RESEARCH ARTICLE

ISSN: 0331 - 670X

https://doi.org/10.51412/psnnjp.2023.24

The Nigerian Journal of PHARMACY

AS MEN OF HONOUR WE JOIN HANDS

THE OFFICIAL ORGAN OF THE PHARMACEUTICAL SOCIETY OF NIGERIA FOUNDED 1927

Fatty Acid Composition, Physicochemical and Antioxidant Characteristics of Indigenous Telfairia Occidentalis (Fluted Pumpkin) Seed Oil from Ogun State, Nigeria

Olufunmilayo Ebunoluwa Adejumo[1*], Opeyemi Oludare Adekoya[1]

[1]Department of Pharmaceutical and Medicinal Chemistry, Faculty of Pharmacy, Olabisi Onabanjo University, Sagamu, Ogun State, Nigeria.

ARTICLE INFO

Article history:

Received 26 May 2023
Revised 27 June 2023
Accepted 29 June 2023
Online Published 30 September 2023

Keywords:

alpha-tocopherol,
fatty acids,
physicochemical parameters,
phytonutrients,
HPLC, *T*
elfairia occidentalis seed oil.

* *Corresponding Author:*
Email: funmijumo85@gmail.com
+234 8132512825
https://orcid.org/0000-0003-4487-3957
https://orcid.org/0000-0003-1923-9962

ABSTRACT

Background: Seed oils are a rich source of phytochemicals and can be another source of edible vegetable oil with commercial prospects. This study aimed to determine the physicochemical, and antioxidant properties in addition to the fatty acid composition of *Telfairia occidentalis* seed oil.

Methods: The physicochemical parameters, classes of screened phytochemicals, alpha-tocopherol concentration, and fatty acid composition of *Telfairia occidentalis* seed oil extracted from the seeds using the soaking method and Soxhlet extraction with n-hexane, were analysed. Alpha-tocopherol content and fatty acid analyses were determined by ICH-validated HPLC and GC-MS methods, respectively.

Results: The oil had percentage yields of 17% and 27.3% for the soaking and Soxhlet methods. The refractive index was 1.469 ± 0.01, relative density (0.891 ± 0.01 g/mL), viscosity (55.60 ± 0.06 MPa. s), acid value (2.184 ± 0.02 mg KOH g^{-1}), saponification value (179.52 ± 0.16 mgKOH/g), iodine value (7.14 ± 0.03 gI_2/100g) and ester value (177.33 ± 0.11 mgKOH/g). Screened phytochemicals present included terpenoids, flavonoids, saponins, alkaloids, and cardiac glycosides. There was no detectable concentration of alpha-tocopherol in the sample. GC-MS analysis revealed the presence of unsaturated fatty acids that included eicosapentaenoic acid, docosahexaenoic acid, gamolenic acid, arachidonic acid, and dihommogammalinolenic acid, aside from others.

Conclusion: *Telfairia occidentalis* seed oil can be another source of edible vegetable oil which will also enhance healthy nutrition with possible commercial prospects. Also, it is a rich source of phytochemicals that have been reported to have antioxidant, antimicrobial, and other nutraceutical activities.

1. Introduction

Telfairia occidentalis commonly known as fluted pumpkin or fluted gourd, of the family Cucurbitaceae, is a tropical vine grown in West Africa for its edible seeds and is utilized as a leaf vegetable[1]. Indigenous people in Nigeria, including the Ibos, Efiks, Ibibios, and Urhobos are part of an estimated 30 to 35 million people that use *T. occidentalis* traditionally for culinary and medicinal purposes.[1]. The greatest diversity of the plant population can currently be found in South-eastern Nigeria, where it is known locally as Ugwu by the Igbo and Ugu by the Yoruba[2]. The fluted pumpkin is considered an oil seed because it is reported to be high in oil content, 52 - 54%[3].

Vegetable oil or fats are oils extracted mainly from seeds or other parts of the fruits. Oil seeds are those seeds that are considerably high in oil content and reportedly possess nutritional, industrial, and nutraceutical applications. The seeds of sunflower, palm kernel, groundnut, soybean, olive, cotton seed, rapeseed, sesame seed, linseed, and safflower seed are some of the most studied well-known oilseeds[4]. There is an increase in the need to find alternative sources of edible oil from underutilized oilseeds consequent to an

increased demand in the consumption of vegetable oil.

Vegetable oils are established sources of the antioxidant alpha-tocopherol[5], an essential micronutrient that protects the body from degenerative diseases[6]. The oil from fluted pumpkin has been reported to have a substantially greater quantity of alpha-tocopherol (24 mg/100g) in comparison with other oils derived from the seed oil of 12 other pumpkin cultivars (Stevenson *et al*., 2007)[7]. Even though the physicochemical properties of *T. occidentalis* seed oil obtained in Nigeria have been reported[8], and despite the many studies that have been done on this seed oil there is scanty or nil information on the characterization of the oil extracted from the seeds of *T. occidentalis* indigenous to Ogun State, Nigeria.

The differences, if any, may be because elements and ions present in the soil which plants absorb to form their metabolic compounds, vary from one geographical zone to another[9]. This study aimed to screen for different classes of phytochemicals, detect the presence of, and determine the concentration of the alpha-tocopherol, if any, and the fatty acid composition of the seed oil of *Telfairia occidentalis* planted in Sagamu but sampled *from* Ijebu-Ode, South-West, Nigeria.

2. Materials and Methods

2.1 Materials

Solvents and reagents used in this study included alpha-tocopherol, aqueous potassium hydroxide, 0.5 M hydrochloric acid, 1M alcoholic potassium hydroxide, 1% phenolphthalein, distilled water, diethyl ether, ethanol (96%), n-hexane, dichloromethane, isopropanol, methanol, potassium hydroxide, all analar grade. Equipment included a Rotary evaporator, Soxhlet extractor, thermostated oven dryer, Agilent 5977 GC-MS, ADAM AAA250LE weighing balance (UK), Heidolph REAX 2000 (Germany) Vortex mixer, Radwag Analytical balance, and Glass centrifuge tube (50mL),

2.2 Collection and preparation of samples

Mature and healthy pods of *T. occidentalis* were purchased from the Oke-Aje market, (GPS Coordinates ***6.8166,3.92968)*** is located *around Idobi,* Oke Suna Street, *Epe motor park, and along Dipo Dino Stadium in Ijebu Ode* City, Ogun state, Nigeria. This sample was reaped from a fluted pumpkin vegetable plant (also called *Ugwu in the Ibo language, Ikong ubong in the Ibibio language*) planted in Sagamu, Ogun State, Nigeria, a town, 30 minutes to Ijebu-Ode by road.

The pods were opened, and the seeds were washed with water and air-dried for 24 hours. After the seeds were dried, they were de-hulled, and the naked seeds were oven-dried at 45° C for one (1) week using a thermostated oven dryer. The dried seeds were blended and preserved for oil extraction[10].

2.3 Extraction of oil

Telfairia occidentalis oil was extracted from the powdered seeds at the laboratory facility of the Department of Pharmaceutical Chemistry, University of Ibadan, Nigeria. Ground seeds (1013.00 g) were divided into two equal halves for cold extraction (506.5 g) and hot extraction (506.5 g) and extracted with n-hexane (b.pt range of 60-70^{0}C) as solvent according to the method described by Sunmonu *et al*[11]. Cold Extraction/Soaking of the ground seed of *Telfairia occidentalis* was carried out using the ground seeds (506.5 g) which were divided equally into two Winchester bottles and soaked with n-hexane (700 mL) for 72 hours. The container was tightly sealed to avoid evaporation of the solvent. After 72 hours, the solvent was decanted, and distilled off under vacuum in a rotary evaporator. The percentage yield of the oil was determined gravimetrically. The extracted oil samples were transferred into bottles wrapped with foil[11].

2.4 Hot extraction of the ground seed of *Telfairia occidentalis*

The ground seeds (506.5 g) were also divided into two and put in a muslin cloth and the muslin cloth was placed in the extraction tube, after which the extraction tube and condenser tube were fixed into the conical flask, one after the other. The whole setup was then placed in the heating mantle and left to run for three (3) hours at a temperature of 70^{o}C with 1.5 L of n-hexane. The percentage yield of the oil was determined gravimetrically. The extracted oil samples were also transferred into bottles wrapped with foil[11].

2.5 Physicochemical parameters of the *Telfairia occidentalis* seed oil

The acid, saponification, iodine, and ester values were determined according to previous methods[6,12]. The refractive index at 40°C, was determined using Abbe Refractometer model 2WAJ (Wincom, China) refractometer, relative density (at 25°C) was determined using a pycnometer, and the viscosity (mpa. S at 40°C), was determined using Ubbelohde glass capillary viscometer (size 2. A149, Cannon instrument, PA, USA).

2.6 Determination of alpha-tocopherol content

2.6.1 Preparation of standard

DL-α-tocopherol (25 mg) was dissolved in 5 mL of n-hexane and made up to volume with isopropanol in a 25 mL volumetric flask to give a stock solution of 1 mg/mL. Different concentrations (10 ppm, 20 ppm, 50 ppm & 100 ppm) were then prepared through various dilutions with isopropanol to obtain the standard solutions for the calibration curve. The solutions were protected from light by transferring them into amber HPLC vials.

2.6.2 Sample preparation and determination of α-tocopherol content

The oil sample (0.5 g) was weighed into a 10 mL volumetric flask wrapped with foil paper and dissolved with 2 mL of n-hexane. The solution was made up to mark with isopropanol. Analysis was by a high-performance liquid chromatography method (AOCS Official Method No. Ce 8-86)[13] used with modifications. The Agilent HPLC 1100 series instrument was equipped with an analytical column (Waters C18 (100 x 4.6 mm I.D, 3.5 µm) with a syringe of 20 µL loop. The mobile phase was methanol (99.9%) and deionized water, pumped at a flow rate of 1.0 mL per minute with a UV detector at a wavelength of 295 nm with a sensitivity of 0.50. The chromatogram that resulted was a graph of absorbance as a function of elution time.

2.7 Determination of fatty acid composition

2.7.1 Fatty acid methyl ester preparation

Oil extract (1 g) was weighed and dissolved with *n*-hexane (8 mL) in a 10 mL flask. In accordance with AOCS Official Method Ce 1-62[14], methanolic KOH 2N (1 mL) was added and the mixture was shaken using a Heidolph REAX 2000 (Germany) vortex mixer thoroughly for 30 seconds and made up to the mark with n-hexane The mixture was then centrifuged, and the supernatant obtained which was then transferred into 2 mL vials and injected into the GC-MS.

2.8 GC-MS analysis

The equipment is an Agilent 8860 gas chromatograph coupled to a 5977C inert mass spectrometer with an electron-impact source (Agilent Technologies). Separation for the compounds was achieved through a stationary phase, made up of HP-5 capillary column coated with 5% phenyl methyl siloxane (30m length x 0.32 mm diameter x 0.25 µm film thickness) (Agilent Technologies). Hydrogen was the carrier gas, and it was used at a constant flow of 1.48 mL/min with an initial nominal pressure of 1.49 psi and an average velocity of 44.22 cm/sec. The samples (1µL) were injected in splitless mode at a temperature of 300 °C. Purge flow to spilt vent was 15.0 mL/min at 0.75 min with a total flow of 16.67 mL/min, while gas saver mode was switched off. The oven was initially programmed at 100 °C (5 min) and then ramped at 7 °C/min to 250 °C (2 min). and the run time was 28 min with a 3 min solvent delay. The mass spectrometer was operated in electron-impact ionization mode at 70eV with an ion source temperature of 230 °C, quadrupole temperature of 150 °C and transfer line temperature of 300 °C. Thereafter, the samples were analyzed after calibration, and the corresponding FAMEs concentration was determined.

2.9 Statistical analysis

Results for physicochemical properties on Table 2 are presented as mean ± standard deviation of the mean value using Microsoft Excel 2016 version[15].

3.0 Results

The oil extracted from *Telfairia occidentalis* (fluted pumpkin) seeds was golden yellow in colour and liquid at room temperature with a distinctive smell. The percentage yield of oil from the sample was 17% and 27.3% for cold extraction and hot extraction respectively.

Table 1 shows the results for the physicochemical properties: refractive index, relative density, viscosity, acid, saponification, iodine, and ester values of the analysed oil.

Table 1: Physicochemical properties of *Telfairia occidentalis* seed oil.

Parameters	Value
Refractive index	1.469 ± 0.01
Relative density	0.8791 ± 0.01 g/mL
Viscosity	55.60 ± 0.06
Acid value	2.184 ± 0.02 mgKOH/g
Saponification value	179.52 ± 0.16 mgKOH/g
Iodine value	7.14 ± 0.03 gI_2/100g
Ester value	177.33 ± 0.11 mgKOH/g

Screening for phytochemicals in the seed oil suggest the presence of bioactive constituents such as terpenoids, flavonoids, saponins, alkaloids and cardiac glycosides as shown in Table 2; but this would have to be confirmed.

Test	Result
Anthraquinones	-
Terpenoids	+
Flavonoids	+
Saponins	+
Tannins	-
Alkaloids	+
Cardiac glycosides	+

Key: + = present;

The standard DL-alpha tocopherol calibration curve showed acceptable linearity with a correlation coefficient (R^2) of 0.9996 as presented in Figure 1 and a retention time of 6.177 min.
Table 3 summarizes the HPLC conditions for running alpha-tocopherol analysis.

The chromatograms in Figure 2a and 2b give the HPLC runs for the alpha-tocopherol standard and the sample of *Telfairia occidentalis* seed oil, but the HPLC analysis indicated no detectable amount of alpha-tocopherol for the sample as shown in Figure 2b.

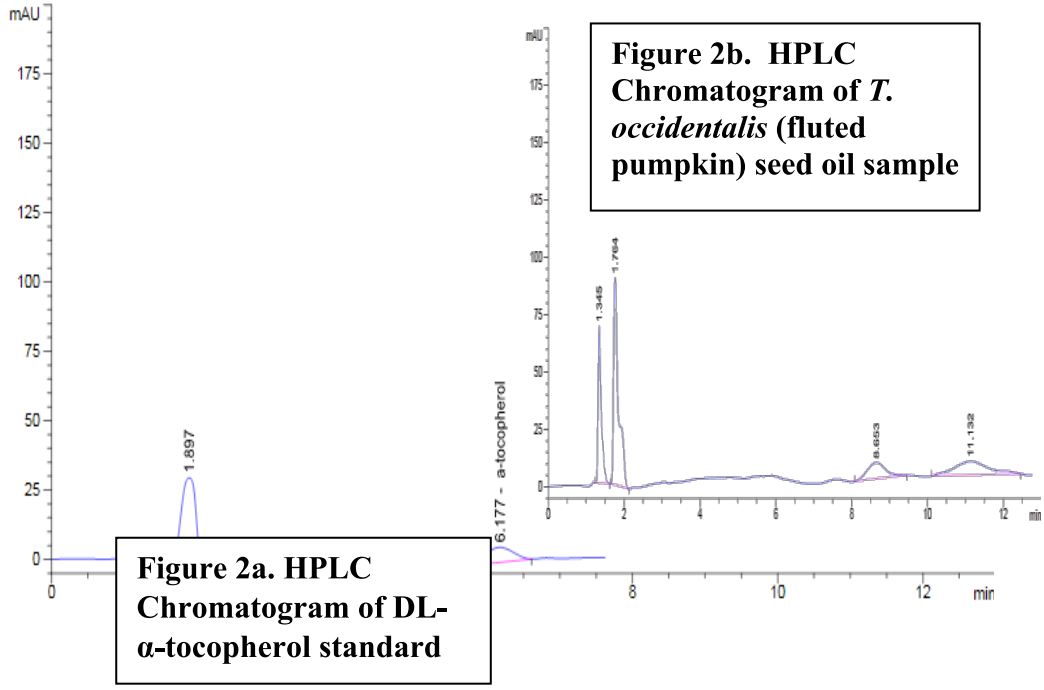

Figure 2a. HPLC Chromatogram of DL-α-tocopherol standard

Figure 2b. HPLC Chromatogram of *T. occidentalis* (fluted pumpkin) seed oil sample

HPLC validation results are enumerated in Table 4.

Table 4. Validation parameters for running alpha-tocopherol analysis.

Validation parameter	Value
Linearity Range	10-100 ppm
Correlation (R^2)	0.9998
Retention time precision (n=3)	0.4299% rsd
Area precision (n=3)	0.2510% rsd
Limit of Quantitation (LOQ)	5.8388 µg/mL
Limit of Detection (LOD)	1.7516 µg/mL

rsd=relative standard deviation

The sample was pretreated via sample extraction, clean up, and pre-concentration to have a processed sample that generates better analytical results compared to the initial sample. However, the analysis of fatty acid methyl esters (FAMEs) obtained from vegetable oils through transesterification is used for the characterization of the lipid fraction in food and is one of the most important analyses for food. The GC chromatogram of the fatty acid methyl esters which were prepared as enumerated under section 2.7.1 for our fluted pumpkin seed oil sample is shown in Figure 3, while the fatty acid distribution of the seed oil is presented in Table 5. Table 5 indicates the presence of saturated (SAFA) (9), monounsaturated (MUFA) (7), di-unsaturated (DUFA) (2), and polyunsaturated (PUFA) (5) fatty acids.

Table 5: Fatty acid composition of fluted pumpkin seed oil

S/N	Compound	Common name	Retention time	Concentration (mg/L)	Molecular formula	Molecular weight (g/mol)	Saturation
1	Octanoic acid, methyl-	Methyl octanoate	3.665	2.09	$C_9H_{18}O_2$	158.24	SFA
2	Methyl myristate	-	15.962	0.75	$C_{15}H_{30}O_2$	242.40	SFA
3	Methyl myristoleate	-	16.139	0.17	$C_{15}H_{28}O_2$	240.38	MUFA
4	Cis-10-pentadecenoic acid	-	17.489	0.43	$C_{15}H_{28}O_2$	240.38	MUFA
5	9-Hexadecenoic acid, methyl-	Palmitoleic acid	18.817	0.80	$C_{16}H_{30}O_2$	254.41	MUFA
6	Hexadecanoic acid, methyl-	Palmitic acid	19.137	1.87	$C_{17}H_{34}O_2$	270.45	SFA
7	cis-10-Heptadecenoic acid	-	20.242	0.87	$C_{17}H_{32}O_2$	268.40	MUFA
8	Heptadecanoic acid, methyl-	Methyl margarate	20.522	0.20	$C_{18}H_{36}O_2$	284.50	SFA
9	gamma. -Linolenic acid	Gamolenic acid	21.220	1.64	$C_{18}H_{30}O_2$	278.40	PUFA
10	9-Octadecenoic acid	Ricinoleic acid	21.501	5.00	$C_{18}H_{34}O_2$	282.50	MUFA
11	Methyl stearate	-	21.850	1.58	$C_{19}H_{38}O_2$	298.50	SFA
12	5,8,11,14-Eicosatetraenoic acid	Arachidonic acid	23.561	2.24	$C_{20}H_{32}O_2$	304.50	PUFA
13	5,8,11,14,17-Eicosapentaenoic acid	Eicosapentaenoic acid (EPA)	23.652	2.24	$C_{20}H_{30}O_2$	302.50	PUFA
14	8,11,14-Eicosatrienoic acid	Dihomogammalinolenic acid	23.801	1.93	$C_{20}H_{34}O_2$	306.50	PUFA
15	cis-11,14-Eicosadienoic acid	Homogammalinolenic acid	24.104	1.82	$C_{20}H_{36}O_2$	308.50	DUFA
16	cis-11-Eicosenoic acid	Gondoic acid	24.207	0.84	$C_{20}H_{38}O_2$	310.50	MUFA
17	Eicosanoic acid, methyl-	Methyl arachidate	24.602	0.71	$C_{21}H_{42}O_2$	326.60	SFA
18	Heneicosanoic acid, methyl-	Methyl heneicosanoate	26.444	1.22	$C_{22}H_{44}O_2$	340.60	SFA
19	4,7,10,13,16,19-Docosahexaenoic acid	Cervonic acid	26.971	3.23	$C_{22}H_{32}O_2$	328.50	PUFA
20	cis-13,16-Docasadienoic acid	Methyl docasadienoate	28.070	3.01	$C_{23}H_{42}O_2$	350.60	DUFA
21	Docosanoic acid, methyl-	Methyl behenoate	28.893	2.12	$C_{23}H_{46}O_2$	354.60	SFA
22	15-Tetracosenoic acid	Nervonic acid	35.216	6.06	$C_{24}H_{46}O_2$	366.60	MUFA
23	Tetracosanoic acid, methyl-	Methyl lignocerate	36.389	4.29	$C_{25}H_{50}O_2$		SFA

Key: SFA= Saturated Fatty Acid; MUFA= Monounsaturated Fatty Acid; DUFA= Di-unsaturated Fatty Acid; PUFA= Saturated Fatty Acid

4. Discussion

The oil yield in our study was relatively lower when compared to Chibor *et al*[3] (52-54%); Sunmonu *et al*,[11] who obtained 43.92% for the soaking method and 28.91% for the Soxhlet method; and 58.41% from Eddy *et al*[16], where petroleum ether was used for extracting solvent in both studies. The differences observed in the oil yield could be due to the solvents used for extraction, or to species-related factors or seasonal changes. The refractive index of 1.469±0.01 in our study, is lower than the 1.548 in a previous study for *Hura crepitans*[18].

The degree and kind of saturation, type of substitutions of component fatty acids, and the presence of companion chemicals all affect the refractive index value[19]. The refractive index of crude vegetable oils reviewed is within the range of 1.447 – 1.471 and the refractive index (40 °C) for our oil sample falls within this range[20]. The oil had a viscosity (mpa. s 40 °C) of 55.60 ± 0.06 and a relative

density (25 °C) of 0.8791 ± 0.01, being less dense than water, it would be beneficial in the creation of creams since it will allow freer oil flow and spread on the skin.

The parameters that define the quality of edible oil are acid value, saponification value, and iodine value[21]. The acid value of oil is a measure of its fatty acid quality. Oil with low acid value will be stable over time and is protected against rancidity and peroxidation[19]. The acid value of 2.184 ± 0.02 mg KOH/g for the fluted pumpkin seed oil in our study falls within the range of 0.00 to 3.00 mg KOH/g; hence, can find an application in cooking as recommended by Oderinde *et al*[18].

Saponification value (SV) is a measure of oxidation during storage, as well as an indicator of the oil's deterioration. A low saponification value indicates that the oil may not be suitable for soap or shampoo production[19] *Telfairia occidentalis* seed oil SV in this study was 179.52 ± 0.16 mg KOH/g, which is lower compared with the SV of coconut oil (248 – 265 mg KOH/g) and of palm kernel oil (230 – 254 mg KOH/g) which are known for their use in soap making. Our SV result is also lower than 294.04 ± 0.11 mg KOH/g reported for *Hura crepitans* oil by Oderinde *et al*[18]. Nevertheless, the studied *Telfairia occidentalis* seed oil can still find use in the production of liquid soap, shampoos, and lather shaving creams.

Iodine value (IV) is a measure of the degree of unsaturation and thus, the degree of oil stability. *Telfairia occidentalis* seed oil in this study gave an iodine value of 7.14 ± 0.03 gI_2/100g, which is a very low IV, but falls within the range of iodine values (6 – 150 gI_2/100 g) required for making edible oils[20]. Therefore, the oil sample, if purified, may have potential for utilization for edible purposes.

The oil in our study has a higher acid value, but a lower saponification and iodine value compared to results from earlier studies on fluted pumpkin seed oil as reported by Aguebor-Ogie *et al*[22] that have AV, SV, and IV of 0.64 mg KOH/g, 189.73 mg KOH/g and 60.72 g/100g respectively. However, our values for saponification, specific gravity, and refractive index agree with values reported by Anhwange *et al*[23], while the acid value was lower (2.184 ± 0.02 vs 3.4.8) Uba and Mohammed[24] in another study gave values for specific gravity as 0.892, refractive index as 1.120, iodine value as 80-100 I_2/100g, acid value as 45.23 mg KOH/g, saponification value as 260.87 mg KOH/g, and free fatty acid to be 3.86% respectively for pumpkin seed oil. Their refractive index and specific gravity agree with our results while other parameters were higher than our results for IV, AV, and SV as shown in Table 2. The variation in these parameters could be a direct result of the age of reagents, and differences in geographical and climatic conditions. Ester value (EV) is a measure of the actual amount of saponifiable glyceride present in a sample of oil. The greater the EV number, the higher the content of ester in the oil sample.

Plants produce phytochemicals through either primary or secondary metabolism[25]. Hence, *Telfarias occidentalis* can be said to be a rich source of phytochemicals, some of which have been reported to have antioxidant, antimicrobial, and other nutraceutical activities.

The HPLC method displayed good specificity and selectivity as standard alpha-tocopherol eluted without any other peak interference at the retention time. The partial validation parameters fell within the acceptance criteria as stipulated in the analytical methods validation protocol[26]. Ideally, Table 5 results present our sample to have more unsaturated fatty acids (UFAs), but this is discordant with the rather very low iodine value derived for the sample. Consequently, it is possible that factors such as the quality of the seeds, extraction systems, and the state of reagents used in determining the iodine value as well as analysts' expertise may have contributed to the abysmally low iodine value for our sample. Other fatty acid methyl esters (FAMEs) such as palmitate, palmitoleate, arachidate, behenoate, myristate, stearate were also present in the sample as earlier reported[27].

Of the fatty acids present in the oil sample, the results suggest that two (2) are omega-3 fatty acids; eicosapentaenoic acid (EPA) and cervonic acid also called docosahexaenoic acid (DHA), four (4) are omega-6 fatty acid; gamolenic acid, arachidonic acid, dihomogammalinolenic acid, homogammalinolenic acid and one (1) omega-9 fatty acid; gondoic acid. EPA is a polyunsaturated fatty acid that has been shown to be effective in the treatment of mental illnesses like schizophrenia[28]. It has been proposed that EPA reduces depression and, more importantly, suicidal behavior[28]. These omegas 3, 6, and 9 (ω3, 6, 9 FA) are a group of polyunsaturated FA (PUFA), which are essential fatty acids that humans cannot synthesize, so obtained primarily from the diet. Thus, they are required for numerous biological functions, such as in cell membrane formation, decreasing blood pressure, lower cardiovascular disease risk, fertility, and reducing inflammation amongst others[29]. Hence, our oil sample may have implications in supporting mental health, improving heart health, and promoting brain health since omega-3 fatty acids play a critical role in the development and function of the central nervous system[29].

In addition, previous studies have reported that medium-

chain fatty acids (MCFAs) possess functional properties including antibacterial, antiprotozoal, anti-inflammatory, and antiviral in addition to nutritional properties[30]. Also, the presence of polyunsaturated fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in fluted pumpkin seed oil makes it a ready source of heart-friendly essential fatty acids, with potential usefulness for domestic and culinary purposes. The nanoencapsulation of eicosapentaenoic acid too, could be a useful dietary supply of essential fatty acids in food formulation. Results from this study suggest that *Telfairia occidentalis* oil sampled from Ijebu-Ode but indigenous to Sagamu, Ogun state, Nigeria did not present as a good source of alpha-tocopherol (Vitamin E) as in earlier reported studies.

The fact that the concentration of alpha-tocopherol in our sample was below the detection limit could be due to factors including fruit quality or seeds, extraction systems, and refining procedures, which could have influenced our results which are at variance with previous reports. The time of collection of the seed sample, soil type, and soil pH may also be contributory factors[31]. Sagamu, where the sample was harvested has a tropical climate (temperature averages 26.1 °C | 78.9 °F; precipitation is about 1970 mm | 77.6 inches per year). The Köppen-Geiger climate classification is Am. (Climate-Data.org)[32]. Ijebu-Ode with high temperatures all year round ranging between 27°C (80°F) and 34°C (93°F) is close to the A121 highway with a warm tropical climate on latitude: 6°49′09″ N and longitude: 3°55′02″ E with elevation above sea level of 74 m = 242 ft within 100 km of the Atlantic Ocean.[32] The effect of these prevalent climatic conditions might be responsible for the low and undetectable α-tocopherol content of the *Telfairia occidentalis* sample in this study.

5. Conclusion

The physicochemical characteristics and quality evaluation of *T. occidentalis* (fluted pumpkin) seed oil indigenous to Sagamu and marketed in Ijebu-Ode, Ogun State, South-West, Nigeria in this study have not been previously reported to our knowledge. Seed oil can be considered as another source of edible vegetable oil with commercial prospects, aside from enhancing healthy nutrition. *Telfairia occidentalis* seed oil can also find use in the production of liquid soap, shampoos, and lather shaving creams. Additionally, it is a rich source of phytochemicals that have been reported for their antioxidant, antimicrobial, and other medicinal activities.

Declaration of competing interest

The authors declare no known competing interest.

Acknowledgements

The authors thank Mrs. Morenike A Oluboba of the Department of Pharmaceutical and Medicinal Chemistry, Olabisi Onabanjo University; and Mr. Gbenga Adeyemi and other laboratory staff of the Department of Pharmaceutical Chemistry, University of Ibadan, Nigeria for providing laboratory facilities for the physicochemical and quality analysis of the oil sample. Mr. Jarvis Mpock of Hydrochrom Laboratory is also appreciated for running the HPLC.

References

1. Akoroda MO (1990) "Ethnobotany of *Telfairia occidentalis* (Cucurbitaceae) among Igbos of Nigeria." *Economic Botany* 44 (1): 29-39 JSTOR, https://www.jstor.org/stable/4255209
2. Akwukwaegbu PI, Peters DE and Wegwu MO (2016) Proximate Analysis and Phytochemical Screening of Fluted Pumpkin (*Telfairia occidentalis*) pod. *American Journal of Food, Nutrition and Health* 1 (1): 1-6 http://www.aascit.org/journal/ajfnh
3. Chibor BS, Kiin-Kabari DB and Eke-Ejiofor J (2018) Comparative Assessment of the Physicochemical Properties and Fatty Acid Profile of Fluted Pumpkin Seed Oil with Some Commercial Vegetable Oils in Rivers State, Nigeria. *Research Journal of Food and Nutrition* 2 (2): 32-40
4. Ajala AS and Adeleke SA (2014) Effect of Drying Temperatures on Physicochemical Properties and Oil Yield of African Star Apple (*Chrysophyllum alibidum*) Seeds. *Global Journal of Engineering Design and Technology* 3 (3): 12-16
5. Hammond EW (2003) Vegetables and oils composition and analysis. In: Encyclopedia of Food Sciences and Nutrition (Caballero B, Tugo LC, Finglas PM, Eds.). Elsevier Science Ltd. 5916-5921
6. Adejumo OE, Popoola EA, Bamiro OA, Daodu JO, Olaitan OJ (2021) Physicochemical Characteristics and HPLC Determination of Alpha-Tocopherol in Eighteen Edible Vegetable Oils Marketed in Nigeria. *Dhaka University Journal of Pharmaceutical Sciences* 20 (1): 49-57 https://doi.org/10.3329/dujps.v20i1.54032
7. Stevenson DG, Eller FJ, Wang JL, Wang T, Ingleth GE (2007) Oil and Tocopherol Content and Composition of Pumpkin Seed Oil in 12 Cultivars. *Journal of*

Agricultural and Food Chemistry 55**:** 4005-4013. https://doi.org/10.1021/jf0706979

8. Johnson J, Ekpo G, Gbashi S, Peter H (2018) Evaluation of Selected Physicochemical Properties and Anti-Trypsin Activity of Fluted Pumpkin *Telfairia occidentalis* Hooker (*Cucurbitaceae: Cucurbitales*) seed and seed oil. *Advanced Research in Gastroenterology and Hepatology* 8 (3): 54-58. 555738.
9. Cataldo DA and Wildung RE (1978) Soil and Plant Factors Influencing the Accumulation of Heavy Metals by Plants. *Environmental Health Perspectives* 27: 149-159
10. Daramola OI, Akindele OO, Bolarinwa AF, Raji Y (2015) Effects of Telfairia occidentalis Seed Oil on Female Reproductive Functions in Wistar Rats. *Nigerian Journal of Physiological Sciences*: Official Publication of the Physiological Society of Nigeria. 30: 95-101.
11. Sunmonu M, Ajala O, Odewole M, Morrison S, Alabi M. (2017) Comparative Analysis of Physicochemical Properties of Oil Extract from Two Varieties of Fluted Pumpkin Seeds using Different Extraction Methods. Kathmandu University Journal of Science, Engineering, and Technology 13 (2): 48-60. https://doi.org/10.3126/kuset.v13i2.2128310.3126/kuset
12. British Pharmacopoeia (2000) Appendix XB, IA, IB. Acid value; Appendix XF, IA, IB. Peroxide value. Appendix XE, IA, IB. Iodine value, Appendix XG, IA, IB. Saponification value.
13. AOCS (1998) Method Ce 8-86 Tocopherol Composition by High-Performance Liquid Chromatography. Official Methods and Recommended Practices of the American Oil Chemist´s Society, Champaign, IL, USA.
14. AOCS (1998) Method Ce 1-62 Preparation of Fatty Acid Methyl Ester. Official Methods and Recommended Practices of the American Oil Chemist's Society, Champaign, IL, USA.
15. Microsoft Corporation (2016) *Microsoft Excel*. Retrieved from https://office.microsoft.com/excel
16. Eddy NO, Ukpong JA and Ebens EE (2011) Lipid's Characterization and Industrial Potentials of Pumpkin Seeds (*Telfairia occidentalis*) and Cashew Nuts (*Anacardium occidentale*). *E-J Chemistry* http://www.e-journals.net. 8 (4):1986-1992.
17. Zhuang X, Zhang Z, Wang Y, Li Y (2018) The effect of alternative solvents to n-hexane on the green extraction of *Litsea cubeba* kernel oils as new oil sources. Industrial Crops and Products 126: 340-346. https://doi.org/10.1016/j.indcrop.2018.10.004
18. Oderinde RA, Ajayi IA and Adewuyi A (2009) "Characterization of Seed and Seed Oil of Hura crepitans and the Kinetics of Degradation of the Oil During Heating". Electronic Journal of Environmental, Agricultural and Food Chemistry 8 (3): 201-208.
19. Aremu MO, Ibrahim H and Bamidele TO (2015) Physicochemical Characteristics of the Oils Extracted from some Nigerian Plant Foods. Chemical and Process Engineering Research 32: 22-25
20. Codex Alimentarius (2003) Codex standard for named vegetable oils Codex Stan. 210, 5–13.
21. Khan S, Sharmin AL, Obaid M, Chowdhury K (2015) Tocopherol Content of Vegetable/Oils and Fats and their Oxidative Deterioration during Storage. World Journal of Pharmacy and Pharmaceutical Sciences 4 (4): 1537-1548
22. Aguebor-ogie BN, Ukwuonwo-ediale AC and Eriyamremu GE (2021) Physicochemical Property and some Vitamin Contents of *Telfairia Occidentalis* Seeds Oil. Journal of Applied Science and Environmental Management 25 (4): 677-681 https://www.ajol.info/index.php/jasem
23. Anhwange BA. Ikyenge BA. Nyiatagher DT, Ageh JT (2010) Chemical Analysis of *Citrullus lanatus* (Thunb.), *Cucumeropsis mannii* (Naud.) and *Telfairia occidentalis* (Hook F.) Seeds Oils. Journal of Applied Science Research 6 (3): 265-268 http://www.insipub.com/.../265-268.pdf
24. Uba B and Muhammad C (2019) Determination of Fatty Acid Composition and Physicochemical Properties of *Cucurbita Maxima* (Pumpkin) Seed Oil Cultivated in Northeast Nigeria. *East African Scholars Multidisciplinary Bulletin* 2 (8): 2617-4413. https://doi:10.36349/easmb.2019.v02i08.009
25. Molyneux RJ, Lee ST, Gardner DR, Panter KE, James LF (2007) "Phytochemicals: The Good, the Bad and the Ugly?". *Phytochemistry* 68 (22–24): 2973–2985. https://doi:10.1016/j.phytochem.2007.09.004
26. AOAC-Association of Official Analytical Chemists (2002) AOAC Official Methods Analysis. Appendix G: Guidelines for Collaborative Study Procedures to Validate Characteristics of a Method of Analysis. 12
27. Alademeyin JO and Arawande JO (2016) Effect of Processing on Physicochemical Properties and Fatty Acid Composition of Fluted Pumpkin (*Telfairia occidentalis)* Seed Oil. *Pakistan Journal of Scientific*

and Industrial Research Series A: Physical Sciences 59 (2): 83-89 https://doi:10.52763/PJSIR.PHYS.SCI.59.2.2016.83.89

28. Huan M, Hamazaki K, Sun Y, Itomura M, Liu H, Kang W, Watanabe S, Terasawa K, Hamasaki T (2004) "Suicide Attempt and N-3 Fatty Acid Levels in Red Blood Cells: A Case-Control Study in China." *Biological Psychiatry* 56 (7): 490-496. SIEC No: 20100442.
29. MacIntosh SC, Shaw M, Connelly M, Yao ZJ (2021) Food and Feed Safety of NS-B5ØØ27-4 Omega-3 Canola (*Brassica napus*): A new source of long-chain omega-3 fatty acids. Frontiers in Nutrition 8: 716659. https://doi.org/10.3389/fnut.2021.716659
30. Prasanth Kumar PK and Gopala Krishna AG (2015) Physicochemical Characteristics of Commercial Coconut Oils Produced in India. *Grasas Y Aceites.* 66 (1): e062 https://dx.doi.org/10.3989/gya.0228141
31. Minasny B., Hong SY, Hartemink AE, Kim YH, Kang SS (2016) "Soil pH increase under paddy in South Korea between 2000 and 2012," *Agriculture Ecosystems and Environment* 221: 205–213. https://doi.org/10.1016/j.agee.2016.01.042
32. Climate-Data.org Climate data for Ijebu-Ode and Sagamu. (2022) Available from: https://en.climate-data.org. Accessed on March 27, 2022.