LIPID COMPOSITIONS OF THREE POTENTIALLY VALUABLE VEGETABLES USED AS HUMAN AND ANIMAL FOODS

Jonathan Adeolu Adesina*[1] and, Abdul Ademola Olaleye [2]

[1*]Chemistry Department, Ekiti State University, Ado-Ekiti. PMB 5363, Ado-Ekiti, Ekiti State, Nigeria
[2]Chemistry Department, Federal University Dutse, Jigawa State, Nigeria

(Received on Date: 24th February 2017 Date of Acceptance: 4th March 2017)

ABSTRACT

The levels of fatty acids, phospholipids and sterols were determined in three vegetables: *Cucurbita maxima, Solanum macrocarpon L.* and *Amaranthus viridis* L locally consumed in South Western Nigeria using standard analytical methods. Results showed crude fat varied from 3.40 – 4.65 g/100 g; SFA from 22.9 – 31.3 % of total fatty acids, total monounsaturated fatty acids (MUFA) varied from 1.15 – 5.86 %, PUFA range was 62.7 – 76.0 %, MUFA/SFA ranged from 0.050 – 0.187, essential PUFA status index (EPSI) ranged from 10.7 – 65.9 and PUFA/SFA ranged from 2.0 – 3.32 .The three vegetables had low levels of *n*-3 fatty acids but high in *n*-6 fatty acids, the ratios (*n*-6/*n*-3) ranged from 1.49 – 1.82. In the phospholipids, lecithin was highest the three vegetables with values ranging from 725 - 794 mg/100 g. Among the sterols, sitosterol was highest in all the vegetables with values which varied from 206 - 220 mg/100 g. Chi-square (χ^2) was significantly and positively high at $r_{=0.05}$ for the values recorded for EPSI, energy due to fat, phophatidylethanolamine, Phosphatidylserine and 5-Avenasterol content of the three vegetables. The samples would serve as good sources of palmitic, linoleic, alpha linolenic acids, lecithin and sitosterol in human and animal nutrition.

Keywords: Vegetables, fatty acid, phospholipids, sterols composition

No: of Tables: 5 **No:of References**: 32

INTRODUCTION

In recent years researchers have intensified the search for lesser known crops in the wild, many of which are potentially valuable as human and animal's foods to maintain balance between population growth and agricultural productivity, particularly in the tropical and sub-tropical areas of the world (Barminas *et al.,* 1998). Green leafy vegetables constitute an indispensable constituent of the human diet in Africa generally and West Africa in particular. It has been estimated that over 60 species of green leafy vegetables are consumed in Nigeria alone. In Nigeria and other developing countries, as a result of food shortage and high cost of cultivated green leafy vegetables, wild and semi-wild food resources are frequently consumed as the dominant source of leafy vegetables especially in the rural communities (Kubmarawa *et al.,* 2008).

Pumpkins, including *Cucurbita moschata*, *C. pepo*, and *C. maxima* are gourd squashes of the genus *Cucurbita* and the family Cucurbitaceae. *Cucurbita moschata* seeds have been used as an anthelmintic (Okada, 2002), and *Cucurbita pepo* seeds as an anthelmintic and a diuretic (Andrew, 2000). *Cucurbita maxima* (English name: squash, pumpkin, Japanese name: kabocha) is indigenous to the plateaus of central and south America, but is cultivated throughout the World. Its fruits, flowers, and seeds have been eaten as vegetables containing vitamins A, C, and E.

Solanum, a widespread plant genus of the family Solanaceae, has over 1000 species worldwide with at least 100 indigenous species in Africa and adjacent islands; these include a number of valuable crop plants and some poisonous ones (Jaeger and Hepper, 1986). It is represented in Nigeria by some 25 species including those domesticated with their leaves, fruits or both eaten as vegetables or used in traditional medicine (Gbile, 1987; Gbile and Adesina, 1988). Among them are two African eggplants, *S. aethiopicum L.* (Ethiopian eggplant) and *S. macrocarpon L.* (Gboma eggplant), which are widely cultivated in Nigeria and across the African continent. African eggplants, also called garden eggs (Hausa: Dauta; Igbo: afufa or añara; Yoruba: igbagba), are highly valued constituents of the Nigerian foods and indigenous medicines; they are commonly consumed almost on daily basis by both rural and urban families. The eggplants form part of the traditional sub-Saharan African culture. The fruits, said to represent blessings and fruitfulness, are offered as a token of goodwill during visits, marriages and other social events. They are eaten raw and also when boiled or fried as ingredient of stews, soups and vegetable sauces. Wide variations exist within the vegetative and fruit characters both within and between the African eggplant species including variations in characters like diameter of corolla, petiole length, leaf blade width, plant branching,

fruit shape, and fruit colour (Osei *et al.,* 2010).

Amaranthus viridis L. (Family Amaranthaceae) is distributed in the warmer parts of the world .In addition the whole plant possesses analgesic and anti-pyretic properties and is used for the treatment of pain and fever respectively in traditional systems of medicine (Eluwa, 1977). *A. viridis* is possibly of Asian origin but now a cosmopolitan weed in the tropical and subtropical regions of the world, also ubiquitous faraway to temperate regions (e.g. in Europe, North America, Asia and Australia). In equatorial Africa it is also a profound and common weed. It is occasionally cultivated (e.g. in Nigeria, Gabon and DR Congo) (Brenan, 1981). *A. viridis* Linn. Is Erect or ascending annual or short-lived perennial herb up to 1 m tall; glabrous, angular, bear branches, stem slender to sparsely pubescent in upper part with multicellular hairs. *A. viridis* contains several compounds like amino acids lysine, arginine, histidine, cystine, phenylalanine, leucine, isoleucine, valine, threonine, methionine, tyrosine etc. In search of new activities chemical entities, pytochemical screening of the extract from leaves of *A. vilidis* L. indicates the prese nce of biologically active constituent: saponins, tannins and phenols, flavonoids, alkaloids, cardiac glycoside, steroid and triterpenoids. *A. vilidis* L have some chemical constituent that exhibits potent anti-inflammatory, antihepatotoxic, antiulcer antiallergic, antiviral actions (Md Reyad-ul-Ferdos *et al.,* 2015).

The above-listed non- conventional leafy vegetables play important roles in everyday cooking, especially in the rural areas. The purpose of this study therefore is to evaluate the levels of lipid composition (fatty acids, phospholipids and phytosterols) in the selected vegetables: *Cucurbita maxima, Solanum macrocarpon L.* and *Amaranthus viridis* L. The essence of their selection was because they are generally consumed in this part of the country and are gradually becoming popular as edible vegetables in most homes. The report would provide necessary information on the lipid compositions of the three vegetable species and basis for their wider utilization.

MATERIALS AND METHODS

Collection and treatment of samples

The vegetable samples (*Amaranthus viridis* L (PK), *Amaranthus viridis* L (AV) and *Solanum macrocarpon* (GB)] were collected from Ado-Ekiti central market (Oja-Oba), Ekiti State, Nigeria. The tender leaves were carefully plucked and air-dried, after which the dried leaves were ground into fine powder using pestle and mortar and stored in screw capped plastic containers prior to analysis.

Extraction of Lipid

Each sample (0.25g) was weighed into the extraction thimble. A volume of 200 mL of petroleum ether (40-60°C boiling range) was measured and added to the dried 250 mL capacity flask. The covered porous

thimble with the sample was placed in the condenser of the Soxhlet extractor arrangement that has been assembled[12]. The lipid was extracted for 5 h. The extraction flask was removed from the heating mantle arrangement when it was almost free of petroleum ether. The extraction flask with the crude oil was oven dried at 105°C for the period of 1h. The flask containing the dried oil was cooled in the desicator and the weight of the cooled flask with the dried oil was taken.

Preparation of Methyl Esters and Analysis

The extracted fat (50 mg) was saponified for 5 min at 95°C with 34 mL of 0.5 M KOH in dry methanol the mixture was neutralized by 0.7 M HCl. A volume of 3 mL of 14 % boron trifluoride (BF_3) in methanol (14% v/v; Supelco Inc Bellefonte PA USA) was added[13]. The mixture was heated for 5 min at 90°C to achieve complete methylation process. All the fatty acid methyl esters (FAME) were extracted into redistilled n-hexane (2 x 3 mL). The content was concentrated to 1 mL for analysis and 1µL was injected into the injection pot of the GC The FAME were analysed using a gas chromatograph (GC; HP 5890 Series II auto sampler 7673 powered with HP 3365 ChemStation; Hewlett-Packard Co Avondale PA USA) fitted with a flame ionization detector. Nitrogen was used as the carrier gas. The oven programme was: initial temperature at 60°C first ramping at 10°C/min for 20 min maintained for 10 min The injection temperature was 250°C whilst the detector temperature was 320°C A polar (HP INNOWAX) capillary column (30 m, 0.25 mm i.d., 0.25 µm film thickness) (Supelco Inc Bellefonte PA USA) was used to separate the esters Split injection was used having a split ratio of 20:1. The peaks were identified by comparison of their retention times with authentic standards of FAME.

Sterol analysis

The sterol analysis was as described by AOAC (2005). Known weights of the aliquots of the extracted fat were added to the screw-capped test tubes. Each sample was saponified at 95°C for 30 min, using 3 mL of 10% KOH in ethanol, to which 0.20 mL of benzene had been added to ensure miscibility. Deionised water (3 mL) was added and 2 mL of hexane was used in extracting the non-saponifiable materials. Three extractions, each with 2 mL of hexane, were carried out for 1h, 30 min and 30 min respectively, to achieve complete extraction of the sterols. The hexane was concentrated to 1 mL in the vial for gas chromatographic analysis and 1 µL was injected into the injection pot of GC. The peaks were identified by comparison with standard sterols. The sterols were analyzed using similar conditions as for fatty acid methyl ester analyses.

Phospholipid Analysis

Modified method of Raheja., *et al*. (1973) was employed in the analysis of phospholipids. A weight of 0.01g of the extracted fat was added to each test tube. To ensure complete dryness of the oil

for phospholipids analysis, the solvent was completely removed by passing a stream of nitrogen gas on the oil. A volume of 0.40 mL of chloroform was added to the tube followed by the addition of 0.10 mL of chromogenic solution. The tube was heated at 100°C in water bath for about 1 min and 20 sec. The content was allowed to cool to the laboratory temperature and 5 mL of hexane was added and the tube shaken gently several times. The solvent and the aqueous layers were allowed to separate. The hexane layer was recovered and concentrated to 1.0 mL for analysis. The phospholipids were analysed using an HP 5890 powered with HP gas chromatograph (HP 5890 powered with HP ChemStation rev. AO9.01 [1206] software [GMI, Inc, Minnesota, USA]) fitted with a pulse flame photometric detector. Nitrogen was used as the carrier gas with a flow rate of 20-60 mL/min. The oven programme was: initial temperature at 50°C, first ramping at 10°C/min for 20 min, maintained for 4 min, second ramping at 15°C/min for 4 min and maintained for 5 min. The injection temperature was 250°C whilst the detector temperature was 320°C. A polar (HP5) capillary column (30 m, 0.25 mm i.d., 0.25 µm film thickness) was used to separate the phospholipids. Split injection type was used having a split ratio of 20:1. The peaks were identified by comparison with standard phospholipids.

Quality Assurance

Standard chromatograms were prepared for phytosterols, phospholipids and fatty acid methyl esters which were then compared with respective analytical results; calibration curves were prepared for the standard mixtures and correlation coefficient was determined for each fatty acid, phytosterol and phospholipid. Correlation coefficient ≥ 0.95 was considered acceptable.

Calculation of Fatty Acid as Food per 100 g in Sample

At the data source and reference database levels, values for individual fatty acids are usually expressed as percentages of total fatty acids. At the user database level, values per 100g of food are required. A conversion factor derived from the proportion of the total lipid present as fatty acids is required for converting the percentages of total fatty acids to fatty acids per 100 g of food. Total lipid level (crude fat) was multiplied by conversion factor of 0.8. For fatty acids, precision is best limited to 0.1g/100g of fatty acids (Greenfiel and Southgate, 2003).

Statistical analysis

Statistical analysis was carried out to determine the mean, standard deviation, coefficient of variation in per cent (Oloyo, 2001). Also calculated was the chi-square (χ^2). The χ^2 values were subjected to the Table (critical) value at a = 0.05 to see if significant differences existed in the values of fatty acids, phytosterols and phospholipids between the vegetable samples.

RESULTS AND DISCUSSION

Table 1 depicts the total lipid and the calculated total fatty acid levels as food of the vegetable samples on dry weight basis. The values of the total lipid between the samples were very close with the coefficient of variation percent of 16.8. The total lipid found in the three vegetables were close to the values reported for most parts of male and female common West African fresh water crab *Sudananautes africanus africanus* with values of 1.69-8.88 g/100 g (dry weight basis) (Adeyeye. 2002), higher than the value reported for the testa of Bambara groundnut (*Vigna substerranea* L), flour (2.84 g/100g) (Adeyeye *et al.,* 2015) and fermented lima bean (1.8 – 3.9 g/100g) (Adegbehingbe, 2013) but comparably lower than levels reported for raw and roasted *Terminalia catappa* seeds kernel (45.2 – 46.1 g/100g) (Adesina, 2013) and fermented and unfermented *Parkia biglobosa* seeds (16.9 – 19.5 g/100g) (Adeyeye, 2013). The energy density in the *Cucurbita maxima* (due to fat) was 141 kJ/100 g whilst it was 140 kJ/100 g from the *Amaranthus viridis* and 103 kJ/100 g from *Solanum macrocapon*. The statistical analysis (Chi- square) at $r_{= 0.05}$ and critical values of χ^2 showed that significant difference only existed between the values recorded for energy values in the three vegetable samples. This was probably due to the comparatively low energy value recorded in the *Solanum macrocapon* sample whereas the values in the other two samples were higher and almost equally distributed.

Table 2 shows the saturated fats (SFA) and the monounsaturated fats (MUFA) of the samples. The following members were found in traces: C20:0; C22:0; C24:0; C14:1*n*-9, *cis*; C20:1*n*-11, cis; C24:1*n*-15, *cis* and C18:1n-11, *trans*. SFAs from the three samples were with coefficient of variation (CV %) of 16.2. C16:0 was the most concentrated fatty acid in the three samples with values ranging between 17.5 – 24.3 % whilst C18:0 level was the second most concentrated in the three samples. SFA with C12:0, C14:0 and C16:0 are the primary contributors to elevated blood cholesterol, and so contribute to cardiovascular diseases; C14:0 is the major culprit. SFA with 12, 14, or 16 carbons generally constitute about 25 % - 50 % of the total fat in animal foods. C18:0 is also thought to increase the risk of cardiovascular disease. The negative effect on the heart is probably due in part to an increase in blood clotting that might be caused by the SFA (Wardlaw, 2003). However, C18:0 may not be as hypercholesterolemic as the other SFA (apparently because it is converted to oleic acid). This is done by the desaturation of stearic acid by stearoyl-CoA desaturase-1 which produces oleic acid. Fish are able to synthesise, *de novo* from acetate, the even chain SFA. Radio tracer studies have shown that fish can convert C16:0 to monoene. Unlike in SFA, C18:1n-6, *cis* was the most concentrated fatty acid in the group of monounsaturated fatty acid (MUFA) for the *Cucurbita maxima* (2.70 %), 2.18 % for *Amaranthus viridis* and C18:1n-9, *cis* for *Solanum macrocapon* (0.803 %). In

the *trans* MUFA group, C18:1n-6, *trans* was the most concentrated in the three samples; all *trans* MUFA value was 0.0186 % in *Cucurbita maxima,* 0.0469 % in *Amaranthus viridis* and 0.0099 % in *Solanum macrocapon* but the total MUFA (*cis* + *trans*) was 5.86 % in *Cucurbita maxima*. 4.33 % in *Amaranthus viridis* and 1.15 % in *Solanum macrocapon* with CV % of 63.5 % showing the unequal distribution of the fatty acids. The natural *trans* fatty acids in butter are said not to be harmful and may even have health-promoting properties, such as preventing certain forms of cancer. Most results on the fatty acid composition are favourably comparable to the results obtained by Yusuf *et al*. (1993) who worked on fatty acid composition of the body oils of 12 marine fish species of the Bay of Bengal and two other freshwater fishes for comparison and of some vegetables consumed in South Western Nigeria (Adeyeye *et al.,* 2016).

Table 2 also shows the polyunsaturated fatty acids (PUFA) composition of *n*-6 and *n*-3 in skin and muscle. Among the *n*-6 family, C18:3*n*-6, cis was the most concentrated with a values ranging from 24.2 to 32.0 % followed by C18:2 *n*-6, *cis* with values ranging between 9.38 and 16.5 % in the three samples. Whilst total PUFA *n*-6, *cis* was 40.5 % in the *Cucurbita maxima* and 41.9 % in *Amaranthus viridis,* it was 46.5 % in the *Solanum macrocarpon* sample. C18:2n-6, *trans* had a value of 0.02 % in *Cucurbita maxima*, 0.051 % in *Amaranthus viridis* and 0.011 % in the *Solanum macrocarpon* sample. C18:2n-6, *trans* is known as conjugated linoleic acid (CLA) which occurs naturally. The bacteria that live in the rumens of some animals, for example, produce trans fatty acids that eventually appear in foods such as beef, milk and butter (Wardlaw and Smith, 2009). The only *n*-3 fatty acid that was of significant contribution was C18:3n-3 in the three samples: 22.2 % (*Cucurbita maxima*), 28.0 % (*Amaranthus viridis*) and 29.4 % in the *Solanum macrocarpon* sample; this brought the total PUFA (*cis* + *trans*) in *Cucurbita maxima* as 62.7 %, in *Amaranthus viridis* as 70.0 % and 76.0 % in the *Solanum macrocarpon* sample. These results showed that the eicosanoids in the samples were the major fatty acids. The relative values of PUFA in the three vegetable samples made them relevant in human nutrition. However, C18:3 *n*-6, *cis* constituted the highest levels of PUFA in the samples. The eicosanoids help to regulate blood clot formation, blood pressure, blood lipid (including cholesterol) concentrations, the immune response, the inflammation response to injury and infection and many other body functions (Whitney *et al.,* 1994). The three vegetable samples would be good sources of the PUFA (in combination).

Summary of the quality parameters from the fatty acids are presented in Table 3. The relative amounts of PUFA and SFA in oils is important in nutrition and health. The ratio of PUFA/SFA (P/S ratio) is therefore important in determining the detrimental effects of dietary fats. The higher the P/S ratio the more nutritionally useful is the oil.

This is because the severity of atherosclerosis is closely associated with the proportion of the total energy supplied by saturated fats and polyunsaturated fats (Adeyeye *et al.,* 1999). The present PUFA/SFA (P/S) in the samples are: *Cucurbita maxima,* 2.00; *Amaranthus viridis,* 2.75 and *Solanum macrocarpon*, 3.32, the values of P/S in the samples are good enough to ameliorate atherosclerotic tendency. The ratio of *n*-6/*n*-3 value in the samples ranged from 1.49 –1.82. The *n*-6 and *n*-3 fatty acids have critical roles in the membrane structure (Lynch and Thompson, 1984) and as precursors of eicosanoids, which are potent and highly reactive compounds. Since they compete for the same enzymes and have different biological roles, the balance between the n-6 and the *n*-3 fatty acids in the diet can be of considerable importance. The ratio of *n*-6 to *n*-3 in the diet should be between 5:1 and 10:1(Lynch and Thompson, 1984) or 4-10 g of *n*-6 fatty acids to 1.0 g of *n*-3 fatty acids. However, strictly speaking the C18 polyunsaturated fatty acids, linoleic acid [18:2(*n*-6)] and alpha linolenic acid [18:3(*n*-3)], are the main essential fatty acids in that they cannot be synthesised in animal tissues. The statistical analysis (Chi- square) at $r_{= 0.05}$ and critical values of χ^2 showed that significant difference only existed between the values recorded for the calculated essential PUFA Status index (EPSI) in the three vegetable samples, the reason could be as a result of the large concentration of PUFA in *Solanum macrocarpon* sample.

Table 4 shows the levels of the various phospholipids in skin and muscle of *A. macrolepidotus*. Among the phospholipids, cephalin (PE) was the second largest concentrated entity in muscle and in skin. PE is found in all living cells, although in human physiology it is found particularly in nervous tissue such as the white matter of brain, nerves, neural tissue and in spinal cord (Adeyeye, 2011). Phosphatidylserine (Ptd-L-Ser or PS) supplementation promotes a desirable hormonal balance for athletes and might attenuate the physiological deterioration that accompanies overtraining and/or overstretching (Starks *et al.,* 2008). In recent studies, PS has been shown to enhance mood in a cohort of young people during mental stress and to improve accuracy during tee-off by increasing the stress resistance of golfers. The US Food and Drug Administration (USFDA) had stated that consumption of PS may reduce the risk of dementia in the elderly and may also reduce the risk of cognitive dysfunction in the elderly (Starks *et al.,* 2008). The present results recorded the following (mg/100g): phosphatidylethanolamine (476 - 610), phosphatidylcholine (725 - 794), phosphatidylserine (210 - 335), lysophosphatidylcholine (0.731 – 0.737) and phosphatidylinositol (297 - 306) these values were comprarbly higher than the values reported for beef (69 mg/100 g) and pork (57 mg/100 g) particularly in the skin; but were much better than the value in European pilchard (sardine) of 16.0 mg/100 g. Phosphatidylcholine (lecithin) is usually the most abundant phospholipid in

animal and plants, often amounting to almost 50 % of the total, and as such it is the key building block of membrane bilayers. This observation is true for lecithin (phosphatidylcholine) values in *Cucurbita maxima* (794 mg/100 g or 41.5 %), it is also true in *Amaranthus viridis* (788 mg/100 g or 41.5 %) and in *Solanum macrocarpon* (725 mg/100g or 39.5 %). Lecithin is also the principal phospholipid circulating in plasma, where it is an integral component of the lipoproteins, especially the HDL. Large doses of lecithin may cause gastrointestinal upsets, sweating, salivation and loss of appetite. Phosphatidylinositol (PtdIns, PI) is a negatively charged phospholipid and a minor component in the cytosolic side of eukaryotic cell membranes. The inositol can be phosphorylated to form phosphatidylinositol phosphate (PIP), phosphatidylinositol bisphosphate (PIP2) and phosphatidylinositol trisphosphate (PIP3). PIP, PIP2, and PIP3 are collectively called phosphoinositides. Phosphoinositides play important roles in lipid signalling, cell signalling and membrane trafficking (Heinemann, 1991). PI was of averagely high concentration in the three vegetable samples (297 – 306 mg/100g with a CV % of 1.52). The only phospholipid with minor concentration in the samples was Lysophosphatidylcholine, the values being, 0.731 – 0.943 mg/100g. The statistical analysis (Chi- square) at $r_{= 0.05}$ and critical values of χ^2 showed that significant difference only existed between the values recorded for phosphatidylethanolamine and phosphatidylserine in the three vegetable samples.

The sterol levels are shown in Table 5. The values recorded for the cholesterol, cholestanol and ergosterol in the samples were all in traces (1.80 e-5 – 5.70 e-3 mg/100g). Sitosterol was of the highest concentration among all the sterols in the three samples (*Cucurbita maxima*, 220 mg/100 g or 55.0 %; *Amaranthus viridis*, 217 mg/100 g or 63.3 % and *Solanum macrocarpon,* 206 mg/100g or 61.1 %). Plant sterols interfere with the uptake of both dietary and biliary cholesterol from the intestinal tract in humans (Heinemann, 1991). The reason for this is not fully understood; however, plant sterols appear to decrease the solubility of cholesterol in the oil and micellar phases, thus displacing cholesterol from bile salt micelles and interfering with its absorption (Ikeda and Sugano, 1998). In humans, intestinal infusion of sitostanol was more efficient in reducing cholesterol absorption than infusion of sitosterol (-85% and -50%, respectively (Heinemann, 1991). In addition, Becker *et al.* (Becker, 1993) showed that 1.5 g/d of sitostanol increased fecal secretion of neutral and acid steroids more effectively (88 %) than did 6 g/d of sitosterol (45%). Stigmasterol is used as a precursor in the manufacture of synthetic progesterone, a valuable human hormone that plays an important physiological role in the regulatory and tissue rebuilding mechanisms related to estrogen effects, as well as acting as an intermediate in the biosynthesis of androgens, estrogens and corticoids. Research has indicated that

stigmasterol may be useful in prevention of certain cancers, including ovarian, prostate, breast and colon cancers (Adeyeye, 2011). Studies with laboratory animals fed stigmasterol found that both cholesterol and sitosterol absorption decreased 23 % and 30 % respectively over a 6 week period (Adeyeye, 2011). Stigmasterol is also known as Wulzen antistiffness factor. The levels of Stigmasterol in the present report were between 7.59 and 13.2 mg/100g. The statistical analysis (Chi- square) at $r_{= 0.05}$ and critical values of χ^2 showed that significant difference only existed between the values recorded for 5-Avenasterol and the total sterol content in the three vegetable samples.

Table 1 Crude fat, total fatty acid and total energy content of *Cucurbita maxima* leaf, *Amaranthus viridis*, *Solanum macrocarpon* samples consumed in South Western Nigeria

Parameters	PK	AV	GB	Mean	SD	CV%	χ^2	Critical value of χ^2	Remark
Crude Fat	4.65	4.60	3.40	4.22	0.708	16.8	0.238	5.991	NS
Total fatty acids (g/100g)	3.72	3.68	2.72	3.37	0.566	16.8	0.190	5.991	NS
Energy (kJ/100g)	141	140	103	128	21.5	16.8	7.22	5.991	S

PK=*Cucurbita maxima* leaf, AV= *Amaranthus viridis*, GB= *Solanum macrocarpon*, χ^2= Chi-square (critical value of χ^2 at $\alpha_{=0.05}$), NS= not significant (χ^2_{cal} < critical χ^2), S= significant (χ^2_{cal} > critical χ^2), SD= standard deviation, CV= coefficient of variation

Table 2 Fatty acid composition (%) of *Cucurbita maxima* leaf, *Amaranthus viridis*, *Solanum macrocarpon* samples consumed in South Western Nigeria

Fatty acids	PK	AV	GB	Mean	SD	CV%	X^2	Critical value of X^2	Remark
C12:0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.991	-
C14:0	2.80	1.96	2.34	2.37	0.421	17.8	0.150	5.991	NS
C16:0	24.3	19.9	17.5	20.6	3.45	16.8	1.157	5.991	NS
C18:0	4.10	3.31	3.02	3.48	0.559	16.1	0.180	5.991	NS
C20:0	0.0475	0.121	0.025	0.065	0.050	77.8	0.078	5.991	NS
C22:0	0.0438	0.111	0.0234	0.059	0.046	77.2	0.071	5.991	NS
C24:0	0.0054	0.014	0.0029	0.007	0.006	78.3	0.009	5.991	NS
Total SFA	31.3	25.4	22.9	26.5	4.30	16.2	1.40	5.991	NS
C14:1(cis-9)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.991	NS
C16:1(cis-9)	0.377	0.233	0.076	0.229	0.151	65.8	0.198	5.991	NS
C18:1(cis-6)	2.70	2.18	0.159	1.68	1.34	79.9	2.15	5.991	NS
C18:1(cis-9)	2.57	1.38	0.803	1.58	0.901	56.9	1.02	5.991	NS

C20:1 (cis-11)	0.180	0.456	0.096	0.244	0.188	77.2	0.291	5.991	NS
C22:1(cis-13)	0.0151	0.038	0.008	0.020	0.016	77.0	0.024	5.991	NS
TOTAL MUFA *cis*	5.84	4.29	1.14	3.76	2.39	63.7	3.05	5.991	NS
C18:1 (trans-6)	0.0171	0.043	0.0091	0.0231	0.0177	76.8	0.027	5.991	NS
C18:1 (trans-9)	0.0015	0.0039	0.00083	0.0021	0.0016	77.7	0.003	5.991	NS
C18:1 (trans-11)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.991	NS
TOTAL MUFA *trans*	0.0186	0.0469	0.00993	0.025	0.019	76.9	0.030	5.991	NS
MUFA Total	5.86	4.33	1.15	3.78	2.40	63.5	3.05	5.991	NS
C18:3 (cis-9,12, 15)	22.2	28.0	29.4	26.5	3.82	14.4	1.10	5.991	NS
C20:2 (cis-11,14)	0.0067	0.017	0.0036	0.009	0.007	77.1	0.011	5.991	NS
C20:3 (cis-11,14,17)	0.029	0.0737	0.0155	0.039	0.0305	77.3	0.047	5.991	NS
Total (n-3)	22.2	28.1	29.4	26.6	3.82	14.4	1.10	5.991	NS
C18:2 (cis-9,12)	15.9	9.38	16.5	13.9	3.95	28.4	2.24	5.991	NS
C18: 2 (trans-9,11)	0.020	0.0508	0.011	0.027	0.021	76.5	0.032	5.991	NS
C18:3 (cis-6,9,12)	24.2	32.0	30.0	28.7	4.05	14.1	1.14	5.991	NS
C20:3 (cis-8,11,14)	0.347	0.428	0.034	0.270	0.208	77.2	0.321	5.991	NS
C20:4 (cis-5,8,11,14)	0.041	0.0398	0.00	0.027	0.023	86.6	0.040	5.991	NS
C22:2 (cis-13,16)	0.0054	0.0137	0.0029	0.007	0.006	77.1	0.009	5.991	NS
Total (n-6)	40.5	41.9	46.5	43.0	3.16	7.35	0.464	5.991	NS
Total PUFA	62.7	70.0	76.0	69.6	6.62	9.51	1.26	5.991	NS

PK=*Cucurbita maxima* leaf, AV= *Amaranthus viridis*, GB= *Solanum macrocarpon*, χ^2= Chi-square (critical value of χ^2 at $\alpha_{=0.05}$), NS= not significant (χ^2_{cal} < critical χ^2), S= significant (χ^2_{cal} > critical χ^2), SD= standard deviation, CV= coefficient of variation

Table 3 Summary of the quality parameters of fatty acids of *Cucurbita maxima* leaf, *Amaranthus viridis*, *Solanum macrocarpon* samples consumed in South Western Nigeria

Parameter	PK	AV	GB	Mean	SD	CV%	X^2	Critical value of X^2	Remark
SFA	31.3	25.4	22.9	26.5	4.30	16.2	1.40	5.991	NS
MUFA *cis*	5.84	4.29	1.14	3.76	2.39	63.7	3.05	5.991	NS
MUFA *trans*	0.0186	0.0469	0.00993	0.025	0.019	76.9	0.030	5.991	NS
MUFA total	5.86	4.33	1.15	3.78	2.40	63.5	3.05	5.991	NS
Total *n*-3	22.2	28.1	29.4	26.6	3.82	14.4	1.10	5.991	NS
Total *n*-6	40.5	41.9	46.5	43.0	3.16	7.35	0.464	5.991	NS
Total PUFA	62.7	70.0	76.0	69.6	6.62	9.51	1.26	5.991	NS
MUFA/SFA	0.187	0.171	0.050	0.136	0.075	54.9	0.082	5.991	NS
PUFA/SFA	2.00	2.75	3.32	2.69	0.658	24.4	0.321	5.991	NS
n-6/*n*-3	1.82	1.49	1.58	1.632	0.171	10.4	0.036	5.991	NS

EPSI	10.7	16.2	65.9	30.9	30.4	98.4	59.9	5.991	S
LA/ALA	0.716	0.335	0.561	0.537	0.192	35.7	0.137	5.991	NS

EPSI= essential PUFA status index, SFA= saturated fatty acid, MUFA= monounsaturated fatty acid, LA= linoleic acid, ALA = alpha linolenic acid, PK=*Cucurbita maxima* leaf, AV= *Amaranthus viridis*, GB= *Solanum macrocarpon*, χ^2= Chi-square (critical value of χ^2 at $\alpha_{=0.05}$), NS= not significant (χ^2_{cal} < critical χ^2), S= significant (χ^2_{cal} > critical χ^2), SD= standard deviation, CV= coefficient of variation

Table 4 Phospholipids levels in *Cucurbita maxima* leaf, *Amaranthus viridis*, *Solanum macrocarpon* samples consumed in South Western Nigeria

Phospholipids	PK	AV	GB	Mean	SD	CV%	X^2	Critical value of X^2	Remark
Phosphatidylethanolamine	478	476	610	521	76.8	14.7	22.6	5.991	S
Phosphatidylcholine	794	788	725	769	38.2	4.97	3.80	5.991	NS
Phosphatidylserine	335	332	210	292	71.3	24.4	34.8	5.991	S
Lysophosphatidylcholine	0.737	0.731	0.943	0.804	0.121	15.0	0.036	5.991	NS
Phosphatidylinositol	306	303	297	302	4.58	1.52	0.139	5.991	NS
Total	1914	1900	1842	1885	38.0	2.02	1.53	5.991	NS

PK=*Cucurbita maxima* leaf, AV= *Amaranthus viridis*, GB= *Solanum macrocarpon*, χ^2= Chi-square (critical value of χ^2 at $\alpha_{=0.05}$), NS= not significant (χ^2_{cal} < critical χ^2), S= significant (χ^2_{cal} > critical χ^2), SD= standard deviation, CV= coefficient of variation

Table 5 Phytosterols levels in *Cucurbita maxima* leaf, *Amaranthus viridis*, *Solanum macrocarpon* samples consumed in South Western Nigeria

Phytosterol	PK	AV	GB	Mean	SD	CV%	X^2	Critical value of X^2	Remark
Cholesterol	4.5e-4	5.7 e-3	4.2 e-5	2.0 e-3	3.1 e-3	153	0.0096	5.991	NS
Cholestanol	2.7 e-4	3.2 e-4	1.8 e-5	2.0 e-4	1.6 e-4	79.8	0.0003	5.991	NS

Ergosterol	2.3 e-3	2.4 e-3	1.8 e-3	2.2 e-3	2.8 e-4	12.8	0.00007	5.991	NS
Campesterol	93.4	65.9	81.3	80.2	13.8	17.2	4.74	5.991	NS
Stigmasterol	13.2	9.35	7.59	10.0	2.87	28.6	1.64	5.991	NS
5- Avenasterol	73.5	50.3	42.2	55.3	16.2	29.4	9.54	5.991	S
Sitosterol	220	217	206	214	7.37	3.44	0.507	5.991	NS
Total	400	343	337	360	34.9	9.71	6.78	5.991	S

PK=*Cucurbita maxima* leaf, AV= *Amaranthus viridis*, GB= *Solanum macrocarpon*, χ^2= Chi-square (critical value of χ^2 at $\alpha_{=0.05}$), NS= not significant (χ^2_{cal} < critical χ^2), S= significant (χ^2_{cal} > critical χ^2), SD= standard deviation, CV= coefficient of variation

Conclusion: The findings of this study showed that the samples contained unequal distribution of all the parameters determined. The samples were high in *n*-6 fatty acids but low in *n*-3 fatty acids. The samples had unsaturated acids as the predominant fatty acids. Significant differences occurred in the energy due to fat, EPSI, phophatidylethanolamine, Phosphatidylserine and 5-Avenasterol content of the three vegetables. Quality assurances of the determinations were highly satisfactory. The samples would serve as good sources of palmitic, linoleic, alpha linolenic acids, lecithin and sitosterol in human and animal nutrition.

REFERENCES

Barminas, J.T., Charles, M and Emmanuel, D. (1998). Mineral composition of non-conventional leafy vegetables. *Plant Foods for Human Nutrition* 53: 29-36.

Kubmarawa, D., Andeyang, I.F and Magomya, H. (2008). Amino acid profile of two non-conventional leafy vegetable, *Sesamum* and *Balanites* aegyptiaca, *African ournal of Biotechnology* **7**(19): 3502-3504.

Okada, M, Ed. (2002). *Newly Revised Illustrated Medicinal Plants of World*; Hokuryukan Pablishing Co., Ltd.: Tokyo, Japan, p. 514.

Andrew, C. (2000). *The Encyclopedia of Medicinal Plants*; Seibundo Shinkosha Publishing Co., Ltd.: Tokyo, Japan, p. 194.

Jaeger, P.M.L and Hepper, F.N. (1986). A review of the genus *Solanum* in Africa, In: *Solanaceae: biology and systematics* (eds) W. G. D'Arcy (New York: Columbia University Press) pp 41–55.

Gbile, Z. O. (1987). Nigerian *Solanum* species, *Nigerian Field, 52***:** 19-26.

Gbile, Z.O and Adesina, S.K. (1988). Nigerian *Solanum* species of economic

importance, *Annals Missouri Bot. Garden,* 75: 862-865.

Osei, M.K., Banful1, B., Osei, C.K and Oluoch, M.O. (2010). Characterization of African eggplant for morphological characteristics *Journal of Agricultural Science Technology* 4(3): 33-37.

Eluwa, M.C. (1977). Studies on *G. rhomboidalis* (Boheman) (*coleoptera: Curculionidea)*, a pest of African spinach. *Journal of Natural History* 11: 417 – 424.

Brenan, J.P.M. (1981). The genus *Amaranthus* in southern Africa. *Journal of South African Botany*. 47:451–492.

Md-Reyad-ul-Ferdous, D.M., Shamim, S., Sharif, T and Mohsina, M. (2015). Present Biological Status of Potential Medicinal Plant of *Amaranthus viridis:* A Comprehensive Review. *American Journal of Clinical and Experimental Medicine* 3(5-1): 12-17

AOAC. (2005). Official Methods of Analysis, 18th ed. Association of Official Analytical Chemists. Washington DC, USA.

Raheja, R.K., Kaur, C., Singh and Bhatia, I.S. (1973). Colorimetric method for the quantitative estimation of phospholipids without digestion. *Journal of Lipid Research* 14: 695-697.

Greenfield, H and Southgate, D.A.T. (2003). Composition data production, management and use. Food and Agriculture Organization of the United Nations, Rome.

Oloyo, R.A. (2001). Fundamentals of research methodology for social and applied sciences. ROA Educational Press Ilaro Nigeria.

Adeyeye, E.I. (2002). Determination of the chemical composition of the nutritionally valuable parts of male and female West African fresh water crab *Sudananautes africanus africanus*. *International Journal of Food Science and Agriculture* 53:189-196.

Adeyeye, E.I., Olaleye, A.A and Adesina, A.J. (2015). Lipid composition of testa, dehulled seed and whole seed of Bambara groundnut (*Vigna subterranea* L. verdc). *Current Advances in Plant Sciences Research*. 2(1): 1 – 9.

Adegbehingbe, K.T. (2013). Microbiological and nutrient studies of fermented cooked lima bean (*Phaseolous lunatus*) seeds, *Global Journal of Biology Agriculture and Health Science* 2(2): 94-101.

Adesina, A.J. (2013). Effects of roasting on the Lipid Quality of Raw *Terminalia catappa* L (Tropical almond) Kernels. *Open journal of analytical chemistry research* (OJACR) 1(2): 26-36.

Adeyeye, E.I. (2013). The effect of fermentation on the dietary quality of lipids from African locust bean (*Parkia biglobosa*) seeds *Elixir Food Science* **58**: 14912-14922.

Wardlaw, G.M. (2003). Contemporary nutrition: issues and insights, 5th ed. Boston, McGraw-Hill, pp 143-186.

Yusuf Harun, K.M., Rumi, A.S., Quazi, R.R and Anwar, S.H. (1993). Fatty acids of 12 marine fish species of Bay of Bengal. *Journal of Food Composition and Analysis* 6(4): 346-353.

Adeyeye, E.I., Adesina, A.J and Olatunde, O.C. (2016). Lipid Composition of Three Types of Vegetables: *Corchorus olitorius, Telferia occidentalis* and *Amaranthus hybridus,* Consumed in Nigeria". *E Cronicon Nutrition* 3(2):567-581.

Wardlaw, G.M and Smith, A.M. (2009). Contemporary nutrition, 7th ed. McGraw-Hill Higher Education: New York, USA; pp. 161-201.

Whitney, E.N., Cataldo, C.B. and Rolfes, S.R.(1994). Understanding normal and clinical nutrition. New York, USA, West Publishing Company, pp 132-168, 880-909.

Adeyeye, E.I., Oshodi, A.A and Ipinmoroti, K.O. (1999). Fatty acid composition of six varieties of dehulled African yam bean (*Sphenostylis stenocarpa*) flour. *International Journal of Food Science and Nutrition* 50(5):357-365.

Lynch, D.V and Thompson, G.A. (1984). Re-tailored lipid molecular species: a tactical mechanism for modulating membrane properties. *Trends Biochemical Science* 9: 442-445.

Starks, M.A., Starks, S.L., Kingsley, M.. Purpura, M and Jager, R. (2008). The effects of phosphatidylserine on endocrine response to moderate intensity exercise *Journal of International Society Sports Nutrition* 5:11.

Adeyeye, E.I. (2011). Levels of fatty acids, phospholipids and sterols in the skin and muscle of tilapia (*Orechromis niloticus*) fish. *La Rivista Italiana Delle Sostanze Grasse*. LXXXVIII (Gennaio/Marzo): 46-55.

Heinemann, T. (1991). Mechanisms of action of plant sterols on inhibition of cholesterol absorption. Comparison of sitosterol and sitostanol". *European Journal of Clinical Pharmacology* 40(1suppl): S59-S63.

Ikeda, I and Sugano, M. (1998). Inhibition of cholesterol absorption by plant sterols for mass intervention". *Current Opinion in Lipidology* 9(6): 527-531.

Becker, M. (1993). Treatment of severe familiar hypercholesterolemia in childhood with sitosterol and sitostanol *Journal of Pediatrics* 122(2): 292-296.