Comparative Study on the Effects of Different Extraction Methods on the Micro components and Oxidative Stability of African Pear (*Dacryodes edulis*) Pulp Oil

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Abstract

The effects of different extraction methods on some micro-components and oxidative stability of African pear pulp oil were studied. Three different methods; Soxhlet, traditional and screw press were used to extract oil from African pear pulp. The chlorophyll, copper, vitamin E, carotene and iron contents of the oil were determined and the oxidative stability of the oil samples was studied for four weeks. The oils were assessed for peroxide value, free fatty acid, density, viscosity and thiobarbituric acid level. The micro-components result ranged from 0.00 to 41.50% for chlorophyll, 0.00 to 1.25 µg/100g for total carotenoids, 0.02 to 0.04 mg/100g for iron, 0.00 to 0.01 mg/100g for copper, 18.25 to 208.50 mg/100g for vitamin E. The oxidative stability results showed that, the peroxide values ranged from 0.13 to 2.69 meq O_2/kg at week 0 to 0.92 to 3.62 meq O_2/kg after storage, FFA ranged from 0.36 to 7.04% at week 0 to 0.39 to 11.47% after storage, density ranged from 0.89 to 0.91 g/cm^3 at week 0 to 0.91 to 0.98 g/cm^3 after storage, viscosity ranged from 17.17 to 51.57 RVU at week 0 to 20.31 to 55.05 RVU after storage and thiobarbituric acid level ranged from 0.02 to 1.11 mg/g at week 0 to 0.09 to 1.31 mg/g after storage. Conclusively, D. edulis pulp oil extracted through Soxhlet extraction method had better micro-component composition and oxidative stability at the end of storage period (4 weeks).

Keywords: *Extraction, African pear, Pulp oil, Oxidative stability, Micro-components.*

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Introduction

Vegetable oil is a valuable product with universal demand (Gayas and Kaur, 2017). It is composed largely of triglycerides (Nicholes *et al.*, 2011) and obtained basically from vegetable sources. They are rich in essential fatty acids, provide energy and serve as a carrier of fat-soluble vitamins (Nayak *et al.*, 2015). Aside their use for frying, both in industrial and domestic food preparations (Falade *et al.*, 2017), they are also used as major ingredient in the production of mayonnaises, shortenings and margarines. Oil seed crops such as groundnut, soybean, oil palm fruit, rapeseed and many more have been exploited for their lipid content (Ajala and Adeleke, 2014), while crops such as African pear are lesser known especially to the international community.

African pear is known in South-Eastern Nigeria as "ube". There are two varieties of *D. edulis* in Nigeria: *D. e. var. edulis* and *D. e. var. parvicarpa* (Isaac and Ekpa, 2009). African pear fruits have seed that is enveloped or covered by a pulpy edible mesocarp, which is consumed either in its cooked or raw form (Sofowora, 2008). The fruit can be softened when placed in hot ash or in hot water then salted and eaten as a snack or with other foods like roasted, fried or boiled maize, and occasionally with bread, yam, soaked "garri" (cassava flakes), or rice (Okeke *et al.*, 2008). Its pulp is rich in protein, fibre, minerals and essential amino acids (Onuegbu *et al.*, 2016), and could be an important source of vegetable oil. The fresh mesocarp of *D. edulis* contains about 26.73 to 35.05% oil (Nwosuagwu *et al.*, 2009). Oil extraction from oil bearing mesocarp can be done with numerous methods such as solvent extraction, traditional and mechanical press (Alenyorege *et al.*, 2015). Vegetable oil extracted from African pear pulp has been reported to contain palmitic acid (9.06%), stearic acid (15.46%), oleic acid (26.63%) and linoleic acid (30.85%) (Ikhuoria and Maliki, 2007). Evaluation of the ability of vegetable oil extracted from African pear pulp to resist oxidative rancidity over storage periods is of immense importance (Hu and Jacobsen, 2016), as it

influences the acceptability and market value of edible oils (Almeida *et al*., 2017). Various methods are used in assessing the oxidative stability of vegetable. However, Rancimat test, Schaal Oven Test, thermostatic test and chemical determinations of peroxide value (PV), anisidine value (AnV) and Thiobarbituric acid value (TBA) are conventional methods of assessing oxidative stability of vegetable oil (Maszewska *et al*., 2018).

The dependence on conventional oilseeds like peanut seeds for vegetable oil production has resulted to oils with increased cost due to high demand of the oil products which eclipse production and supply. One of the major challenges in edible oil is the development of rancidity (oxidative) and deterioration of its quality due to environmental and storage conditions. Oxidation results in alteration of quality parameters and sensory properties. Such degradation, although relatively slow, may occur during heating and/or storage of the final product, thereby affecting its shelf life. Consumption of oxidized edible oils negatively influence the lipid profile (increased low-density lipoprotein (LDL), decrease high-density lipoprotein (HDL) and elevated cholesterol level) and kidney function (Falade *et al*., 2017). More so, there are limited studies on the oxidative stability and minor components of African pear. It is therefore important to conduct a research on the oxidative stability and minor components of African pear pulp oil extracted using different extraction methods. Findings of this research will reveal the extraction method that is suitable for extracting African pear pulp oil that is more stable to oxidative deterioration, minimize the over reliance on conventional oilseeds like peanut for oil production, increase the market for vegetable oils as well as value addition to African pear fruit. This will be of immense benefits to consumers, considering the numerous adverse health effects of consuming oxidized vegetable oil and providing consumers with cheaper oil varieties. Food professional, researchers and oil producing industries will find outcome of this research highly valuable.

Materials and Methods
Source of raw materials
Matured and wholesome *D. edulis* fruits that was used for this study as well as the reference standard (Golden Soya soybean oil) was procured from Ubani main market in Umuahia North Local Government Area, Abia State.

Sample preparation
Preparation of *D. edulis* for Soxhlet extraction method
African pear fruits (3 kg) were sorted, washed thoroughly with distilled water and split open with a sharp stainless knife to remove the seed. The deseeded African pear fruits were cut into smaller pieces (2 cm wide), dried at 70°C in a Gallenkamp hot air oven (Model OV 160) for 48 h and milled with attrition mill to obtain African pear pulp powder. The powder was packaged in an air-tight cellophane bag prior to extraction (Musa *et al.,* 2012).

Preparation of *D. edulis* for traditional and screw press extraction methods
African pear (3 kg) fruits were sorted, washed with distilled water and split open with a sharp stainless knife to remove the seed. The Adedokun and Onuegbu (2011), pulp was cut into smaller pieces (2 cm wide) and packaged in an air-tight cellophane bag at room temperature for 18 h to soften the pulp prior to extraction (Adedokun and Onuegbu, 2011).

Extraction of *D. edulis* pulp oil
Extraction of *D. edulis* pulp oil using Soxhlet extraction method
The Soxhlet extraction method described by Musa *et al*. (2012), was used in extraction of *D. edulis* pulp oil. Two hundred and fifty milliliters (250 ml) of n-Hexane was poured into a round bottom flask. Ten grams (10 g) of *D. edulis* pulp powder was introduced into the thimble and was placed at the center of the Soxhlet extractor. The extractor was then heated to 79°C (this temperature

was chosen because n-hexane has an optimum boiling point of 78^0C.) and was held at that temperature throughout the duration of the reflux process (5 hours). At the end of the process, the oil was recovered and the residual n-hexane was evaporated by heating in an oven for 10 minutes at $80°C$. The obtained oil samples were packaged in an air-tight container and stored in a refrigerator prior to analysis.

Extraction of *D. edulis* pulp oil using traditional extraction method

The method described by Adedokun and Onuegbu (2011), was used in the traditional extraction of *D. edulis* pulp oil. Three kilograms (3 kg) of the softened pulp was mashed manually with plastic mortar and pestle and transferred to a stainless bowl with subsequent addition of 4000 ml of boiled water. Cleaned sieving cloth was used to separate the mixture of oil and water from the mashed pulp. The mixture was allowed to separate into distinct layers of oil and water. The oil was separated from the water using separating funnel and the oil samples were placed on a hot plate regulated at $120°C$ and was allowed to boil for 2 minutes to remove water. The obtained oil samples were packaged in an air-tight container and stored in a refrigerator prior to analysis.

Extraction of *D. edulis* pulp oil using screw press extraction method

Screw press extraction of *D. edulis* pulp oil was carried out using the modified method of Adedokun and Onuegbu (2011). Three kilograms (3 kg) of soften *D. edulis* pulp was mashed manually with mortar and pestle, and was subjected to low heat of $45°C$ for 2 minutes to loosen the fat globules before transferring it to a sieving cloth. The mashed *D. edulis* pulp was tied in a sieved cloth with rope to curb leakage. This was followed by placing the tied material in a screw press and pressure was applied and the oil collected. The obtained oil samples were packaged in an air-tight container and

stored in a refrigerator prior to analysis. Codes representing each extracted sample are represented in Table I.

Table I: Codes representing each oil sample.

Samples	Codes
Soybean oil (reference standard)	SOYBEAN
Soxhlet extracted Dacryodes edulis pulp oil	SOXHLET
Screw press extracted Dacryodes edulis pulp oil	SCREW
Traditional extracted Dacryodes edulis pulp oil	TRADITIONAL

Methods of Analyses
Micro-component analysis
The method described by Ankapong. (2010), was used for the determination of chlorophyll and total carotenoid contents of the edible oil samples. The vitamin E content was determined by the method described by Amankwa *et al.* (2009). The method described by Akintayor and Bayer (2002), was used in the determination of iron and copper content.

Determination of oxidative stability
The oxidative stability study was carried out for a period of 4 weeks after the initial quality was ascertained. Each oil sample was divided into five (5) portions and stored in an airtight bottle such that each bottle was withdrawn each week for analysis. The occurrence of oxidation was ascertained by assessing the free fatty acid value (AOCS Official Method Cd 18 – 90, 1996), peroxide value (AOCS Official Method Cd 18 – 90, 1996), viscosity (Ankapong, 2010), thiobarbituric acid value (AOCS Official Method Cd 18 – 90, 1996) and density (Enyoh *et al.*, 2017) at the beginning and end of storage.

2.5 Statistical analysis
All experimental data was analyzed using the SPSS version 19.0 software and was expressed as mean $\pm$ SD (standard deviation).

One-way analysis of variance (ANOVA) was carried out on the data. The Duncan Multiple Range Test (DMRT) method was used to compare the means of experimental data at 95 % confidence interval when a significant difference was observed from the One-way ANOVA (SPSS 2018).

Results and Discussion
Micro-components composition of the oil samples

The micro-components composition of the oil samples is presented in Table II. African pear pulp oil samples had higher chlorophyII content (31.50-41.00%) than the reference standard (SOYBEAN) (0.00%). SCREW had the highest chlorophyll content (41.50%), followed by TRADITIONAL (41.00%). The result indicated that, the extracted oil samples, particularly SCREW and TRADITIONAL may deteriorate quickly compared to other samples since chlorophyII has been reported to increase the rate of oxidation in edible oils (Akindele and Nsuhoridem, 2018). The absence of chlorophyII in SOYBEAN could be attributed to efficiency of refining towards the removal of pigments. More so, the presence of pigmentation in the African pear pulp oil samples suggested the necessity of refining, specifically, bleaching.

The total carotenoid content of the oil samples ranged from 0.00 to 1.25%. *D. edulis* pulp oil samples had higher carotenoid content than the reference standard, with SOXHLET having the highest value. The absence of carotenoid for SOYBEAN (0.00 µg/100g) could be attributed to the refining process the oil was subjected to during processing which may affects its oxidation stability when stored improperly. The high total carotenoid content recorded for African pear pulp oil samples suggested the presence of appreciable amount of *β*-carotene which has the capacity to slow down oil oxidation by light filtering, singlet oxygen quenching, sensitizer inactivation and free radical scavenging activity (Angaye and Maduelosi, 2015). However, the total carotenoids value obtained from this study was lower than the value (64.3 mg/100g) reported for crude palm oil (Oderinde *et al.,* 2009).

Table II: Micro-components composition of the oil samples.

Samples	Chlorophyll (%)	Total Carotenoids (µg/100g)	Iron (mg/100g)	Copper (mg/100g)	Vitamin E (mg/100g)
SOXHLET	$31.50^{b}\pm0.71$	$1.25^{a}\pm0.01$	$0.04^{ab}\pm0.00$	$0.00^{b}\pm0.00$	$208.50^{a}\pm1.41$
SCREW	41.50 ± 2.12	$1.17^{b}\pm0.01$	$0.04^{ab}\pm0.00$	$0.00^{b}\pm0.00$	$201.00^{b}\pm0.71$
TRADITIONAL	$41.00^{a}\pm1.41$	$1.17^{b}\pm0.01$	$0.04^{ab}\pm0.00$	$0.00^{b}\pm0.00$	$40.50^{c}\pm0.71$
SOYBEAN	$0.00^{c}\pm0.00$	$0.00^{b}\pm0.00$	$0.02^{a}\pm0.01$	$0.01^{a}\pm0.00$	$18.25^{d}\pm0.07$

a-d: Values are means $\pm$ standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different ($p<0.05$).

The iron content of the oil samples ranged from 0.02 to 0.04 mg/100g and there were no significant differences (p>0.05) among the oil samples. The presence of transition metals such as iron is related to the oxidative stability of oils because of their catalytic effect on the decomposition of hydroperoxide. Metals increase the rate of oil oxidation due to the reduction of activation energy of the initial step in the autooxidation process. Metals such as iron react directly with lipids to produce lipid alkyl radicals (Hosikian *et al*., 2011). The low iron content obtained for oil samples suggested that the iron content may not influence significantly their oxidation rate.

Similar to iron, copper is also a transition metal that increases the rate of oil oxidation in edible oil with a mechanism similar to that of iron and its presence increases oxidation rate (Choe and David, 2006) but 50 times faster than ferrous iron (Fe^{2+}) (Asuquo *et al.,* 2012). From the results obtained in this study, the presence of copper was not detected in the studied oil samples and as such, would not be considered as a contributory factor to the oxidation rate of the oil samples.

The vitamin E obtained in this study showed significant differences among the oil samples with values ranging from 18.25 mg/100g to 208.50 mg/100g. The African pear pulp oil samples had higher tocopherol content (40.50-208.50 mg/100g) than the reference standard (SOYBEAN) (18.25 mg/100g). SOXHLET had the highest value of vitamin E (208.50 mg/100g), followed by SCREW (201.00 mg/100g). The low value obtained for SOYBEAN could be attributed to the refining process it was subjected to. The higher vitamin E content in the African pear pulp oil samples might impact better oxidative stability since vitamin E (tocopherol) has been reported to increases the oxidative stability of edible oils (Asuquo *et al.,* 2012).

Initial quality of the oil samples (week 0)
The initial quality of the oil samples prior to storage at room temperature, away from sunlight was presented in Table III.

Peroxide value is a measure of the extent to which oxidation has progressed during storage. It also provides information on the freshness of edible oils (Atinafu and Bedemo, 2011).

Table III: Oxidative stability of the oil samples at week 0 (initial quality), week 1 (at the first week of storage) and week 4 (end of storage) respectively.

Samples	Peroxide value (meq O_2/kg)	Free fatty acid (%)	Density (g/cm³)	Viscosity (RVU)	Thiobarbituric acid (mg/g)
Week 0 (initial quality)					
SOXHLET	2.69[a]±0.01	5.12[b]±0.01	0.89[d]±0.01	17.17[d]±0.01	0.77[c]±0.01
SCREW	1.81[b]±0.01	7.04[a]±0.01	0.91[a]±0.01	17.35[c]±0.01	1.08[b]±0.01
TRADITIONAL	0.94[c]±0.01	2.12[c]±0.01	0.90[b]±0.01	18.21[b]±0.01	1.11[a]±0.01
SOYBEAN	0.13[d]±0.01	0.36[d]±0.01	0.90[c]±0.01	51.75[a]±0.07	0.02[d]±0.00
Week 1					
SOXHLET	2.97[a]±0.01	7.07[b]±0.01	0.90[c]±0.00	18.06[d]±0.01	0.81[c]±0.01
SCREW	1.93[b]±0.01	7.64[a]±0.01	0.93[a]±0.00	18.67[c]±0.01	1.10[b]±0.01
TRADITIONAL	1.04[c]±0.01	3.34[d]±0.01	0.92[b]±0.00	18.90[b]±0.01	1.15[a]±0.01
SOYBEAN	0.15[d]±0.01	0.38[c]±0.01	0.90[d]±0.00	52.30[a]±0.14	0.02[d]±0.00
Week 4					
SOXHLET	3.62[a]±0.02	11.47[a]±0.37	0.92[c]±0.01	20.53[b]±0.01	1.03[b]±0.01
SCREW	1.36[b]±0.01	9.04[b]±0.01	0.98[a]±0.01	20.31[b]±0.01	1.31[a]±0.02
TRADITIONAL	1.38[b]±0.01	6.64[c]±0.01	0.96[b]±0.01	20.41[b]±0.01	1.28[a]±0.01
SOYBEAN	0.92[c]±0.02	0.39[d]±0.01	0.91[d]±0.01	55.05[a]±0.35	0.09[c]±0.00

a–d: Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different ($p < 0.05$)

The higher the peroxide value, the lower the quality of the edible oil sample. However, in some instances, low peroxide value is an indication of advanced rate of oxidation due to condensation of hydrogenproxides to form secondary oxidation product, resulting to their reduced quantity in the oil (Atinafu and Bedemo, 2011). The peroxide value of the oil samples at week 0 ranged from 0.13 to 2.69 meq O_2/kg with SOXHLET having the highest value while the reference standchard (SOYBEAN) had the lowest value. The low peroxide value in TRADITIONAL and SCREW may be attributed to the formation of secondary oxidation products. There were significant differences ($p<0.05$) in the peroxide values of African pear pulp oil samples which suggested that, the different extraction methods had effect on their freshness. According to the CODEX Alimentarius standard for vegetable oil, the maximum allowable limit for peroxide value of crude and refined vegetable oils is 10 meq O_2/kg fat (CODEX, 2011). It could therefore, be inferred that the oil samples are still fresh at week 0 since all oil samples are below this limit.

The free fatty acid (FFA) value of edible oils is an important qualitative parameter. High amount of FFA in edible oils is undesirable since its presence increases the diffusion rate of oxygen, which in-turn, increased the rate of oxidation. Free fatty acid of the oil samples at week 0 ranged from 0.36 to 7.04% with significant differences existing among the oil samples. The FFA values obtained in this study exceeded the value (0.05 to 0.50%) recommended by the Codex Alimentarius Commission (CODEX, 2011) except the reference standard (SOYBEAN), which suggested that the oil samples may undergo faster oxidation when exposed to undesirable storage conditions. More so, the high FFA present in African pear pulp oil samples may be as a result of cell degradation during size reduction (Atinafu and Bedemo, 2011) and therefore suggested the need for refining process since the initial quality with respect to FFA is poor.

Density is an important factor which influences oil absorption as it affects the drainage rate after frying and also the mass transfer rate during the cooling stage of frying. The higher the oil density, the slower the mass transfer rate of the oil during frying (Mengistie *et al*., 2018). The density of the oil samples at week 0 ranged from 0.89 to 0.91 g/cm^3, with significant differences (P<0.05) existing among the oil samples. SCREW had the highest value (0.91 g/cm^3), followed by TRADITIONAL (0.90 g/cm^3) and SOYBEAN (0.90 g/cm^3) while SOXHLET (0.89 g/cm^3) had the lowest value. The results indicated that processing had significant effect in the density of the oil samples. Edible oils with higher density, has slower mass transfer rate which makes them unsuitable for frying operations. The results of the African pear pulp oil are within the values for edible oils and compares favorably with the reference standard which suggest that the oil samples may be suitable for frying operations (Dian *et al*., 2017).

Viscosity is one of the main factors which governs oil absorption and drainage. It is a measure of the oil's resistance to shear. Viscosity is affected by the degree of unsaturation and chain length of fatty acids. A longer carbon chain and a decreasing degree of unsaturation results in an increase in viscosity (Hoekman *et al.,* 2012; Pandurangan *et al*., 2012). The higher the oil viscosity, the slower is the oil drainage after frying. The viscosity of the oil samples at week 0 ranged from 17.17 to 51.75 RVU, which suggested that, the different methods employed in extracting the different oil samples had an influence. The viscosities of the African pear pulp oils were significantly lower than the value obtained for SOYBEAN. SOYBEAN had the highest viscosity (51.75 RVU) while SOXHLET had the lowest value (17.17 RVU). Higher value of viscosity in SOYBEAN implied that it may contain substantial amount of saturated fatty acids (Musa *et al*., 2012). Thus, the values obtained suggested that, the extracted oil samples might have better absorption and drainability than the reference sample.

Thiobarbituric acid (TBA) is the most widely used method for the measurement of secondary oxidation products. The results obtained revealed that there were significant differences ($p>0.05$) among the oil samples. The obtained values ranged from 0.02 mg/g in SOYBEAN to 1.11 mg/g in TRADITIONAL, revealing higher thiobarbituric acid value in the extracted oils than SOYBEAN (0.02 mg/g). Notably, SOXHLET had the lowest TBA value (0.77 mg/g) compared to other African pear oils which suggested slower rate of deterioration and as well, may substantiate the reason why SCREW and TRADITIONAL had lower peroxide value. The higher TBA levels in the African pear oil samples may be due to the presence of higher concentration of malondialdehyde, a secondary oxidation product.

Oxidative stability of the oil samples at the first week of storage (week 1)
The oxidative stability of the oil samples at the first week of storage was presented in Table III. Peroxide value (PV) of the oil samples at week 1 ranged from 0.15 to 2.97 meq O_2/kg which was higher than the values obtained when the initial quality of the oils were accessed at week 0 (0.13-2.69 meq O_2/kg), which indicated the possible progress of primary oxidation. SOXHLET had the highest PV (2.97 meq O_2/kg) while SOYBEAN had the lowest peroxide value (0.15 meq O_2/kg). Higher peroxide value in SOXHLET implied the presence of higher amount of hydrogen peroxides. However, the PV of the oil samples at the beginning of storage are below the CODEX recommended limit (10 meq O_2/kg fat) (CODEX, 2011) for edible oils, hence, the oils samples are still fresh.

The free fatty acid (FFA) value of edible oils is an important qualitative parameter. Since fats and oil contain some level of FFA, there will always be an increase in acidity with time during transport and storage (Gupta., 2002). Free fatty acid of the oil samples at the first week of storage ranged from 0.38 to 7.64%

which was higher than the value obtained when accessing the initial quality (week 0) of the oil samples (0.36 to 7.04%). The increased FFA signified an increase activity of lipases coming from the source (Atinafu and Bedemo, 2011), which also suggested the increased occurrence of lipid oxidation.

The density of the oil samples at week1 ranged from 0.90 to 0.93 g/cm^3, with significant differences (p<0.05) existing among the oil samples. SCREW had the highest value of density (0.93 g/cm^3), followed by TRADITIONAL (0.92 g/cm^3) while the lowest value was obtained in SOYBEAN and SOXHLET (0.90 g/cm^3). Notably, the density of the oil samples at week 1 significantly differ from the values obtained at week 0 (0.89-0.91 g/cm^3), which indicated changes in the chemical composition of the oil samples due to possible occurrence of oxidation.

Viscosity of oil has a direct relationship with degree of unsaturation and chain length of the fatty acids in lipids. Its value increases with increasing degree of saturation (Almeida *et al*., 2019). Viscosity of the oil samples at week 1 ranged from 18.06 to 52.30 RVU. Similar to density, the viscosity values obtained at week 1 were higher than the values obtained at week 0, which again, could possibly be attributed to the fact that the oil samples are undergoing changes due TO oxidation. Consequently, leading to increasing level of saturation. SOXHLET had the lowest value of viscosity (18.06 RVU) while SOYBEAN had the highest value of viscosity. This implied that SOYBEAN may contained substantial amount of saturated fatty acids compared to the extracted oil samples (Musa *et al*., 2012).

The results of thiobarbituric acid ranged from 0.02 mg/g in SOYBEAN to 1.15 mg/g in TRADITIONAL. The extracted *D. edulis* pulp oils had higher thiobarbituric acid value compared to SOYBEAN (0.02 mg/g). These results showed significant increase from the values obtained at week 0 (0.02-1.11 mg/g). The higher TBA levels in the *D. edulis* oil samples might be attributed to the presence of higher concentration of malondialdehyde, a secondary oxidation product.

Oxidative stability of the oil samples at the end of storage (week 4)

The oxidative stability of the oil samples at the end of storage (week 4) was presented in Table III. The Peroxide value of the oil samples at the end of storage ranged from 0.92 to 3.62 meq O_2/kg. The values obtained showed consistent increase from the value obtained at the beginning of storage but were below the CODEX maximum limit (10 meq O_2/kg) for edible oils. The results indicated increasing formation of primary oxidation products, however, the results implied that the quality of the oils samples with respect to peroxide value can still be considered to be fresh and acceptable after four (4) weeks of storage.

The suitability of a vegetable oil for any direct consumption or industrial application depends on its FFA value (Al-Bachir, 2015). FFA of the oil samples at the end of storage ranged from 0.39 to 11.47%, with significant differences ($p<0.05$) existing among the oil samples. The obtained results showed that the FFA increased steadily and would therefore, increase the rate of oxidation in the oil samples. Furthermore, the FFA values of African pear oil samples at the end of storage exceeded the value (0.05 to 0.5%) recommended by the Codex Alimentarius Commission (CODEX, 2011). However, the reference standard (SOYBEAN) had an FFA value that is within the CODEX recommendation. The results suggested that African pear oil samples may not be suitable for direct consumption and may have to undergo the process of refining.

The density of the oil samples at the end of storage ranged from 0.81 to 0.98 g/cm^3. There was significant increase ($p<0.05$) at the end of storage compared to the value obtained at the beginning of storage which might be an indication of the occurrence of oxidation. The values obtained for SOXHLET (0.92 g/cm^3) and SOYBEAN (0.91 g/cm^3) were within the recommended value stipulated by FAO/WHO (0.919-0.925 g/cm^3) for oils suitable for frying and cooking operations (CODEX, 2011) for density, while SCREW (0.98 g/cm^3) and TRADITIONAL (0.96 g/cm^3) had

exceeding values after four (4) weeks of storage. It can therefore be implied that, among the extracted oil samples, SOXHLET may still possess properties suitable for domestic and industrial applications after for weeks of storage at room temperature (Dian *et al*., 2017).

Viscosity of the oil samples at the end of storage ranged from 20.31 to 55.05 RVU. Notably, the results for viscosity increased steadily from week 0 to week 4 in all the samples with no significant differences existing among the extracted oil samples (SOXHLET, SCREW and TRADITIONAL) after the storage period. The increased viscosity might be attributed to the impact of deterioration caused by oxidative processes.

Thiobarbituric acid number of the oil samples at the end of storage ranged from 0.09 to 1.31 mg/g. There were no significant differences ($p > 0.05$) between SCREW and TRADITIONAL. The steady increase in the results after four weeks of storage may be attributed to the increase in the formation of secondary oxidation products as a result of condensation of primary oxidation products. Notably, among the extracted oil samples, SOXHLET had the lowest thiobarbituric acid value compared to SCREW and TRADITIONAL which suggested better stability and freshness of sample at the end of storage. The higher thiobarbituric acid value of SCREW and TRADITIONAL could be attributed to the increase condensation of primary oxidation products, which might be the reason SCREW and TRADITIONAL had lower peroxide value at the end of storage (Atinafu and Bedemo, 2011).

Conclusion
The effect of different extraction methods on the micro-components composition and oxidative stability of African pear pulp oil was investigated in this study. From the results of micro-component analysis, SOXHLET had better micro-component content. During the four weeks' oxidative stability period, the studied parameters was found to increase steadily with SOXHLET having a better oxidative stability at the end of the storage period. However, the

peroxide value and TBA value did not exceed the CODEX maximum limit at the end of storage across all samples, while the FFA exceeded the CODEX maximum limit. The presence of significant amount chlorophyII as well as poor initial quality in terms of FFA suggest the necessity of refining. Within the period of study, it was established that the freshness of African pear pulp oil did not deteriorate under the studied condition.

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