dark for one minute. Following the addition of 75 ml of water, which was then blended, the freed iodine was titrated with 0.002 M sodium thiosulphate solution using soluble starch solution (1%) as an indicator. The titre value was recorded as V. Additionally, a blank determination (Vo) was noted.

$$\text{Peroxide value} = \frac{(V-Vo)T}{M}\ x\ 103m\ Eq/kg$$

where T = exact molarity of sodium thiosulphate solution.

3. RESULTS & DISCUSSION

The results of Physiochemical analysis of palm oil gotten from Ezeiobo and Naze community Owerri West and Owerri North local government in Imo state, are as follows:

Table 1. Beta Carotene equivalent of palm oil from different location.

Palm oil location	Weight of Sample	Gradient	Dilution Factor	Absorbance at 440nm				Beta Carotene (Ug/100g)			
				Room T°C	40°C	60°C	120°C	Room T°C	40°C	60°C	120°C
Ezeiobo 2232.89	2.5g	66.75	10.00	0.77	0.79	0.55	0.86	2698.65	3344.56	3133.97	
Naze 2246.55	2.3g	66.75	10.00	0.79	0.78	0.54	0.88	2998.75	3466.64	3578.45	

Table 2. Peroxide value of palm oil.

Palm oil location	Weight of Sample	M $Na_2S_2O_3$	Blank titre value bCm^3	Palm oil Samples Titre Value (a cm3)				Peroxide value			
				Room T°C	40°C	60°C	120°C	Room T°C	40°C	60°C	120°C
Ezeiobo	1.00	0.002	1.20	4.20	4.30	4.62	5.77	6.00	6.20	6.84	9.14
Naze	1.0	0.002	1.20	3.67	3.87	4.10	5.27	4.94	5.34	5.80	8.14

Table 3. Iodine value of the palm oil.

Palm oil location	Weight of Sample	blank titre value bCm^3	Palm oil Samples Titre Value (a cm^3)				Iodine value			
			Room T°C	40°C	60 °C	120°C	Room T°C	40°C	60 °C	120°C
Ezeiobo	0.50	20.20	1.350	1.083	0.883	0.433	47.84	48.519	49.037	50.17
Naze	0.50	20.20	1.116	0.867	0.750	0.377	48.44	49.07	49.36	50.31

Table 4. Specific gravity of the palm oil.

Palm oil location	Weight of Sample H_2O = W1	Weight of oil sample 10 ml = W_2				Specific gravity = W_2/W_1			
		Room T°C	40°C	60 °C	120°C	Room T°C	40°C	60 °C	120°C
Ezeiobo	9.78	8.970	8.820	8.760	8.597	0.917	0.902	0.895	0.879
Naze	9.78	8.887	8.757	8.717	8.537	0.909	0.890	0.891	0.872

Table 5. Acid value and free fatty acid value of oil.

Palm oil location	Weight of Sample	Titre value (Cm^3)			Acid value			% free fatty acid = Acid value/2		
		Room T°C	40°C	60°C	120°C	Room T°C	40°C	60°C	120°C	Room T°C	40°C	60°C	120°C
Ezeiobo	2.0	0.823	0.880	10026	1.36	2.309	2.468	2.878	3.815	1.155	1.234	1.439	1.908
Naze	2.0	0.483	0.633	0.716	1.037	1.354	1.775	2.0908	2.908	0.677	0.887	1.004	1.454

Table 6. Saponification value of palm oil.

Palm oil location	Weight of Sample (g)	value b (cm3)	Sample titre value a (cm^3)				Saponification value (mg KOH/g)			
			Room T°C	40°C	60°C	120°C	Room T°C	40°C	60°C	120°C
Ezeiobo	2.0	27.90	13.25	13.45	13.65	14.25	204.77	202.66	199.86	191.44
Naze	2.0	27.90	13.825	13.90	14.15	14.65	197.40	196.35	192.84	185.85

Table 7. Ester value (saponification value – acid value) of the palm oil.

Palm oil locations	Ester value at room T°C	Ester value at 40°C	Ester value at 60°C	Ester value at 120°C
Ezeiobo	203.615	201.426	198.421	189.532
Naze	196.723	195.463	191.836	184.376

Table 8. Melting point of the palm oil.

Palm oil locations	Melting point
Ezeiobo	45°C
Naze	43°C

Table 9 . Refractive index of oil.

Palm oil locations	At room TºC	40ºC	60ºC	120ºC
Ezeiobo	1.4560	1.4517	1.4497	1.4431
Naze	1.4620	1.4588	1.4523	1.4433

Crude palm oil is a complex mixture consisting mainly of glycerides representing the major components, while carotenoids, tocopherols, tocotrienols, phytosterols, and phosphatides represent minor components. Red palm oil is produced from crude palm oil through a lighter refining process that allows to retain most of the carotenes and vitamins in the refined oil (Alyas, S. A., *et al.,* 2006). Therefore, red palm oil is considered as one of the sources. Plants rich in carotenes in which is the precursor of vitamin A and vitamin E (Nagendran, U. R., *et al.,* 2000). Therefore, carotene and vitamin E play an important role as antioxidants that can provide oxidative balance to the oil. The balance of oil relies upon in part, on the volume of degradation throughout heating or storage. It is thought that during residing tissues, lipid materials together with unsaturated fatty acids are sufficiently strong with the aid of using herbal antioxidants and enzymes that save you lipid oxidation. However, as soon as residing tissues are eliminated from plant or animal materials, lipids become worse effortlessly (Krings, U., *et al.,* 2001). Common first-class deteriorations that could arise throughout oil processing are oxidation and hydrolysis.

Criteria for assessing the volume of degradation are vital now no longer most effective for medical and enterprise hobbies however additionally due to fitness implications (Anon, 2004). The volume of bodily and chemical adjustments taking place in palm oil is normally measured with the aid of chemical approaches that degree he numbers one and secondary merchandise of lipid oxidation, as peroxide fee and carotene content material. Free fatty acid content material is measured due to the fact that is nonetheless one dependable parameter for first-class meals and its miles used as indication of hydrolysis. It is likewise essential to assess thermal balance of palm oil (Alyas, S. A., *et al.,* 2006).

3.1. Beta Carotene

In this study, it was observed from Table 1 that the β-carotene content ofpalm oil decreased with increasing temperature and Naze palm oil had the highest β-carotene content at different temperatures of theexperiment compared to the Ezeiobo palm oil. This result is consistent with Chen *etal.,* (1996) and other scholars who observed that beta-carotene content decreased with increasing temperature. The difference in β-carotene content between Naze palm oil and Ezeiobo is that Naze palm oil is more stable and therefore may be of higher quality.

3.2. Peroxide Value

The number one merchandise of lipid oxidation are hydroperoxides, consequently, the result of peroxide cost offers a clean indication of oxidation (Suja K.P., *et al.,* 2004). The peroxide cost of palm oil at 120°C turned into much less than the peroxide cost at decrease temperatures of the test (Table 2).

The discount of peroxide cost at better temperature might be attributed to the fast decomposition of hydroperoxide to secondary oxidation product (Tan, C.P., *et al.,* 2002). It turned into located that palm oil pattern from Ezeiobo has the best peroxide cost at the same time as pattern from Naze has the least once. Peroxide cost of diverse palm oil samples expanded with boom in garage time. This is in line with the findings of (Aidos*et al*., 2001) and (Skara*et al*., 2004) who mentioned a vast boom in peroxide cost with growing garage time in exclusive oils. By implication, it can be stated that the peroxide cost of the exclusive palm oil samples pondered the kingdom of oxidation and consequently the steadiness and first-class of the oil.

3.3. Iodide Value

Oil samples from Naze had the highest iodine value at various temperatures, while sample from Ezeiobo has the least iodine value (Table 3). Iodine value increased with increase in temperature. It has been reported that lowering the iodine value improves the stability and good yield of the liquid oil (Tan, C.P., *et al.,* 2002).

3.4. Specific Gravity

Samples from Ezeiobo had the highest specific gravity, while sample from Naze had the least specific gravity at various temperatures (Table 4). Specific gravity of the various palm oil samples decreased with an increase in temperature. Sample from Ezeiobo was greatly viscid.

3.5. Fatty Acid

The amount of free fatty acids in palm oil is an index of for palm oil quality, and high free fatty acid content is an index of for lipid oxidation (Alyas, 2006). Table 3.5 shows that Naze sample has a high content of free fatty acids due to the highest fatty acids fatty acid values while Ezeiobo sample had the lowest free fatty acid values. The free fatty acid index of different palm oil samples increased with increasing temperature and agreed with the report of Alyas et al (2006).

3.6. Saponification Value

The saponification index is an indicator of the amount of saponifiable fat in an oil or grease. It provides information regarding the properties of the fatty acids of oils or fats and regarding their soap solubility in water. The higher the saponification index of the oil, the easier it is to dissolve the soap that can be obtained from it and thus would be sufficient for soap production (Table 6). The saponification value of for different oil samples decreases with increasing temperature, this implies that soap is easily formed with increasing temperature.

3.7. Ester Value

Table 7 shows that samples from Naze had the highest ester value, while samples from Ezeiobo had the least ester value. Ester value of the various palm oil samples decreased with increased temperature.

3.8. Melting Point

Table 8 shows that samples from Naze had the highest melting point, while samples from Ezeiobo had the least melting point. Our results also show that samples from Naze had the highest refractive index at various temperatures.

3.9. Refractive Index

Table 9 shows the refractive index of both samples from Naze and Ezeiobo decreases with increased temperature of experimentation.

4. CONCLUSIONS

This study has shown that palm oil produced at different local mills in western Nigeria exhibits different physicochemical properties that tend to reflect the stability and quality of palm oil It is also shown that temperature affects the physicochemical properties of palm oil and that the β-carotene content decreases by with increasing temperature. This confirms that heating will destroy the beta-carotene content of palm oil and reduce its nutritional value as a source of vitamin A. Heating different palm oil samples will promote accelerate peroxide formation, and this increases with prolonged heating. We did not evaluate the relationship between storage time and physicochemical changes of different palm oil samples. This study was limited to palm oil produced in Imo state, eastern part of Nigeria; therefore, the outcome of the study cannot be said to be a true representative of palm oil from all parts of Nigeria. Further studies that will investigate the effects of storage and processing procedures on the components of palm oil are recommended.

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