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COMPARATIVE QUALITY EVALUATION OF SELECTED TRADITIONAL PROCESSED PALM OILS (Elaeis guineensis Jacq) FROM SOUTH-EAST NIGERIA

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ABSTRACT

Traditional processed palm oil from five different localities in south-east Nigeria were evaluated for their physical properties, chemical characteristics, fatty acids profile, microbial and sensory qualities. The results showed significant differences ($p<0.05$) in most of the quality parameters. The physical properties ranges were: melting point (32.65-36.50 °C), smoke point (129.35-118.55 °C) and total impurities (0.15-0.22%). Sample 901 had the highest acid and saponification values (0.86 and 194.76 mgKOH/g) while sample 902 had the lowest (0.21 and 183.78 mgKOH/g). The peroxide values were lowest in 901 and 905 (1.61 mEq/kg). Sample 904 had the lowest iodine value (27.44 g/100g), followed by 902 (28.62 g/100g). Palmitic (38.71-48.26%) and Oleic acids (38.41-47.82%) were the most prominent fatty acids. 904 had the highest vitamin A (60.21 µg/g) and vitamin E (16.22 mg/100g) contents and902 the lowest vitamin A (49.61 µg/g). The total microbial count was low in the oils (6.13 - 9.42×104cfu/ml). Sample 902 was organoleptically the most preferred (6.48) while 903 was the least preferred (4.96).Traditional methods of processing palm oil had significant effect on the quality of the oils. However, the oil samples were within regulators quality standard and are therefore fit for consumption

Keywords: Fat and oils, fatty acids, physical properties, vitamins, sensory analysis

1. INTRODUCTION

Palm oil is an edible vegetable oil derived from the mesocarp of the fruit of the oil palm tree (*Elaeis guineensis*). It is an important part of human diet, and an essential raw material in some pharmaceutical and food manufacturing industries (Frank, 2011; Ngando, 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 (Tagoe *et al*., 2012; Ohimain *et al.,* 2013).

Palm oil (*Elaeis guineensis*) contains rich balanced mixture of saturated, monounsaturated and polyunsaturated fats, providing a high level of bio available lipids than any other vegetable source (Bannie and Choo, 2000; Sodamade, *et al*., 2013). It is abundant in medium chain triglycerides (MCTs), which mobilize body fat stores, increase the metabolic rate and is a great source of energy. It is a veritable source of antioxidants especially vitamin E and is the highest dietary source of provitamin A carotenes (beta-carotene and Alpha carotene) (Yousefi *et al*., 2013; Idris *et al*., 2014; Ndife, 2016).

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In Nigeria, many of the food industries use palm oil as their basic raw material because of its availability and cheapness for manufacture. It also serve as raw material in the pharmaceutical industries for the production of detergents, soap and cosmetics (Agbaire, 2012; Akubor and Ogu 2012). Most of the crude palm oils for domestic consumption in Nigeria are produced in local mills with traditional techniques without appropriate equipment (Ohimain *et al*., 2013; Nwosu-Obieogu *et al*., 2015). The methods used affect the yield, quality and shelf stability of the oil products. Traditional production most often does not meet international standards for edible oil quality and safety. The quality of the oil varies depending on the processing method and storage techniques (Udensi and Iroegbu, 2007; Okonkwo, 2011; Agbaire, 2012).

Despite the nutritional and health benefits Nigerians derive from palm oil consumption, not much attention has been given to the quality of the palm oils produced and sold in the market, hence, the need to evaluate the quality of these oils in comparison with international oil standards. The outcome of the study will also help the oil producers, nutritionists and consumers with information in areas that require upgrade and improvement.

2. MATERIALS AND METHODS

2.1 Raw material Sourcing

The traditional processed palm oil samples were collected from five different oil producing localities of South-East states namely; Imo, Anambra, Enugu, Ebonyi, and Abia States and were labelled 901, 902, 903, 904 and 905 respectively (Plate 1). The chemical reagents and equipments that were used were from National Roots Crops Research Institute (NRCRI), Umudike, Abia State.

Plate 1: Traditionally processed palm oil samples from five different southern states of Nigeria

2.2 Methods of Analyses

2.2.1 Determination of physical properties

The physical properties which include cloud, melting, smoke, flash and fire points, as well as the refractive index, specific gravity, impurities and moisture contents of oil samples were determined by the methods described by Onwuka (2018).

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2.2.2 Evaluation of chemical characteristics

The oil quality characteristics such as acid value, iodine value, free fatty acid and saponification value, were evaluated according to the methods described by AOAC (2005).

2.2.3 Analysis of fatty acid composition

Fatty acid composition was examined using the Gas Chromatography (GC) protocol, as described by AOAC (2005).The oils were converted to their fatty acid methyl esters (FAMEs) which were identified with pure standards. The results were expressed as a % of the individual fatty acids.

2.2.4 Determination of zinc and iron contents

The Zn and Fe were determined with wet ashing method (Onwuka, 2018). The minerals in the digests were quantified with pure standards using the Atomic Absorption Spectrophotometer (AAS).

2.2.5 Vitamin assay

The fat soluble vitamins: A (carotenoid), E (tocopherol), D (Vit.D_2) and K contents of the palm oil samples were determined (Nielsen, 2003) with some modifications using UV-VIS spectrophotometer. The vitamins were quantified using their respective standards.

2.2.6 Microbiological assay

Total microbial count of the palm oil was determined by the method outlined in compendium of methods for the microbiological examination of foods (APHA, 1992) with some modifications.

2.2.7 Sensory analysis

The sensory evaluation was done using the method described by Iwe (2010). The samples were presented to a twenty five semi-trained panellist drawn from students and staff of the university. The sensory attributes of appearance, taste, aroma and general acceptability were assessed using the 9-point Hedonic scale, with 9 as like extremely, 5 neither like nor dislike and 1 as dislike extremely.

2.2.8 Experimental design and statistical analysis

A completely randomized experimental design was used. The statistical significance of the observed differences among the means of triplicate readings of the experimental results obtained were evaluated by analysis of variance (ANOVA) one-way and Duncan multiple range test (SPSS, version 16).

3. RESULTS AND DISCUSSION

3.1 Physical properties of oil samples

The result of the physical properties of the various palm oil samples is presented in Table 1. There were significant differences ($p<0.05$) in the physical properties of the oils. The cloud point is important in determining the temperature at which oil turned cloudy in the first stage of crystallization (Norizzah *et al.*, 2014). The cloud point ranged from 6.45 to 10.15^{o}C of which sample 905 had the highest cloud value (10.15^{o}C) while sample 902 had the lowest (6.45^{o}C). The cloud points observed in the present study compared favourably with 6.3 to 11°C earlier reported by Norizzah *et al.*(2014) on various palm oil fractions after interesterification. The cloud point is directly related to the degree of unsaturation (Khalid *et al.*, 2011). Lai *et al*. (2005) reported the cloud point for palm oil as 11.5°C.

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There was significant difference ($p<0.05$) in the smoke point of the oils. Sample 902 had the highest smoke point (129.35 ℃) while sample 905 had the least (118.55 ℃). According to Lai, (2005), the recommended smoke point for palm oil must be above 215℃ and smoke point of oil is dependent on the component free fatty acids. The smoke point of the oil samples were below the recommended value (220 ℃). The low smoke point (118.55 to 129.35 ℃) indicates that, the oil samples may not be good frying oil.

Sample 902 had the highest flash point (184.45 ℃) while sample 903 had the highest fire point (336.65 ℃). Sample 901 had the lowest flash (176.55 ℃) and fire (220.50 ℃) points. The flash (176.55 - 184.45 ℃)and fire (220.50 - 226.65 ℃)points in this study were within the ranges of 1.75 to 1.88 ℃ (flash point) and 196 to 222 ℃ (fire point) reported by Nwosu-Obieogu *et al.* (2017) on palm oil.

The melting point range (32.65 - 36.50 ℃) in this study was lower than 36.7 to 48.3 ℃ reported by Norizzah *et al.* (2014) on various palm oil fractions after interesterification. The melting point was also lower than 41 to 48 ℃ reported by Akinola *et al*. (2010) on palm oil from different palm oil local factories in Nigeria. Changes in melting characteristics of oils are generally due to redistribution of the fatty acid chains within the triacylglycerol molecules (Bannie and Choo, 2000).

Refractive index is an indicator of the degree of purity of the oil. It is a parameter that relates to molecular weight, fatty acid chain length, degree of unsaturation and degree of conjugation (Yousefi *et al.,* 2013). The variation in the processing techniques did not have any significant ($p>0.05$) effect on the refractive index of the oils (1.46 - 1.47). This range is close to 1.44 to 1.45 specified by Codex (2011).

Sample 904 had the highest specific gravity (0.90) which was not significantly different ($p>0.05$) from sample 902 (0.89). Amira *et al*. (2014) stated that the lower the molecular weight of oil, the higher is its unsaturation. The result showed that samples 904 and 902 may have higher degree of unsaturation indicating that processing technique affected the specific gravity of palm oil. The specific gravity range (0.82 to 0.90) in this study was lower than 0.91 to 0.92 observed by Amira *et al*. (2014) on coconut and groundnut oils.

The impurity values range from 0.15 to 0.24%. Sample 903 had the highest impurity value (0.24%) which was not significantly different ($p>0.05$) from samples 904 (0.21%) and 901 (0.22%). Sample 902 had the lowest impurity (0.15%). Oil impurities may have been derived from mesocarp fibres, insoluble materials, phosphatines, trace metals and oxidation. High levels of these substances are typically prohibited in standard edible oils (Ngando *et al*., 2011).

The moisture content of the oils ranged from 0.21to 0.33%. Sample 905 had the highest moisture (0.33%) while 902 had the lowest (0.18 %). The moisture level was due to the production process. Agbaire (2012) reported a range of 0.14 – 0.17%. The higher the moisture contents the lower shelf life of the oils because of hydrolytic rancidity. The moisture values in this study are close to the recommended value (0.29%) for fresh oil by Codex, (2011).The method of processing will affect the moisture content of the oil which in turn increases hydrolytic rancidity of palm oil (2018).

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Table 1: Physical properties of palm oil samples

Sample	Cloud point (°C)	Smoke point (°C)	Flash point (°C)	Fire point (°C)	Melting point (°C)	Refractive index	Specific gravity	Impurity (%)	Moisture (%)
901	$9.60^{b}\pm0.00$	$119.95^{d}\pm0.21$	$176.55^{d}\pm0.07$	$220.50^{e}\pm0.14$	$34.35^{c}\pm0.35$	$1.47^{a}\pm0.00$	$0.83^{b}\pm0.00$	$0.22^{ab}\pm0.01$	$0.30^{a}\pm0.02$
902	$6.45^{e}\pm0.07$	$129.35^{a}\pm0.07$	$184.45^{a}\pm0.21$	$226.25^{b}\pm0.21$	$32.65^{d}\pm0.21$	$1.47^{a}\pm0.01$	$0.89^{a}\pm0.01$	$0.15^{c}\pm0.01$	$0.18^{c}\pm0.01$
903	$8.15^{c}\pm0.07$	$120.90^{c}\pm0.14$	$180.35^{c}\pm0.21$	$226.65^{a}\pm0.07$	$36.50^{a}\pm0.28$	$1.47^{a}\pm0.01$	$0.82^{b}\pm0.01$	$0.24^{a}\pm0.01$	$0.25^{b}\pm0.01$
904	$7.85^{d}\pm0.07$	$121.90^{b}\pm0.14$	$182.55^{b}\pm0.21$	$223.70^{c}\pm0.14$	$34.75^{bc}\pm0.21$	$1.47^{a}\pm0.01$	$0.90^{a}\pm0.01$	$0.21^{ab}\pm0.10$	$0.21^{c}\pm0.01$
905	$10.15^{a}\pm0.07$	$118.55^{e}\pm0.21$	$176.85^{d}\pm0.07$	$221.20^{d}\pm0.14$	$35.15^{b}\pm0.07$	$1.46^{a}\pm0.01$	$0.82^{b}\pm0.01$	$0.21^{b}\pm0.01$	$0.33^{a}\pm0.01$

Values are mean ± standard deviation; Means in the same column with different superscript are significantly different ($p<0.05$)

3.2 Chemical characteristics of oil samples

The result of the chemical composition of the various palm oil samples is shown in Table 4.2. There were significant differences ($p<0.05$) in the chemical parameters of the oils. Sample 901 had the highest AV (0.86 mgKOH/g) while sample 902 had the lowest (0.21 mgKOH/g). The AV from the different palm oil samples (0.21 - 0.86 mgKOH/g) were lower than 2.7 mgKOH/g obtained by Amira *et al.* (2014) for palm kernel oil. The low acid values indicate the low extent to which the glycerides in the oil had been decomposed by lipase action. Therefore the oil samples are still in good condition and edible.

Saponification values (SV) of oils measure the number of mg of KOH necessary to saponify one gramme of the oil (Onwuka, 2018).The SV of the oils ranged from 183.78 to 194.76 mgKOH/g.The saponification value of oil increases with decreases in the average molecular weight of the oil (Akinola *et al*., 2010; Akubor and Ogu, 2012).Sample 901 had the highest SV (194.76 mgKOH/g) while 902 the lowest (183.78 mgKOH/g).

Sample 902 had the highest PV (4.88 mEq/kg) while 901 and 905 had the lowest of PV of 1.6 and 1.61 mEq/kg respectively. PV measures the amount of lipid peroxides and hydroperoxides formed during the initial stages of oxidative degradation of oils (Frank *et al*., 2011). Crude palm oil was reported to be less susceptible to oxidative rancidity and hence is widely used for frying of foods (Matthaus, 2007). According to Amira *et al*. (2014) rancidity begins to be noticeable when the PV is above 10 mEq/kg. The PV in this study (1.6 - 14.88 mEq/kg) was below the maximum limit of 15 mEq/kg for oils (Codex, 2011).

Iodine value (IV) is the measure of the level of unsaturation in the oil samples (Chuayjuljit *et al*., 2017). Sample 901 had the highest IV (30.45 g/100g) while 904 had the lowest IV (27.44 g/100g). The IV of the oils (27.44 to 30.45 g/100g) was higher than 8.5 to 15.86 g/100g reported by Amira *et al*. (2014). The iodine values were however, observed to be lower than 45 g/100g allowable limit recommended by Codex, (2011).

The FFA (0.10 - 0.43 mgKOH/g) of the oil samples was lower than 2.73 to 2.89 mgKOH/g earlier reported by Udensi and Iroegbu (2007) for palm oils evaluated. The FFA was also below the maximum oil content of 3.5 mgKOH/g specified by (Codex, 2011).Oil deterioration leads to liberation of fatty acids from triglycerides (Onwuka, 2014).

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The FFA accumulation in crude palm oil is principally due to the action of the endogenous and microbial lipases (Udensi and Iroegbu, 2007; Tagoe *et al*., 2012).

Table 2: Chemical characteristics of palm oil samples

Sample	Acid Value (mgKOH/g)	Saponification Value (mgKOH/g)	Peroxide Value (mEq/kg)	Iodine Value (g/100g)	FFA (mgKOH/g)
901	$0.86^{a}\pm0.00$	$194.76^{a}\pm0.03$	$1.61^{d}\pm0.01$	$30.45^{a}\pm0.02$	$0.43^{a}\pm0.01$
902	$0.21^{e}\pm0.01$	$183.78^{e}\pm0.01$	$4.88^{a}\pm0.01$	$28.62^{d}\pm0.03$	$0.10^{d}\pm0.00$
903	$0.68^{c}\pm0.01$	$186.81^{c}\pm0.01$	$2.82^{b}\pm0.01$	$29.12^{c}\pm0.01$	$0.35^{b}\pm0.01$
904	$0.48^{d}\pm0.00$	$186.12^{d}\pm0.01$	$2.51^{c}\pm0.01$	$27.44^{e}\pm0.02$	$0.23^{c}\pm0.01$
905	$0.81^{b}\pm0.01$	$189.42^{b}\pm0.02$	$1.61^{d}\pm0.01$	$29.82^{b}\pm0.01$	$0.41^{a}\pm0.00$

Values are mean ± standard deviation; Means in the same column with different superscript are significantly different ($p<0.05$)

3.3 Fatty acids composition of oil samples

The fatty acid composition is peculiar to each oil sample (Table3) which in turn affect the physico-chemical properties (Aremu *et al*., 2015). The fatty acid composition alters with the variety, soil, and climatic conditions (Arzoo and Bakeet *et al*., 2014).There were significant differences ($p<0.05$) in the fatty acids composition of the various oil samples analyzed.

The Lauric acid (C12:0) in the oil samples range from 0.21 to 0.25%. Sample 901 and 905 had the highest Lauric acid (C12:0) of 0.25 % while sample 902 had the lowest Lauric acid (C12:0) value of 0.21%. Similar trend was observed in myristic acid (C14:0). It has been reported that lauric acid (C12:0) as well as myristic acid (C14:0) raise plasma total cholesterol concentrations when consumed (Wardlaw, 2004).Oils rich in lauric acid (C12:0) decreased the ratio of total HDL cholesterol (Wardlaw, 2004),

Sample 902 had the lowest Palmitic acid (38.71 %) while sample 901 had the highest (48.26 %). Palmitic acid (C16:0) was the most prominent saturated fatty acid identified among the samples (38.71 - 48.26 %). Similar observation was also made by Arzoo and Bakeet *et al.* (2014) when they evaluated the fatty acid composition of commonly consumed oils marketed in Saudi Arabia.Arzoo and Bakeet *et al.* (2014) reported a similar range (38.61 to 47.13%).

The Palmitoleic acid (C16:1) composition showed that 901 (0.20%) was higher than the rest of the samples. The Palmitoleic acid values ranged from 0.11 to 0.20%. Saturated fatty acids with 12, 14 and 16 carbon atoms are known to be the primary contributors to elevated blood cholesterol and so contribute to cardiovascular diseases, and myristic acid (C14) is found to be the main culprit (Wardlaw, 2004).There was no significant difference ($p>0.05$) in the stearic acid (C18:0) content of the oil samples (2.16 – 4.33%). This implies that the different processing techniques and other conditions earlier mentioned did not affect the stearic acid (C18:0) content of the oils.

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The Oleic (C18:1) and Linoleic acid (C18:2) values ranged from 38.41 to 47.82 % and 9.61 to 12.61% respectively. Sample 902 had the highest oleic (47.82%) and linoleic acids (12.61%) while sample 901 also had the least oleic (38.41%) and linoleic acids (9.61%). Oleic acid (C18:1) has been reported to be associated with a low incidence of coronary heart disease (CHD) because it decreases total cholesterol (10%) and low-density lipoprotein cholesterol (Sodamade *et al*., 2013).Linoleic acid is the one of the most significant polyunsaturated fatty acids in human diet because of its ability to prevent heart and vascular diseases (Arzoo and Bakeet *et al.,* 2014; Ndife, 2016). Similar trend was observed in the Arachidic acid (C20:0) content of the oil samples.

Table.3: Fatty acids composition of palm oil samples (%)

Sample	Lauric (C12:0)	Myristic (C14:0)	Palmitic (C16:0)	Palmitoleic (C16:1)	Stearic (C18:0)	Oleic (C18:1)	Linoleic (C18:2)	Linolenic (C18:3)	Arachidic (C20:0)
901	$0.25^{a}\pm0.01$	$1.06^{a}\pm0.01$	$48.26^{a}\pm0.01$	$0.20^{a}\pm0.00$	$4.33^{a}\pm0.04$	$38.41^{e}\pm0.01$	$9.61^{e}\pm0.01$	$0.41^{a}\pm0.01$	$0.31^{a}\pm0.01$
902	$0.21^{c}\pm0.01$	$0.81^{d}\pm0.01$	$38.71^{e}\pm0.01$	$0.11^{b}\pm0.01$	$3.81^{a}\pm0.01$	$47.82^{a}\pm0.01$	$12.61^{a}\pm0.01$	$0.11^{d}\pm0.01$	$0.11^{d}\pm0.01$
903	$0.23^{b}\pm0.01$	$1.02^{b}\pm0.01$	$43.61^{c}\pm0.01$	$0.11^{b}\pm0.01$	$4.11^{a}\pm0.01$	$46.84^{b}\pm0.01$	$10.41^{d}\pm0.01$	$0.20^{b}\pm0.00$	$0.21^{c}\pm0.01$
904	$0.22^{bc}\pm0.01$	$0.91^{c}\pm0.01$	$41.11^{d}\pm0.01$	$0.11^{b}\pm0.01$	$3.86^{a}\pm0.01$	$42.71^{c}\pm0.01$	$11.31^{b}\pm0.01$	$0.16^{c}\pm0.01$	$0.11^{d}\pm0.01$
905	$0.25^{a}\pm0.01$	$1.08^{a}\pm0.01$	$44.88^{b}\pm0.01$	$0.11^{b}\pm0.01$	$2.16^{a}\pm2.82$	$41.29^{d}\pm0.01$	$10.61^{c}\pm0.01$	$0.21^{b}\pm0.01$	$0.26^{b}\pm0.01$

Values are mean ± standard deviation; Means in the same column with different superscript are significantly different ($p<0.05$)

3.4 Vitamin content of oil samples

The result of the vitamin content of the various palm oil samples is presented in Table 4.Palm oil is rich in vitamin A with carotene as its precursor (Udensi and Iroegbu, 2007).There was significant difference ($p<0.05$) in the vitamin content of the oils. The vitamin A values ranged from 49.61 to 60.21 µg/g, with 904 having highest vitamin A (60.21 µg/g) and 902 the lowest (49.61 µg/g).Vitamin A plays an important role in vision, bone growth, reproduction, cell division and cell differentiation (Onwuka, 2014).

The vitamin D and E of the oil samples ranged from 3.12 to 4.04 µg/g and 13.82 to 16.22 mg/100g. The vitamin D value range was close to 3.01 - 4.20 µg/g reported by Okonkwo and Ozoude (2015).Vitamin D help to absorb calcium and promote bone growth (Ngassapa *et al*., 2012).Sample 904 had the highest vitamin E (16.22 mg/100g) while 903 the lowest (13.82 mg/100g).Vitamin E help the protection oxidation by free radicals (Idris *et al*., 2014; Ndife, 2016). Supplementation with vitamin E in humans decreases the susceptibility of low density lipoprotein (LDL) to oxidation in vivo (Wardlaw, 2004). The vitamin K in the oil samples (7.62 - 10.12 mg/100g) was highest in 902 and lowest in 901.The vitamin variations could be due to different processing and storage techniques used for the palm oils.

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Table 4: Vitamin content of palm oil samples

Sample	Vitamin A (µg/g)	Vitamin D (µg/g)	Vitamin E (mg/100g)	Vitamin K (mg/100g)
901	56.85^{c}±0.03	3.12^{d}±0.02	14.01^{d}±0.01	7.62^{e}±0.02
902	49.61^{e}±0.01	4.04^{a}±0.03	15.35^{b}±0.03	10.12^{a}±0.03
903	51.32^{d}±0.02	3.86^{b}±0.01	13.82^{e}±0.03	8.38^{c}±0.01
904	60.21^{a}±0.01	2.99^{e}±0.01	16.22^{a}±0.02	9.65^{b}±0.03
905	57.41^{b}±0.01	3.45^{c}±0.01	14.86^{c}±0.04	7.94^{d}±0.03

Values are mean ± standard deviation; Means in the same column with different superscript are significantly different ($p<0.05$)

3.5 The Zinc and Iron contents of oil samples

There were significant differences ($p<0.05$) in the iron (Fe) and Zinc (Zn) contents of the palm oil samples (Table 5). The Zn and Fe values range from 0.03 to 0.11 and 0.07 to 0.15 mg/100g respectively. Sample 903 had the highest Fe (0.15 mg/100g) while sample 904 had the highest Zn value (0.11 mg/100g).The presence of the metals could catalyse rancidity reactions. However adequate Fe and Zn in the diet are very imperative for diminishing disease conditions (Wardlaw, 2004).

Table 5: Mineral content of palm oil samples (mg/100g)

Sample	Iron	Zinc
901	0.12^{bc}±0.00	0.05^{c}±0.01
902	0.11^{c}±0.01	0.08^{b}±0.00
903	0.15^{a}±0.01	0.03^{d}±0.01
904	0.13^{ab}±0.01	0.11^{a}±0.01
905	0.07^{d}±0.00	0.03^{d}±0.00

Values are mean ± standard deviation; Means in the same column with different superscript are significantly different ($p<0.05$)

3.6 Total microbial count of oil samples

The total microbial content of the oil samples is shown in Table 6. The total microbial count in the oil samples ranged from 6.13 to 9.42×10^{4} cfu/ml. Sample 901 had the highest microbial count (9.42×10^{4} cfu/ml) while sample 903 had the lowest (6.13×10^{4} cfu/ml). The higher level of microbial count as observed in sample 901 could be due to its high moisture content (0.30 %). The critical moisture level of palm oil is 0.2%, as the action of contaminating microbial lipases and autocatalytic hydrolysis is very unlikely at this level (Udensi and Iroegbu, 2007).

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The range is within permissible limit (10^4 cfu/ml) recommended by the Nigerian agency for food drug administration and control (NAFDAC) (Okechalu *et al.,* 2011). All the oil samples were microbiologically safe for consumption. Spores forming microbes are the most likely to survive the anaerobic environment of the oil (APHA, 1992), and spores are also resistant to heat (Okechalu *et al.,* 2011; Ohimain *et al*., 2013).

Table 6: Total microbial count of palm oil samples

Sample	Total plate count (10^4 cfu/ml)
901	9.42^{a}±0.02
902	8.74^{c}±0.04
903	6.13^{e}±0.04
904	8.51^{d}±0.01
905	9.19^{b}±0.04

Values are mean ± standard deviation; Means in the same column with different superscript are significantly different ($p<0.05$); Cfu-Colony Forming Units.

3.7 Sensory evaluation of oil samples

The sensory evaluation of the different traditional processed palm oil samples is presented in Table 4.8. Sample 902 was generally more preferred than the other oils, with mean score of 6.48while sample 903 was the least preferred (4.96). There was no significant difference ($p>0.05$) on the taste, mouth-feel and aroma of the various palm oil samples; this showed little or no effect by traditional methods used except in appearance. Sample 902(7.44) followed by 905 (7.08) had the highest appearance scores. Sensory quality of edible oils is very important for commercial pricing and consumer acceptance (Ngando *et al*., 2011).

Table 7: Sensory evaluation of palm oil samples

Sample	Taste	Appearance	Mouthfeel	Aroma	General Acceptability
901	6.28^{a}±1.72	4.44^{b}±2.08	5.80^{a}±1.76	5.76^{a}±1.83	5.48^{ab}±2.37
902	5.88^{a}±2.28	7.44^{a}±0.96	5.92^{a}±1.82	6.20^{a}±1.73	6.48^{a}±1.69
903	5.20^{a}±1.91	4.68^{b}±2.10	4.76^{a}±2.24	5.12^{a}±2.20	4.96^{b}±2.07
904	6.00^{a}±2.20	6.76^{a}±1.94	5.80^{a}±2.12	6.08^{a}±2.23	6.48^{a}±2.16
905	5.08^{a}±2.27	7.08^{a}±1.98	5.92^{a}±2.10	5.92^{a}±2.14	6.16^{ab}±2.17

Means in the same column with different superscript are significantly different ($p<0.05$)

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4. CONCLUSION

This study has revealed that traditional methods of processing palm oil have significant effect on the quality of the oil products. However, other factors such as variety, soil, and climatic conditions may have contributed as well. The values of the chemical, vitamins, minerals and fatty acid levels of the various oil samples were within regulators standards and are therefore nutritionally and organoleptically acceptable. However, improved processing methods and hygiene should be adopted. The effects of both natural and artificial preservatives, storage conditions and packaging materials on the shelf stability of these oils should be investigated.

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