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Quality assessment of palm oil on sale in major markets of Ibadan, Nigeria

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ABSTRACT

Determination of the quality of palm oil been consumed in Ibadan metropolis was carried out in the month of June 2009. Palm oil samples on sale in three Ibadan major markets (Bodija, Oje and Aleshinloye) were analyzed for moisture content, mould load, aflatoxin B1 content, free fatty acids (FFA), saponification values and β-carotene contents. Moisture contents and mould load were determined using oven-dry and pour plate methods. Aflatoxin B_1 contents was determined by thin-layer chromatography (TLC) BF method. FFA and saponification values were determined by titration methods while β-carotene was done by spectrophotometric method. The results obtained show value ranges of 0.73 to 2.0% for moisture content; 12.1 to 20.2% for FFA; 8.0×10^3 to 3.7×10^4 cfu/ml for mould load; 218.3 to 242.7 mgKOH/g for saponification; 25.0 to 38.5 mg/100g for β-carotene content and; <2 µg/kg for aflatoxin B1 contents. These results obtained are an indication that the quality of palm oil consumed in Ibadan is poor. Promotion of improved processing, good handling and storage practices that would ensure high quality palm oil for markets in Ibadan should be carried out by regulatory agents.

INTRODUCTION

The tropical rainforests of West and Central Africa are endowed with abundant high value indigenous fruits and medicinal tree species. Many households heavily depend on these resources for their fruits, medicinal, food, constructions needs and for their livelihoods and income (Smith et al., 1983).

The oil palms (Elaeis) comprise two species of the Aracaceae family. They are used in commercial agri-culture in the production of palm oil. The African oil palm (*Elaeis guineensis*) is native to West Africa, while American oil palm (*Elaeis oleifera*) is native to tropical Central America and South America. *E. guineensis* is pinnate-leaved having dense clusters of crowded flowers and bright red fruit that yield high quality palm oil.

The importance of quality palm oil in our diet cannot be overemphasized. It is the main vegetable oil consumed in the world today, accounting for 33% of all oils consumed globally, closely followed by soya oil with 31% (ICEX, 2014). In the previous decade, world palm oil consumption has more than doubled from around 16.7 million tonnes in 1997/98 to over 40 million tonnes in 2007/08 and this figure is estimated to surpass 70 million tonnes by 2020 (Grapevine, 2008). Palm oil is very nutritious. They are useful for bone, joint, and skin health. Not only is palm oil a rare source of medium chain fatty acids, it is also a source of healthy unsaturated fats. It is a well-balanced fat, with 39% oleic acid (omega-9) and 10% linoleic acid (omega-6). These essential fatty acids help to lower blood cholesterol levels in the body. It is the richest vegetable oil source of tocotrienols – which are potent forms of vitamin E. Vitamin E strengthens the immune system, and protects skin cells from toxins and

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UV radiation. From its reddish-orange hue, palm oil is also a good source of β-carotene, a nutrient found in sweet potatoes, carrots, and other orange foods. Ugwu et al. (2002) reported that palm oil contains fat soluble carotenoids which are responsible for its high vitamin A content. β-Carotene is useful as a precursor to vitamin A (retinol) in the body, it is a powerful antioxidant and act to reduce the risk of certain cancer and heart diseases (Tanumiharjo, 2002; Bendish and Olsin, 1989).

The high nutritional value especially its high oil content greatly predisposes it to deterioration. The quality of palm fruits, processing techniques, handling and storage are critical points to be considered in the production of quality palm oil. This is in a bid to minimize the mould load, free fatty acids (FFA), aflatoxin B1 contents, moisture content and other anti-nutritional and deteriorating factors as their presence especially in high values exceeding permissible levels, reduces quality which are undesirable and hazardous to health of consumers.

Moulds are known to effect various biochemical changes in all classes of crops. Previous workers have analysed the overall effect of moulds on oilseeds (Tagoe, 2008; Oso, 1979; Odunfa, 1989; Coursey et al., 1963; Barbosa, 1972; Ward and Denner, 1961). Kuku (1976) quantified the individual contribution of lipolytic mould species on the FFAs, protein contents and moisture contents of palm kernels.

High increase in moulds and FFA level in oilseeds and their products are undesirable. Apart from moulds capable of digesting and exhausting nutrient content of crops, more to be feared is the added danger of aflatoxin production in the oils.

Aflatoxins are highly undesirable in palm oil as they are very toxic and carcinogenic compounds that have been implicated as causative agents in human hepatic carcinogenesis (Singh, 1993). They have been detected in Grapes and Musts in France (Sage et al., 2000), edible nuts and their products, milk and milk products (Prasad, 1998; Taveira and Midio, 2001). Singh (1993) reported that out of 342 samples of different fruits and species collected from commercial centres, 95 of them were positive for aflatoxins. Some of the methods used in processing these agricultural commodities do not remove the toxins as they are heat stable with melting points between 268 and 269°C (Frazier and Westhoff, 1988) and are therefore consumed along with the products. High saponification as well as high moisture in palm oil samples is equally undesirable. High saponification value in palm oil is an indication that the palm is more suitable for soap making than for consumption. While high moisture predisposes palm oil to quick deterioration and spoilage as it provides an enabling environment for microbial proliferation and activity.

In view of this, it is important to check marketed palm oil to assess their quality as palm oil is consumed by various tribes and ethnic groups of continents due to its immense nutritional and health benefits. Quality assessment of palm oil have been carried out in different states of Nigeria: Rivers State (Ohimain et al., 2012), Kogi State (Enemuor et al., 2012), Delta State (Agbaire, 2012), Anambra State (Okonkwo and Ogbuneke, 2010) and Abia State (Udensi and Iroegbu, 2007). Information on quality assessment of palm oil has not been documented in Ibadan, the largest city in West Africa situated in Oyo State. It is therefore, desirable and necessary to determine the quality of palm oil on sale in its markets.

MATERIALS AND METHODS

Five 750 ml of palm oil in bottles from three congregate locations of Aleshinloye, Oje and Bodija markets in Ibadan were purchased and taken to the laboratory for analyses (Figure 1). Before the analyses were carried out, the samples from a location were pooled and homogenized to form Locations 1, 2 and 3 for each market. Moisture contents, aflatoxin levels and FFA contents were determined according to the procedures in AOAC (2000), β-carotene was by Cook and van Reede (1960), saponification was by the method of British Institute (1958.), while mould loads were carried out according to the description of Samson et al., 1995. All analyses were carried out in triplicates and the mean values were calculated (Table 1).

Moisture content determination

Moisture content was determined by the oven dry method, using the procedures from the AOAC (2000). 5 g of palm oil was poured into previously weighed moisture dishes. Each sample was triplicated. They were then introduced into Gallen Kamp oven (BS Model OV-160) (Figures 2 and 3) and were maintained at 63±2°C until constant weight was attained, with the drying period showing additional loss of ≤0.05. The moisture dishes were cooled in a desiccator and the difference in weight obtained was then used to calculate the % moisture content.

$$\text{Percentage moisture content (\%)} = \left(\frac{B-C}{A}\right)\times 100$$

A= sample weight in (g)
B= weight of dish + sample weight prior to drying
C= weight of dish + sample weight after drying
B-C= weight loss after drying (moisture content of sample)

Mould load determination

Pour plate method was employed for mould load

Figure 1. Palm oil samples from Aleshinloye, Oje and Bodija major markets in Ibadan.

Table 1. Mean values of quality parameters assessed from major Markets in Ibadan metropolis.

Sample	Moisture content (%)	Mould load (cfu/ml)	FFA (%)	β-carotene (mg/ 100g)	Saponification (mgKOH/g)	Aflatoxin B1 (µg//Kg
Aleshinloye	1.3a±0.6	$6.17x10^3$a	14.03a±0.2	31.23a±3.3	221.87a±5.6	-
Oje	2.0b±0.0	$2.33x10^4$a	13.93a±1.6	34.33a±3.1	233.47a±1.0	-
Bodija	2.00b±0.0	$2.20x10^4$a	19.00±0.7	31.47b±4.3	234.83a±3.6	-

Means followed by the same letter in each column are not significantly different (P<0.05).

determination as described by Samson et al. (1995). Potato Dextrose Agar (PDA) was prepared by weighing 9.75 g of PDA powder into 250 ml conical flask. 250 ml of sterile distilled water was then added. It was swirled and made to dissolve by heating on hot plate. After dissolving, the mouth of the conical flask was plugged with cotton wool and wrapped with aluminium foil. Thereafter, it was sterilized by autoclaving at 121°C for 15 min. After autoclaving, the media was allowed to cool down to 45°C before it was poured into Petri dishes. The remaining agar in the conical flask was kept in refrigerator until it was used.

The mould count was determined using serial dilution and pour plate method. 1 ml of palm oil was weighed into Maccartney bottle containing 9 ml of sterile distilled water. This was vortexed for 2 min to get a uniform consistency. I ml portion of suitable dilution (10^3) was used to inoculate Petri dishes. PDA already prepared with antibacterial (2 ml mixture of Streptomycin (1%) and Penicillin (5%) in the ration of 1:1) was poured into the inoculated Petri dishes after cooling to 45°C. The plates were swirled gently until the contents were evenly mixed, and then they were incubated at 25°C for 5 days. The resultant moulds were counted and expressed as numbers of mould per ml.

Aflatoxin level determination

Estimation of aflatoxin B1 in palm oil was carried out using AOAC (2000) 970.45 BF method with modification. The concentration of aflatoxin B1 in the palm oil samples

Figure 2. Gallen Kamp oven.

Figure 3. Dishes containing palm oil samples in the oven during moisture content determination.

were determined by Thin-layer chromatographic technique with fluorescent detection at 366 nm. 25 g of palm oil sample was weighed and extracted with 125 ml of 55% aqueous methanol (v/v) and 2 g of NaCl for 3 min in a Waring blender. The mixture was emptied into a 250 ml conical flask and 50 ml n-hexane was added and the flask was vigorously shaken for 10 min on an orbital shaker. For the separation and clean up, RIDA® Aflatoxin columns (Art. No.: R5001 / R5002) was used according to manufacturer's instruction. The internal amplification controls (IACs) were purchased from R-Biopharm AG, Germany.

Equilibration of the column was carried out by rinsing in 2 ml distilled water and the flow rate of extract through the IAC was approximately 1 drop/second. The resulting extract was passed through a bed of anhydrous sodium sulphate into a polypropylene cup to remove residual water and the extract was concentrated on a hot plate. The extract was re-constituted in 500 µl chloroform, and 40 µl extract and 50 µl aliquots of 0.50 µg/ml total aflatoxin standards were separated on pre-coated thin layer chromatographic (TLC) plates (silica gel 60 F254; 20 × 10 cm; Merck, Germany) in chloroform-acetone-water (88:12:1.5). The developed plates were dried in a fume cupboard and visualized under long wavelength UV light (366 nm). The aflatoxin B1 band in each sample spot was identified on the basis of co-migration and characteristic blue fluorescence with aflatoxin standard. The suspected sample and standard spots on dried TLC plates were sprayed with trifluoroacetic acid and tetraoxosulphate (VI) acid according to Bankole et al. (2006). Aflatoxin B1 concentration (µg/kg) in the samples was estimated using the formula described in Atanda et al. (2011).

Free fatty acid determination

The oil obtained as crude fat (oil) extract was used. Official method in AOAC (2000) for fatty acids (free) determination in crude oil was used. 5 g of oil was weighed into a 250 ml Erlenmeyer flask. 50 ml mixture of dietyl ether and ethanol in the ratio 1:1 (V/v) previously neutralize solution by adding 3 drops Phenolphthalin solution (%) and 0.1 N Potassioum hydroxide (KOH) to produce faint pink colour. The neutral solution dissolved the fat. The solution was then titrated against KOH to a phenolphthalein end point. Percentage free fatty acid was expressed as lauric acid for palm oil.

Percentage free fatty acid, FFA (%) = 20.2×VP/W

V= volume of KOH a end point
P= normality of KOH
W= weight of the oil used

β-Carotene determination

This was carried out according to the method described by Cook and van Reede (1960). 2 g of palm oil was weighed into 200 ml round bottom flask. 8 ml of 50% potassium hydroxide and 25 ml ethanol was added and refluxed at 85 to 90°C for 15 min. The soap solution was transferred into a separating funnel after cooling under running water. The soap solution was then extracted with successive portions of 100, 50 and 5 ml of diethyl ether by shaking and washing with distilled water until diethyl ether layer was cleaned out.

The extract was then heated on water bath at 80 to 85°C and rinsed with 15 to 20 ml ether which was then evaporated with nitrogen and then acetone, until all traces of solvent was removed. The residue was dissolved in 1 to 2 ml of petroleum spirit and then 5 ml was introduced to the top of alumina chromatography column under slight nitrogen pressure. 5 ml portions of petroleum ether containing 4, 8 and 12% diethyl ether was eluted respectively and discarded.

Eluate with yellow band was collected after eluting with 5 ml petroleum spirit and the concentration of β-carotene was determined from standard graph of β-carotene standard.

Determination of saponification value

This was carried out according to the method of British Standard Institute (1958). 2 g of the palm oil was weighed into a glass flask resistant to alkali reaction and 25 ml of alcoholic potassium hydroxide solution was added. The content was boiled for 1 h under a reflux condenser and swirled at frequent intervals. Excessive alkali was determined while the solution is still hot by titrating with 0.5 N hydrochloric acid, using 0.5 ml of phenolphthalein as indicator. A blank determination upon the same quantity of the potassium hydroxide solution at the same time under the same conditions was made.

Saponification value was calculated as follows:

Saponification value = $28.05 (T_2 – T_1)/W$

Where:
T_2 = Volume (ml) of 0.5 N acid required for blank ;
T_1 = Volume (ml) of 0.5 N acid required for sample taken;
W = Weight (g) of sample taken.

Statistical analyses

All data obtained were analyzed by Analysis of Variance (ANOVA) procedure using SPSS 15.0 computer

Table 2. Moisture content, mould load, free fatty acid, aflatoxin B1, β-carotene and saponification values of palm oil samples from various locations in Ibadan major markets.

Parameters	Aleshinloye			Oje			Bodija		
	L1	L2	L3	L1	L2	L3	L1	L2	L3
MC (%)	0.7	1.4	1.8	2.0	2.0	2.0	2.0	2.0	2.0
ML (cfu/ml)	2.5×10^4	9.0×10^3	8.0×10^3	3.3×10^4	2.7×10^4	1.0×10^4	1.5×10^4	1.4×10^4	3.7×10^4
FFA (%)	13.9	14.0	14.2	14.9	14.8	12.1	18.5	18.7	19.8
Aflatoxin B1 (µg/Kg)	-	-	-	-	-	-	-	-	-
β-carotene (mg/100 g)	30.0	35.0	28.7	32.0	37.8	33.2	26.9	35.5	32.0
Saponification (mgKOH/g)	228.3	219.0	218.3	242.7	234.8	222.9	234.5	231.4	238.6

MC, Moisture content; ML, mould load, FFA, free fatty acids; aflatoxin B1 level, means undetected; L1, location 1; L2, location 2; L3, location 3.

software. Differences were declared statistically significant when $P<0.05$. Where significant differences were detected, the means were separated by the least significant difference (LSD) at 5% probability level.

RESULTS AND DISCUSSION

Mould load, FFA, moisture content, aflatoxin B1 level, saponification and β-carotene values were parameters used to assess quality of palm oil on sale in Ibadan major markets. Generally, the quality of palm oil is mostly determined by the FFA and moisture contents (Tagoe, 2012; Hartley, 1988; Kardash and Tur'yan, 2005). However, for palm oil meant for export, the most important criterion for assessing the quality is the FFA (Aletor et al., 1990; Kuku and Agboola, 1984). The values of all parameters analyzed in this study exceeded the standard recommended values except for β-carotene which was below the recommended value.

Safe moisture content for fresh oil as reported by SON (2000) and NIS (1992) is 0.29%. The maximum FFA content of palm oil should be 3.5 mgKOH/g, β-carotene level should be within the range of 500 and 2000 mg/kg. Values for saponification must be within the expected range of 195 to 205 mgKOH/g. Limit have not been set specifically for maximum aflatoxin B1 permissible limit in palm oil by SON and NIS.

Moisture content recorded in all the samples were very high with exception to L1 (Aleshinloye) recording 0.7% as shown in Table 2. This is still unacceptable for freshly produced palm oil, but acceptable for palm oil meant for storage as documented by the Nigerian Stored Products Research Institute (NSPRI). The maximum safe moisture level for palm oil storage is 1%. The values of moisture content recorded in this work ranged between 0.7 and 2.0%. This is in agreement with the findings of Okechalu et al. (2011) where palm oil samples on sale in Jos metropolis were analyzed for microbiological quality and chemical characteristics, recorded moisture contents ranged between 0.69 and 1.27% which exceeds SON and NIS recommended values. However, moisture content values obtained in the works of Agbaire (2012) and Udensi and Iroegbu (2007) and from palm oil sold in major markets of Delta and Abia States, ranged between 0.14 and 0.17% and 0.14 and 0.16%, respectively.

These values falls within SON (2000) and NIS (1992) recommended value and it is an indication that they will encourage the storage stability of the palm oil. Mould loads were generally high and this may be attributed to the presence of high moisture in the oil. Palm oil is known to support the growth of fungi and bacteria especially when it contains moisture (Coursey, 1963). When moisture is high, more microbial proliferation should be expected.

The maximum permissible limit of mould load in palm oil is currently being reviewed by Standard Organization of Nigeria (SON) and other relevant regulatory agencies. It is evidenced from Table 1 that the FFAs of palm oil samples were equally high ranging between 12.1% and 19.8%. Opadokun (1988) reported that FFAs of locally processed palm oil stored for one year in metallic containers increased from 13.3 to 19.0% thus, becoming rancid and unacceptable. FFAs contents recorded in this work were between 12.1 and 19.8% and were neither rancid nor organoleptically unacceptable suggesting that the samples are freshly processed but may have been from lypolized palm fruits. These high levels of FFAs may be linked to the activity of moulds prior to processing. The palm oil marketed in Ibadan can be said to be hard as their FFAs exceeded 5% (Hyman, 1990). The range of FFA values obtained in this study exceeded the 2.86 to 2.97 mg/g, 2.73 to 2.89 mgKOH/g, 2.67 to 4.20% and 2.73 to 2.83 mg KOH/g obtained in palm oil samples from Delta State, Jos metropolis in Plateau State, Ihiala Local Government of Anambra State and Abia State as reported by Agbaire (2012), Okechalu et al. (2011), Okonkwo and Ogbuneke (2010) and Udensi and Iroegbu (2007), respectively. It is however in agreement with the findings of Enemuor et al. (2012), as palm oil samples

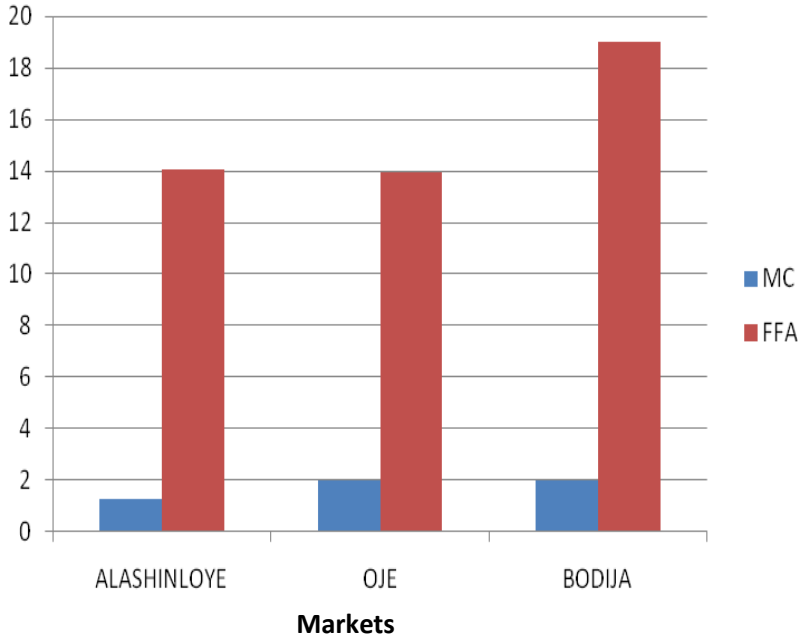

Figure 4: Quality indices of palm oil samples from Ibadan markets in June, 2009.
Keynote: MC and FFA were in percentages.

marketed in Anyingba recorded high FFA values. No aflatoxin B1 was detected in all the samples. This is in accordance with the findings of Opadokun (1988) where none of the analysed oil samples freshly purchased from the market tested positive to aflatoxin B1. Saponification values obtained exceeded the recommended limit permissible by regulatory agencies (SON, 2000; NIS, 1995). This is in contrasts with the findings of Okonkwo and Ogbuneke (2010) that assessed the level of adulteration in palm oil samples marketed within Ihiala Local Government Area of Anambra State Nigeria and obtained 197.75 to 204.30 mgKOH/g as saponification values. A similar report was found in the work of Atinafu and Bedemo (2011) who obtained high saponification value in palm oil after determining the FFA and cholesterol level of nine varieties of edible vegetable oils in Ethiopia, Bahir DAR.

Research finding have shown that palm oil marketed in Ibadan are of low quality as their β-carotene levels ranged between 26.9 and 35.5 mg/100g. These values fall far below the recommended values of SON and NIS (500 – 2000 mg/kg) and contrast the findings of Agbaire (2012) and Udensi and Iroegbu (2007) who recorded higher values in Delta and Abia States.

Among the markets, there were no significant differences except in their moisture contents and FFAs. The values for moisture contents were not significantly different ($P<0.05$) for Oje and Bodija markets but was significantly different for Aleshinloye market. FFA in the palm oil from Bodija market was significantly different from Oje and Aleshinloye markets while Oje and Aleshinloye markets were not significantly different.

From Figure 4, it can be inferred that the market with least palm oil quality is Bodija using the criteria of moisture content and FFA. Bodija is followed by Oje and Aleshinloye markets.

Conclusion

The palm oil sold in Ibadan markets are not of high quality based on the results obtained from this study. This could be due to low quality of raw materials, processing methods or handling practices. There is therefore an urgent need for regulatory agencies to train, regularly inspect and monitor stakeholders in the palm oil industry in order to improve quality of palm oil on sale in the markets specifically in Ibadan Oyo State Nigeria.

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