World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

Check for updates

Chemical assessment of the quality of palm oil produced and sold in major markets in Orlu zone in Imo state, Nigeria

Chinemerem Henry Ugo [1,*], Paul Eze Eme [1], Perpetua Ngozi Eze [2], Henry Asusheyi Obajaja [3] and Afoma Emmanuela Omeili [4]

[1] *Department of Nutrition and Dietetics, University of Nigeria, Nsukka, Enugu state, Nigeria.*
[2] *Department of Nursing Science, University of Nigeria, Enugu campus, Enugu State, Nigeria.*
[3] *Department of Health and Human Performance, Oklahoma State University, Stillwater, OK, USA.*
[4] *Manifest & Company Inc, Waterloo, Ontario, Canada.*

World Journal of Advanced Research and Reviews, 2024, 21(02), 1025–1033

Publication history: Received on 02 January 2024; revised on 11 February 2024; accepted on 14 February 2024

Article DOI: https://doi.org/10.30574/wjarr.2024.21.2.0529

Abstract

Background: This study assessed the quality of palm oil produced and sold in major markets in the Orlu senatorial zone in Imo state, Nigeria.

Methods: Three major markets each from different local governments in Orlu zone were visited and a total of forty-five (45) palm oil samples were procured and homogenized into three samples (Good, Fairly-good, and Bad samples). FFA, DOBI, PV, p-Anisidine, and beta-carotene levels of the oil were analyzed using standard methods. Data were analyzed using SPSS version 21 for means and standard deviation. Analysis of variance (ANOVA) was used to compare the means while Duncan's New Multiple range test was used to separate the means.

Results: The results obtained showed that the peroxide value (PV) of the palm oil sample ranged from 4.80 – 43.20 $MeqO_2$/kg, Free fatty acid from 5.56 – 8.63%, p-Anisidine from 30.00 – 32.00Av, Deterioration of Bleachability Index, 0.12 – 0.18 and beta-carotene value, 2146.67 – 2516.6mg/kg. There were no significant differences ($P > 0.05$) found on the three palm oil samples assessed except in peroxide value which was observed to have a significant difference at $P < 0.05$.

Conclusion: From the result obtained, the 'Fairly good and Bad sample' was proved to be of low quality while the 'Good sample' was of good quality following the quality index considered in the study.

Keywords: Palm oil; Free fatty acid; DOBI; Peroxide value; p-Anisidine; Beta-carotene

1. Introduction

Most of the oilseeds consumed as food are used as cooking oil, to some extent oxidized rather than its fresh state and this oxidation seems to be responsible for the health risk associated with fat and oil consumption (Edem, 2002). The free radicals produced by the oxidation process have been shown to be carcinogenic (Rossel, 2000). Research done in Costa Rica connected cooking oil to increased risks of cardiovascular illness, indicating that substituting saturated vegetable oil in cooking with polyunsaturated non-hydrogenated oils might lessen the risk of heart attacks (Kabagambe, Ascherio & Campos, 2005) and chronic obstructive pulmonary disease (Uche-Okoye et al., 2023). There is a relationship between higher Free Fatty Acid levels and obesity. Large amounts of Free Fatty Acids will impede insulin's anti-lipolytic activity, thereby increasing the pace of Free Fatty Acid circulation and inflicting more damage to the body (Jensen,

* Corresponding author: Chinemerem Henry Ugo

Haymond & Rizza, 2008). Most vegetable oils comprise of triglycerides and free fatty acids but palm oil which happened to be the most consumed vegetable oil as of 2015 (Ebere et al., 2018; SoyStats, 2016) has less free fatty acids and a majority of fatty acids are palmitic acid followed by oleic acid (Corley & Tinker, 2008).

Palm oil is a reddish-colored edible oil obtained from the fruits of the oil palm *Elaeis guineensis*, which is native to West Africa (Poku, 2002; Siew, 2002). The oil palm tree is a perennial tropical tree crop that generates the most oil when compared to other oil-producing plants (Enyoh, Enyoh, & Amaobi, 2017). The crop is notable for producing two kinds of oil. The fleshy mesocarp yields palm oil, which is mostly utilized for its edible features, and the kernel yields palm kernel oil, which is widely used in the palm-based industrial sector (Siew, 2002).

Palm oil is resistant to oxidative degradation, and its ability to withstand high temperatures makes it more effective in frying than other alternative oils (Berger, 1992; Kheiri, 1987). Furthermore, it is high in antioxidants such as carotenoids, tocopherols, and tocotrienol, which when taken increase immunological function through several processes and can improve cardiovascular health (Enyoh, Verla, Enyoh & Verla, 2018). Carotenoids play an important role as biological antioxidants, protecting cells and tissues from the damaging effects of free radicals caused by cigarette smoke, industrial pollution, stress, inadequate diets, pesticide and insecticide residues in food and water, and a variety of other negative environmental influences (Roche, 2000). Degenerative disorders such as heart disease and cancer, as well as non-cancerous proliferation such as Benign prostatic hyperplasia (Chinwe et al., 2022), are linked to a buildup of free radicals in the body. These natural antioxidants operate as shields against free radicals and are thought to protect against cellular aging, atherosclerosis, cancer, arthritis, and Alzheimer's disease (Sutapa & Analava, 2009).

The characteristics of palm oil is mostly related to its chemical composition. Some certain characteristics and attributes cause oil palm to deteriorate faster and these might pose a health risk if ingested (Imoisi, Ilori, Agho, & Ekhator, 2015). Improper post-harvest handling, processing, and storage techniques may have an impact on palm oil quality. Again, there is widespread allegation that palm oil is being tampered with and adulterated for the sole aim of increasing profits. The addition of color dyes, water, and other prohibited food additives as commonly practiced in Imo state Nigeria may influence the quality of palm oil in terms of nutritional content, wholesomeness, use, safety, and shelf-life. The amount of free acid, deterioration of bleachability index (DOBI), beta-carotene level, p-Ansidine and peroxide value, are very useful indices in assessing palm oil quality (Udensi & Iroegbu, 2007). There is a dearth of Information on the Quality assessment of Palm oil produced and sold in Orlu zone of Imo State. On this backdrop, the study aims to assess the chemical qualities of palm oil sold in major markets in Orlu senatorial zone in Imo State using these chemical parameters; free fatty acid, deterioration of bleachability index (DOBI), beta-carotene level, p-Ansidine and peroxide value.

- **Peroxide value:** The amount of peroxides in palm oil indicates the degree of primary oxidation and thus the likelihood of rancidity. A lower number of peroxides indicates good oil quality and preservation status. (Initiative for Public Policy Analysis [IPPA], 2010). A peroxide value of less than 10meqO_2/kg reflects good oil quality (CODEX, 2011).
- **Free Fatty Acid content:** It is the acid content of edible fats given by the quantity of free fatty acids derived from the hydrolytic rancidity of triglycerides (Sambanthamurthi, 2000). Thus, crude palm oil with low FFA is an indication that the oil has been processed from fresh, unbruised fruits and carefully handled during production and storage (Ali & Abdurrhman, 2013). Palm oil with less than 5% free fatty acid (as palmitic acid) is considered safe (CODEX, 2011).
- **Anisidine value (AnV):** The anisidine value test is used to examine the secondary oxidation of oil or fat, which is primarily attributed to aldehydes and ketones, and can thus provide information about the oxidation "history" of oil or fat. It is a sign of excessive oil deterioration in deep frying processes, which produces undesirable flavors (Yorulmaz, Erinc, & Tekin, 2013).
- The lower the p-Anisidine Value, the higher the quality of the analyzed fats and oils. The recommended values vary depending on the state of primary oxidation: for fish oils, the p-Anisidine value must be less than 30 Av, while for vegetable oils, less than 10 Av is recommended; thus, the maximum Anisidine value of palm oil is 10Av (Grossi, Lecce, Arru, & Ricco, 2015; CODEX, 2011).
- **Deterioration of bleachability index (DOBI):** The test predicts the ease of refining crude palm oil, as well as its shelf life. It is a measure of the bleachability of crude palm oil based on the amount of carotenes still present and the amount of secondary oxidation products (Abdul, 2000). A DOBI of 4 implies that the crude palm oil is easily bleached, whereas a DOBI of 2.5 to 3 indicates that the crude palm oil is of average quality (Siew, 2000).

The data gathered from this study will indeed be valuable to Dietitian, Nutritionist, food processors, and palm oil consumers in Imo state in making informed choices and providing evidence-based information for proper dietary

guidance and counseling, and also be added to a database on the theme for the improvement of related industrial applications.

2. Material and methods

2.1. Research design

The study employed an experimental study design.

2.2. Study area

The market survey was carried out in Orlu senatorial zone in Imo State. Imo state has 27 local governments, grouped under three senatorial districts namely: Imo North (Okigwe zone), Imo East (Owerri zone), and Imo West (Orlu zone). Orlu zone is the largest senatorial zone in terms of the number of local government areas (Imo State Government, 2010; Amangabara, 2015) and has the highest number of palm oil production plants (Nwauwa, 2012).

2.3. Sampling procedure

An exploratory study was carried out in Imo West (orlu zone) of Imo State to identify the quality of palm oil produced and consumed in the study areas. A multi-stage sampling technique was used for the survey. Firstly, three local government areas (Nwangele, Isu and Orlu) were selected randomly from the available local governments in orlu senatorial zone of imo state. The Three local government areas (L.G.A) were selected purposively for the study based on cultural food habits. Random sampling also was used to select a major market from each Local Government Area, making a total of three markets (Nkwo-mmiri market in Nwangele L.G.A, Eke-amandugba market in Isu L.G.A and International market in Orlu L.G.A).

2.4. Purchase of sample

The Palm oil samples used for this study were obtained from the selected markets (each market from the three selected local governments in Orlu zone of Imo State). Fifteen samples were purchased from different sellers from each market in each selected local government area, making a total of forty-five samples which were homogenized into 3 samples (Good, fairly good, and bad samples) based on taste, color, and smell after sensory evaluation done by eighteen (18) experts on palm oil production.

2.4.1. Criteria for Good oil are

- **Taste:** mild savory taste (has flavor but not sweet), it is neither bitter nor sour.
- **Color:** dark red (ox-blood red or orange color).
- **Smell:** pleasant and violet (not choking) smell.

2.5. Laboratory analysis

Chemical analysis was done on the Palm oil samples using five basic parameters; Free fatty acid content, Carotene content, Peroxide value, DOBI and Anisidine value. All determinations were done in triplicates and mean values were calculated. Peroxide value and Free fatty acid determination were carried out using the method described by Akinola, Oguntibeju, Adisa, and Owojuyigbe (2010). Anisidine value, DOBI, and beta-carotene content were determined using the method described by the Association of Official Analytical Chemists (AOAC, 2010).

2.6. Data Analysis

Data was analyzed using Statistical Package for Social Sciences version 23 for Means and Standard deviation (SD). Duncan New Multiple Range Test was done to compare the means of samples obtained from the three different markets. $P<0.05$ was set to be significant.

3. Results

3.1. Results of each parameter used in assessing the quality of palm oil samples according to the order of the objectives

Table 1 below shows the result of peroxide values of palm oil samples collected from Orlu Senatorial Zone in Imo state, Nigeria. From the Table, it was observed that there was variability among peroxide values of the three samples assessed,

with means of 4.80MeqO_2/Kg, 17.13MeqO_2/Kg, and 43.20MeqO_2/Kg, respectively. There was a significant difference ($p < 0.05$) found in the peroxide value of the bad sample assessed.

Table 1 Peroxide values of palm oil samples

Samples	Mean ± SD	F-ratio	P-value (sig.)
Good	4.80 ± 4.85^a	13.590	0.006*
Fairly good	17.13 ± 10.98^a		
Bad	43.20 ± 10.51^b		

Values = Mean ± SD (SD = standard deviation) of 3 determination, * = Significant ($p < 0.05$)

Table 2 below shows the result of free fatty acids (FFA) of palm oil samples collected from Orlu Senatorial Zone in Imo state, Nigeria. From the Table, it was observed that there was variability among the means of FFA in the three samples assessed, with means of 5.56%, 7.30% and 8.63% respectively. This variability was also observed on samples collected within and amongst markets in Orlu Senatorial Zone. There was no statistically significant ($p > 0.05$) difference found among the FFA of the three samples assessed.

Table 2 Free fatty acids (FFA) values of palm oil samples

Samples	Mean ± SD	F-ratio	P-value (sig.)
Good	5.56 ± 1.83a	4.163	0.073**
Fairly good	7.30 ± 0.53a		
Bad	8.63 ± 1.23a		

Values = Mean ± SD (SD = standard deviation) of 3 determination, ** = Insignificant ($p > 0.05$)

Table 3 below shows the result of p-Anisidine value of palm oil samples collected from Orlu Senatorial Zone in Imo state, Nigeria. It was found that there was a slight variation among the means of p-Anisidine of the three samples assessed, with means of 30.00 Av, 31.00 Av, and 32.00 Av, respectively. There was no statistically significant ($p > 0.05$) difference found among the samples assessed.

Table 3 p-Anisidine value of palm oil samples

Samples	Mean ± SD	F-ratio	P-value (sig.)
Good	30.00 ± 5.23a	0.212	0.814**
Fairly good	31.00 ± 1.73a		
Bad	32.00 ± 3.46a		

Values = Mean± SD (SD = standard deviation) of 3 determination, ** = insignificant ($p > 0.05$)

Table 4 Deterioration of bleachability index values of palm oil samples

Samples	Mean ± SD	F-ratio	P-value (sig.)
Good	0.18 ± 0.02a	4.287	0.070**
Fairly good	0.15 ± 0.03a		
Bad	0.12 ± 0.03a		

Values = Mean± SD (SD = standard deviation) of 3 determination, ** = Insignificant ($p > 0.05$)

Table 4 below shows the result of deterioration of bleachability index of palm oil samples collected from Orlu Senatorial Zone in Imo state, Nigeria. From the results, it was found that there was a slight variation among the means of the three samples of deterioration of bleachability index assessed, with means of 0.18, 0.15, and 0.12, respectively. There was no statistically significant ($p > 0.05$) difference found among the three samples of deterioration of bleachability index assessed.

Table 5 below shows the result of beta-carotene of palm oil samples sold in major market in Orlu Senatorial Zone in Imo state, Nigeria. From the results, it was found that there was a variation among the means of the beta-carotene of the three samples assessed, with means of 2516.67 Mg/Kg, 2440.00 Mg/Kg and 2146.67 Mg/Kg, respectively. There was no statistically significant ($p > 0.05$) different found among the beta-carotene of the three samples assessed.

Table 5 Beta-Carotene level of palm oil samples

Samples	Mean ± SD	F-ratio	P-value (sig.)
Good	2516.67 ± 1576.08a	0.083	0.921**
Fairly good	2440.00 ± 796.05a		
Bad	2146.67 ± 1002.02a		

Values = Mean ± SD (SD = standard deviation) of 3 determination, ** = Insignificant ($p > 0.05$)

4. Discussion

Peroxide value is an important parameter used in assessing the quality of palm oil. It is an indicator of the level of lipid peroxidation or oxidative degradation. From Table 1, it was observed from the research findings that the peroxide value of fairly good sample and bad sample with mean values of 17.13 $MeqO_2$/kg and 43.20 $MeqO_2$/kg respectively, were high when compared with the safe level (< 10 $MeqO_2$/kg) as specified by CODEX (2011) except Good sample (4.80 $MeqO_2$/kg) which falls within safe level (< 10 $MeqO_2$/kg). A significant difference ($P < 0.05$) was observed in the bad sample which has the highest peroxide value. The variation in peroxide value of the three palm oil samples assessed may be due to the storage period, high temperature during processing, and exposure to air which leads to oxidation and spoilage (Grossi, Lecce, Arru, & Ricco, 2015). Low peroxide value was also recorded by Ngando et al., 2012, Aletor et al., 1990, Onwuka and Akaerue 2006 with values of (2.07, 1.48 – 5.71 and 2.67 $MeqO_2$/kg), (2.70 and 7.40 $MeqO_2$/kg for traditionally processed palm oil) and (5.4 and 0.75 - 7.4 $MeqO_2$/kg) respectively and high peroxide value was also seen in the findings of Okechalu et al. (2011), who reported relatively high peroxide values of 23.2 – 35.5 $MeqO_2$/kg. This oxidized oil could be very harmful for consumption (Tagoe et al., 2012). Besides these visible harmful effects on the sensory quality of the oil, peroxidation also makes the oil dangerous for human health, as the free radicals generated by this process are proven to be carcinogenic (Rossel, 2000).

The research also shows that there was variability in the mean values of free fatty acid among the three palm oil samples assessed as shown in table 2. There were no statistically significant differences ($p > 0.05$) found among the FFA values of the samples assessed. The FFA values of the palm oil sample ranging from 5.56% to 8.63%, were slightly above the safe level (5%) as specified by CODEX (2011) norms. crude palm oil with low FFA (not exceeding normal) is an indication that the oil has been processed from fresh, unbruised fruits and carefully handled during production, storage, and transportation (Ali & Abdurrhman, 2013). Therefore, the increased value of FFA, slightly above normal may be attributed to poor post-handling techniques during the production process, storage period, fermentation, and the use of bruised or ripe palm fruit in palm oil production (Ali & Abdurrhman, 2013). According to Hyman (2001) classification, the crude palm oil produced in Orlu zone of Imo state could be regarded as hard oil because its FFA content is greater than 5%. Aletor et al. (1990) reported 4.9% FFA for mechanical processed palm oil and 7.04 – 12.24% for traditionally processed palm oil. Okechalu et al. (2011) sampled oil palm sold within Jos Metropolis and found that the FFA ranges from 2.67 – 4.20%. Onwuka and Akaerue (2006) found that the % FFA of palm oil differs according to the different methods of processing. They found that the FFA of large-scale industrially processed palm oil is 0.97%, while oil processed using traditional aqueous oil extraction method had FFA of 2.6 – 2.9%. Likewise, Ngando et al. (2012) reported % FFA of traditionally (6.39%), semi-mechanical (5.00 – 10.26%), and industrially processed (4.71%) palm oil in Cameroon. Basically, FFA is the widely used method for examining the quality of palm oil, increased FFA beyond normal (5%) is known to cause an increased risk of coronary heart disease, a leading cause of death in Western nations (Ngando et al., 2011). In order to limit lipase activity, fresh fruit bunches must be handled gently and above all, processed rapidly after harvest to inhibit free radicals of reactive oxygen species, lipid peroxidation, and up-regulating other free radical detoxification mechanisms (Ugo, 2022).

Furthermore, the p-Anisidine value is used to provide information on the oxidative history of fat, as it is appropriate to quantify secondary oxidative products essentially made up of high molecular weight saturated and unsaturated carbonyl compounds. From the research, it was found that there was a slight variation among the mean values of p-Anisidine which ranges from 30 – 32 Av and are above the safe level (< 10 Av) as specified by CODEX (2011). The high p-Anisidine value could be due to the decomposition of glycerides by fungi and micro-organisms and might be accelerated by the exposure of palm oil to either sunlight or heat (Houria et al., 2002; Ekwenye, 2005). There was no statistically significant difference ($p > 0.05$) found among the samples. The p-Anisidine values of samples assessed were above the Codex Alimentarius 2011 norms which recommend a maximum value of 10Av indicating that red oil obtained from this area is not good for consumption because of the high level of p-Anisidine value in the oil which shows that the oil has gone rancid. The p-Anisidine results from Table 3 were not in agreement with the results of Muhammad, Waqar, Saeed, and Ikram, (2008) who recorded lower values for p-Anisidine (6.33 - 9.57 Av).

The deterioration of the bleachability index, or DOBI test attempts to predict the ease of refining crude palm oil, indicating its oxidative status and its shelf life (Abdul, 2000). The research findings in table 4 have shown that there was a slight variation among the mean values of DOBI which ranges from 0.12 - 0.18 and are below the safe level (2 - 4) as specified by Siew (2000). There was no statistically significant difference ($p > 0.05$) found among the deterioration of bleachability index of the samples assessed. A good quality palm oil is easily bleached and should have a DOBI of 4, while average quality crude palm oil will exhibit a DOBI of 2 to 3 (Siew, 2000), but this was in contrast with the research findings which falls below the safe level.

The result from Table 4 was not in line with the findings of Gee (2014), who recorded higher values for DOBI (2.6 – 3.05). The low DOBI value obtained from the research may be due to the quality of palm oil used, the degree of ripeness, and storage conditions (Siew, 2000). This will pose a problem to further bleaching and refining of the palm oil sample.

These research findings have also shown that palm oil marketed in major markets in Orlu senatorial zone is of good quality as their β-carotene levels ranged between 2146.67mg/kg to 2516.67mg/kg. There were no statistically significant differences ($p > 0.05$) found among the beta-carotene content of the samples assessed (table 5). Though the beta-carotene content falls above the recommended values of the Standard Organization of Nigeria and Nigerian Industrial Standard (500 – 2000 mg/kg) but was within the tolerable upper intake level of 2,800mg/Kg (NIS, 1992). The result was in contrast with the findings of Agbaire, (2012) and Udensi & Iroegbu, (2007) who recorded a lower carotene value of 1376.73 - 1568.59 mg/kg and 1082 – 1458 mg/kg respectively, in Delta and Abia States. De-Almeida et al. (2013) also reported very high values ranging from 4.2210 – 9.4002 µg/g (equivalent to 4221 – 9400.2 mg/kg) in Bahia, Brazil. Palm oil is usually rich in vitamin A with carotene as its precursor (Ihekorokye & Ngoddy, 2005). Thus, high levels of carotene in the oil samples indicate high levels of vitamin A which is essential for good sight. The Good sample of palm oil assessed showed the highest carotene content when compared to the other two samples studied (Fairly good sample and Bad sample), which indicates the long storage period of the oil sample. However, the mean values obtained were within the tolerable upper intake level of 2,800mg/Kg (NIS, 1999), beyond this, hypervitaminosis A and carotenemia disease, sets in.

5. Conclusion

The research findings showed that the peroxide value, FFA value, and beta-carotene content of the 'Good sample' falls within the recommended safe level except for the Deterioration of bleachability index (DOBI) which is far below normal and p-Anisidine value which is higher than normal. The other two palm oil samples (Fairly good and Bad sample) assessed have shown from the research result to be of poor quality and may not be good for human consumption and industrial use since it does not conform to the standard safe level.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declared no conflict of interest

Statement of informed consent

All contributing authors read and approved the final manuscript for publication.

References

[1] Abdul, A. (2000). The Effect of CPO Quality Parameters (FFA, M&I, IV, PV, AV, DOBI and Colour) on the Refinery Production Efficiency. Proceedings of the 2000 National Seminar on Palm Oil Milling, Refining Technology, Quality and Environment. July 3-4. Genting Hotel, Genting Highlands, Malaysia. pp.79-88.

[2] Agbaire, P. O. (2012). Quality assessment of palm oil sold in some major markets in Delta State, Southern Nigeria. African Journal of Food Science Technology, 3(9), 223-226.

[3] Akinola, F. F., Oguntibeju, O. O., Adisa, A. W., & Owojuyigbe, O. S. (2010). Physico-chemical properties of palm oil from different palm oil local factories in Nigeria. Journal of Food, Agriculture & Environment, 8(3&4), 264-269.

[4] Aletor, V. A., Ikhena, G. A., & Egharevba, V. (1990). The quality of some locally processed Nigerian palm oil: An estimation of some critical variables. Food Chemistry Journal, 36, 311 – 317.

[5] Ali, A. S. M., & Abdurrhman, A. M. (2013). Determination of Free Fatty Acids in Palm Oil Samples by Non-Aqueous Flow Injection Using Salicyaldehyde-2,4 Dinitrophenylhydrazone as Colorimetric Reagent. Journal of Chemical and Materials Engineering, 1(3), 96-103.

[6] Amangabara, G.T. (2015). Drainage Morphology of Imo Basin in Anambra-Imo River Basin Area, of Imo State, Southern Nigeria. Journal of Geography, Environment and Earth Science International, 3(1), 1-11.

[7] AOAC (2005). Official Methods of Analysis.18th Edition, AOAC International, Arlington, VA.

[8] AOAC (2010). Official Methods of Analysis. 18th Edition, Revision 3, Association of Official Analytical Chemists, Washington DC.

[9] Berger, K.G. (1992). Food uses of palm oil. Kuala Lumpur Bulletin Perkebunan, 22, 230–238.

[10] Chinwe, A. E., Nnaemeka, A. M., Henry, U. C., Kenechukwu, O. C., & Kelechi, A. I. (2022). Anti-Inflammatory Potentials of Aqueous Soursop Pulp Extracts on Induced Benign Prostatic Hyperplasia in Adult Male Wistar Rats. Saudi J Med Pharm Sci, 8(8), 397-402.

[11] Codex Alimentarius Commission/FAO/WHO food standards (2011). Standard for named vegetable oils. CODEX-STAN 210, Ed. FAO/WHO Content. Journal of American Oil Chemist's Society, 86, 798-819.

[12] Codex-Alimentarius-Commission (2015). Joint FAO/WHO food standards programme. Codex Alimentarius Commission, Geneva, Switzerland, Thirty-eighth session CICG, REP 15/FO6-11 July, 2015.

[13] Commission du Codex Alimentarius/FAO/OMS (2005). Normes alimentaires pour huiles et graisses. CODEX-STAN 210, FAO/OMS Content. Journal of American Oil Chemist's Society, 79, 965-969.

[14] Corley, R. H. V., & Tinker, P. B. (2008). The oil palm. John Wiley & Sons.

[15] De-almeida, D.T., Nunes, I.L., Conde, P.L., Rosa, R.P.S., Rogério, W.F., & Machado, E.R. (2013). A quality assessment of crude palm oil marketed in Bahia, Brazil. grasas y aceites, 64 (4), julio-septiembre, 387-394.

[16] Ebere, E. C., Wirnkor, V. A., Chinedu, E. E., & Ngozi, V. E. (2018). A review on the quality of palm oil (Elaeis guineensis) produced locally in Imo State, Nigeria. Sustainable Food Production, 40.

[17] Edem, D. O. (2002). "Palm oil: Biochemical, physiological, nutritional, hematological and toxicological aspects: A review". Plant Foods for Human Nutrition (Formerly Qualitas Plantarum), 57(3), 319–341.

[18] Ekwenye, U. N. (2005). Chemical Characteristics of Palm Oil biodeterioration. Chemical Society for Experimental Biology journal, 18, 141-149.

[19] Ekweye, U. N., & Ijeomah, C. A. (2005). Antimicrobial effect of palm kernel oil and palm oil. Chemistry Science Journal, 5(2), 502-505.

[20] Enyoh, C.E., Verla, A.W., Enyoh, E.C., & Verla, E.N. (2018). A Review on the Quality of Palm Oil (Elaeis guineensis) Produced Locally in Imo State, Nigeria. Sustainable Food Production, 4, 40-50. doi:10.18052/www.scipress.com/SFP.4.40.

[21] Enyoh, E.C., Enyoh, C.E., & Amaobi, C.E. (2017). Quality assessment of palm oil from different palm oil local factories in Imo State, Nigeria. World Scientific News, 88(2), 152-167.

[22] Gee, P.T. (2014). Use of the deterioration of bleachability index to characterize the quality of palm oil. Retrieved on December 15, 2015.

[23] Grossi, M., Lecce, G., Arru, M., Gallina, T., & Ricco, B. (2015). An opto-electronic system for in-situ determination of peroxide value and total phenol content in olive oil. Journal of Food Engineering, 146(5), 1–7.

[24] Houria, A., Comeau, L., Deyris, V., & Hiol, A. (2002). Isolation and Characterisation of an extracellular lipase from Mucor sp strain isolated from palm fruit. Enzyme Microbial Technology Research, 31, 968-975.

[25] Hyman, E. L. (2001). "An Economic Analysis of small scale Technologies for Palm Oil Extraction in Central and West Africa". World Development Research, 18(3), 455 - 476.

[26] Ihekornye, A. I., & Noddy, P. O. (2005). Integrated Food Science and Technology for the Tropics. Macmillian Publishers, 75-77.

[27] Imo State Government (2010). About Imo State, Nigeria. Available: http://www.imostate.gov.ng/info/AboutImo. Retrieved: 10 June 2018

[28] Imoisi, O. B., Ilori, G. E., Agho, I., & Ekhator, J. O. (2015). Palm oil, its nutritional and health implications. Journal of Applied Sciences and Environmental Management, 19(1), 127-133.

[29] Initiative for Public Policy Analysis (IPPA) (2010). African Case Study: Palm Oil and Economic Development in Nigeria and Ghana; Recommendations for the World Bank's 2010 Palm Oil Strategy. Initiative for Public Policy Analysis (IPPA), Lagos.

[30] Jensen, M. D., Haymond, M. W., & Rizza. R. A. (2008). Influence of body fat distribution on free fatty acid metabolism in obesity. Journal of Clinical Investment, 83, 1168–1173.

[31] Kabagambe, B. A., Ascherio, A., & Campos, H. (2005). "The Type of Oil Used for Cooking Is Associated with the Risk of Nonfatal Acute Myocardial Infarction in Costa Rica". Journal of Nutrition, 135(11), 2674–2679.

[32] Kheiri, S.A. (1987). End uses of palm oil: Human Food. In Critical Reports on Applied Chemistry, Vol. 15, Palm oil ed. F.D. Gunstone, London, 1987, pp. 71–83.

[33] Ngando, E. G. F., Mpondo, M. E. A., Dikotto, E. E. L., & Koona, P. (2011). Assessment of the quality of crude palm oil from smallholders in Cameroon. Journal of Stored Products and Postharvest Research, 2(3), 52-58.

[34] Ngando-Ebongue, G. F., Ajambang, W. N., Koona, P., Firman, B. L., & Arondel, V. (2012). Oil palm. In Technological Innovations in Major World Oil Crops, Volume 1 (pp. 165-200). Springer, New York, NY.

[35] Nigerian Industrial Standards, NIS (1992). Standard for edible vegetable oil. Pp. 5-12.

[36] Nwauwa, L.O.E. (2012). Palm oil marketing and distribution pattern in Imo state, Nigeria: An application of linear programming model. E3 Journal of Agricultural Research and Development, 2(1), 037-043.

[37] Okechalu, J. N., Dashen, M. M., Okechalu, B., & Gushop, T. (2011). Microbiological quality and chemical characteristics of palm oil sold within Jos Metropolis, Plateau State. Nigeria Journal of Microbiology Biotechnology Research, 1(2), 107-112.

[38] Onwuka, G. I. (2005). Food Analysis and Instrumentation: Theory and Practice. Naphthali Prints, Lagos, pp: 89-98.

[39] Onwuka, G. I., & Akaerue, B. I. (2006). Evaluation of the quality of palm oil produced by different methods of processing. Research Journal of Biological Sciences, 1(1-4), 16-19.

[40] Poku, K. (2002). "Origin of oil palm". Small-Scale Palm Oil Processing in Africa. FAO Agricultural Services Bulletin 148. Food and Agriculture Organization. ISBN 92-5-104859-2.

[41] Roche, H. M. (2000). Low-fat diets, triglycerides and coronary heart disease risk. Nutrition Bulletin, 25, 49-53.

[42] Rossel, J. B. (2000). Measurement of rancidity. Rancidity In Foods. Allen J.C and Hamilton R.J (editions.), Aspen publishers, United Kingdom, 22-51.

[43] Sambanthamurthi, R., Sundram, K., & Tan, Y. (2000). Chemistry and biochemistry of palm oil. Progress in Lipid Research, (39), 507-558.

[44] Siew, W.L. (2000). Analysis of palm and palm kernel oils: Malaysian Palm Oil Board, Kuala Lumpur, Malaysia. Pp 968-1035.

[45] Siew, W.L. (2002). Chemical and physical characteristics of palm oil and palm kernel oils and their crystalisation behavior, in: M.S. Zainon, M. Johari (Eds.), Lectures on Palm Oil and Its Uses. MPOB, Bangi, pp. 64-85.

[46] Siew, W.L. (2002). Palm oil, in: D.G. Frank (Ed), Vegetables Oils in Food Technology Composition, Properties and Uses. United Kingdom: Blackwell Publishing, pp. 59-97.

[47] SoyStats (2016). World vegetable oil consumption 2015. Available: http://www.soystats.com/wp-content/uploads/SoyStats_2016.pdf. Accessed: 12/06/2018.

[48] Sutapa, M., & Analava, M. (2009). Health effects of palm oil. J. Hum. Ecol., 26(3), 197–203.

[49] Tagoe, S. M. A., Dickinson, M. J., & Apetorgbor, M. M. (2012). Factors influencing quality of palm oil produced at the cottage industry level in Ghana. International Food Resource Journal, 19(1), 271 -278.

[50] Traber, M. (2003). Vitamin E: function and metabolism. The FASEB Journal, 13(10), 145–155.

[51] Uche-Okoye, D., Ajemba, M. N., Amy, B., Arene, E. C., Ugo, C. H., Eze, N. P., ... & Chiwenite, C. M. (2023). Is telerehabilitation an effective maintenance strategy for patients with chronic obstructive pulmonary diseases: a systematic review. Bulletin of the National Research Centre, 47(1), 13.

[52] Udensi, E.A., & Iroegbu, F.C. (2007). Quality Assessment of palm oil sold in major markets in Abia state, Nigeria. Journal of Agriculture, food, environment and extension (agro-science), 6(2), 25-27.

[53] Ugo, C. H. (2022). Nutritional Composition, Bioavailability, Medicinal Functions and Uses of Turmeric: A Review. Sch Bull, 8(8), 248-60.

[54] Yorulmaz, A., Erinc, H., & Tekin, A. (2013). Changes in olive and olive oil characteristics during maturation. Journal of the American Oil Chemists' Society, 90(5), 647-658.