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PHYSICOCHEMICAL CHARACTERISATION AND NUTRITIONAL EVALUATION OF OILS FROM SELECTED UNDERUTILISED OILSEEDS

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Abstract

The study investigated the physicochemical and nutritional parameters of selected underutilized oilseeds: African oil bean seed, tea seed, African locust bean seed, castor seed, cotton seed and tomato seed. The six oilseed samples were collected from different sources in Nigeria. The seed samples were treated with drying, dehulling and grinding, before they were analysed for the physicochemical and nutritional parameters. The physicochemical parameters determined were: iodine value, peroxide value, free fatty acid, acid value, saponification value, refractive index, specific gravity and pH. The nutritional parameters included: vitamins, minerals, amino acids profile, crude protein and fatty acid profile. The acidity or alkalinity of the oils analysed were measured, the protein contents were analysed using Kjeldahl method, while amino acids determination, fatty acid profile together with water and fat soluble vitamins were determined using Isocratic high performance liquid chromatography (HPLC), minerals were measured using atomic absorption spectrophotometers (AAS). Findings in this study revealed that oils with iodine value less than 100 gI2/100g of oil are considered non-drying oils. Therefore, all the oils in this study are considered to be non-drying oils because their iodine values were less than 100g. Therefore, non-drying oils are not suitable for ink and paint production due to their non-drying characteristics. All the oils analysed in this study were considered fresh because their perioxide values are less than 10 mEq/kg. Fatty acids profile had significance diferences in all the columns. The findings in this study revealed the physicochemical and the nutritional levels of oils from the samples analysed which showed that they all have appreciable nutrient levels which are good for human consumption. The level of protein and essential amino acids are generally higher in Tea seeds oil than other samples analysed. It was further revealed that tea seed oil had highest amount of essential amino acids for lysine, methionine, leucine, tryptophan, threonine and arginine. However African oil bean seed had the highest amount of vitamins A, B2, C, and K and also had the highest level of sodium and potassium.

Keywords: Physicochemical, Nutrition, Underutilised, Oilseeds

INTRODUCTION

Oilseed crops are generally planted to produce edible oil (Karoui *et al.*, 2020). Oilseeds have lately received more attention due to the growing demand for their beneficial vegetable oils for human consumption, animal feed, pharmaceuticals, biofuels, and other oleochemical industrial uses (Karoui *et al.*, 2020). Over the previous 30 years, growing interest has resulted in an 82% expansion of oilseed crop cultivation areas and a 240% rise in total global production (Karoui *et al.*, 2020). Fats and oils contain the most concentrated kind of energy available to all living things (Odoemelam, 2005; Aliyu *et al.*, 2010; Barua *et al.*, 2011). The suitability of oil for certain application is determined by its characteristics, fatty acid and triglyceride compositions (Alvarez and Rodriguez, 2000; Akpabio *et al.,* 2012).

Some of the most important agricultural products in the world are oilseeds. The production of edible oils involves crushing oilseeds from a variety of botanical species, the majority of which are herbaceous plants such as maize, sunflower, and soya but some of which are perennials like argan, avocado, and olive. While some of these species have recently undergone genetic modification or traditional breeding operations, others have been traditionally grown for generatsions (Aparicio *et al.,* 2018).

Seed oils were divided into three categories: drying, semi-drying, and non-drying based on their characteristics. Drying oils are highly unsaturated oils, typically in the presence of a catalyst, when exposed to oxygen in the air, they will polymerize (Nour *et al.,* 2009). Fatty acids are widely occurring in natural fats and dietary oils. They are known to have antibacterial and antifungal among other biological properties. Seed oils vary substantially in fatty acid composition across different taxonomic levels (Zhang *et al.,* 2015). The richness of this resource of species provides a wide range of fatty acids in seeds (Motojest *et al.,* 2011). Seed oil fatty acid profiles are distinctive enough among species and genotypes. Moreover, the fatty acid compositions of seed oils differ notably at generic and infrageneric levels (Zhang *et al.,* 2015). The final uses of seed oils depend to a large extent on its properties (physicochemical characteristics) and the nature of its fatty acids (Abeer *et al.,* 2020).

MATERIALS AND METHODS

Materials

African Oil Bean Seeds, African locust bean seeds, Castor bean seeds, Cotton seeds, Tea seeds and Tomato seeds, Hexane, distilled water.

Equipment and Facility

Soxhlet extractor, round bottom flask, specific gravity bottle, Grinding machine, rubber hose, weighing balance, pH meter, thimbles, Condenser, Wijs' reagent (iodine trichloride), iodine, glacial acetic acid, potassium iodide, sodium thiosulphate, starch indicator, chloroform, alcoholic caustic potash solution, ethanol, phenolphthalein, hydrochloric acid, potassium hydroxide, diethyl ester, sodium hydroxide, nitrogen, boric acid indicator mixture, copper sulphate, Kjeldahl catalyst, sulphuric acid, sodium sulphate, boric acid solution, methyl red and methylene blue.

Sample Collection

Samples were sourced from various locations in Nigeria

Preparation of Sample

The samples (seeds) were processed in various ways, in the course of their preparation for the extraction process. The unit operations involved were as follows:

Shelling: This was carried out manually or mechanically to separate the seeds from their seed coat.

Drying: The seeds were sundried in order to reduce the moisture content.

Size reduction: It was carried out by using grinding machine to grind the samples in order to reduce the seeds to smaller sizes for more extractable form by petroleum ether or n-hexane.

Weighing: Forty grammes (40 g) of the sieved sample seed of each particle size were weighed using an electronic weighing balance.

Methods

Extraction of Oils

Extraction of oil was carried out using a Soxhlet extraction method. The standard methods of Association of Official Analysed Chemists (AOAC, 2000).

The following physicochemical parameters and quality indices were measured: pH, density, refractive index, acid value, saponification, iodine value, and peroxide value, fatty acids (Essential and non-essential). The standard methods of Association of Official Analysed Chemists (AOAC, 2000).

Data Analysis

Data obtained from this study was analysed using statistical package for social science (SPSS) version 23 and the level of significant was at $p<0.05$. Statistical analysis was carried out using analysis of variant (ANOVA) and Duncan's multiple comparison test. Results were expressed as mean ± standard deviation.

RESULTS AND DISCUSSION

Table 1: Physicochemical Composition of the Evaluated Samples

Samples	Iodine Value, g/100g oil	Peroxide Value, mEq/kg oil	FFA (%)	Saponification Value, mEq KOH/kg oil	Acid value, mg KOH /g oil	Specific gravity	Refractive index @25 degrees	pH
African Oil Bean Seed	81.11± 0.01^{c}	5.91± 0.00^{c}	3.26± 0.02^{c}	164.01± 0.00^{c}	6.53± 0.01^{c}	0.91± 0.00^{a}	1.45± 0.01^{a}	4.58± 0.01^{a}
Tea Seed Oil	78.99± 0.01^{bc}	3.25± 0.00^{a}	2.15± 0.01^{a}	155.90± 0.00^{a}	4.30± 0.00^{b}	0.88± 0.02^{a}	1.46± 0.01^{a}	5.20± 0.00^{c}
African Locust	85.22± 0.00^{c}	6.14± 0.01^{c}	1.66± 0.02^{a}	167.79± 0.01^{d}	3.33± 0.11^{c}	0.85± 0.02^{a}	1.46± 0.01^{a}	4.90± 0.02^{bc}

Bean Seed Oil								
Castor seed Oil	78.00± 0.00^{b}	6.00± 0.00^{c}	1.65± 0.01^{a}	172.95± 0.02^{f}	3.31± 0.01^{c}	0.89± 0.01^{a}	1.45± 0.01^{a}	4.75± 0.00^{b}
Cotton SeedOil	82.34± 0.01^{d}	4.55± 0.00^{b}	1.58± 0.01^{a}	162.11± 0.01^{b}	3.15± 0.01^{c}	0.85±0. 00^{a}	1.46± 0.01^{a}	4.76± 0.00^{b}
Tomato Seed Oil	73.89± 0.01^{a}	5.41± 0.01^{c}	1.48± 0.01^{a}	170.11± 0.01^{e}	2.95± 0.02^{b}	0.88± 0.00^{a}	1.46± 0.01^{a}	5.00± 0.01^{c}

Results are presented as mean ± standard deviation. Results within the same column with the same superscript indicate no statistically significant difference ($p>0.05$), while results with the different superscripts along the same column statistically differ significantly ($p<0.05$).

Composition of Vitamins in Oils from Oilseeds Samples

Vitamins analysed in the samples are presented in Table 2; the various vitamins present in the samples were vitamins A, B_2, C, D, E and K. Vitamin A content in the samples ranges from 7.99 ± 0.01 mg/100g and 19.45 ± 0.01 mg/100g with Tomato Seed Oil and African Oil Bean Seed having the lowest, and highest concentrations respectively. Vitamin B_2 ranged from 0.56 ± 0.00 mg/100g to 1.88 ± 0.00 mg/100g with Tomato seed oil and African oil bean seed having the lowest and highest vitamin content respectively. Vitamin C composition ranged from 8.15 ± 0.01 mg/100g to 17.33 ± 0.01 mg/100g with Tomato seed oil and African oil bean seed having the lowest and highest respectively. Vitamin D content ranged from 0.07 ± 0.00 mg/100g to 0.15 ± 0.00 mg/100g with African oil bean seed and Cotton seed oil having the lowest and highest vitamin D content respectively. Vitamin E content across the evaluated samples varied between 0.57 ± 0.01 mg/100g to 1.88 ± 0.00 mg/100g with African oil bean seed and Tomato seed oil having the lowest and highest vitamin E content. The content of vitamin K in all the evaluated samples ranged from 0.03 ± 0.00 mg/100g to 0.06 ± 0.00 mg/100g with Tomato seed oil and African oil bean seed having the lowest and highest respectively.

Table 2: Vitamins Composition of the Oils from Oilseeds Samples

Sample (mg/100g)	A	B_2	C	D	E	K
African Oil Bean Seed	19.45± 0.01[e]	1.88± 0.00[d]	17.33± 0.01[d]	0.07± 0.00[a]	0.57± 0.01[a]	0.06± 0.00[a]
Tea Seed Oil	11.66± 0.00[d]	0.86± 0.01[c]	9.77± 0.02[c]	0.07± 0.01[a]	1.68± 0.00[b]	0.05± 0.00[a]
African Locust Bean Seed Oil	9.57± 0.01[c]	0.85± 0.01[c]	9.22± 0.01[b]	0.08± 0.00[a]	1.73± 0.01[b]	0.04± 0.00[a]
Castor Seed Oil	8.70± 0.00[b]	0.73± 0.02[b]	9.05± 0.01[b]	0.10± 0.00[b]	1.75± 0.01[b]	0.04± 0.00[a]
Cotton Seed Oil	8.45± 0.00[ab]	0.71± 0.01[b]	9.00± 0.01[b]	0.15± 0.01[b]	1.84± 0.00[b]	0.04± 0.00[a]
Tomato Seed Oil	7.99± 0.01[a]	0.56± 0.00[a]	8.15± 0.01[a]	0.15± 0.00[b]	1.88± 0.00[b]	0.03± 0.00[a]

Results are presented as mean ± standard deviation. Results within the same column with the same superscript indicate no significant difference, while results with different superscripts within a column are statistically significant ($p<0.05$).

Table 3: Minerals Composition of the Oils from Oilseeds Samples

Sample (mg/100g)	Fe	Mg	Na	K	Mn	Zn
African Bean Seed	15.65±0.00[a]	134.26±0.00[c]	366.35±0.00[f]	986.35±0.00[f]	37.17±0.01[a]	7.12±0.00[a]
Tea Seed	18.46±0.01[b]	141.63±0.00[d]	284.66±0.01[e]	894.06±0.00[e]	55.27±0.00[c]	8.16±0.01[b]
African Locust Bean Seed	18.01±0.01[b]	151.56±0.01[e]	227.46±0.00[d]	786.67±0.01[b]	41.25±0.01[b]	7.55±0.02[ab]
Castor Seed	19.46±0.00[c]	121.76±0.01[a]	219.09±0.01[c]	725.57±0.02[a]	58.35±0.00[cd]	8.67±0.01[c]
Cotton Seed	22.06±0.00[d]	125.23±0.00[b]	185.56±0.00[a]	811.36±0.01[c]	60.01±0.01[d]	9.15±0.01[cd]
Tomato Seed	22.13±0.01[d]	133.96±0.00[c]	192.13±0.01[b]	861.35±0.02[d]	61.00±0.01[d]	9.22±0.02[d]

Results are presented as mean ± standard deviation. Results within the same column with the same superscript indicate no significant difference, while results with the different superscripts within the column indicate statistical significance ($p<0.05$).

Fatty Acids Composition in the Samples

Fatty acids composition in all the analysed samples are presented in Table 4 below. The following fatty acids were revealed in the analysed samples Capric (C10:0), Lauric (C12:0), Myristic (C14:0), Palmitic (C16:0), Stearic (C18:0), Oleic (C18:1), Linoleic (C18:2), Linolenic (C18:3) and Arachidonic acid (C20:1). The composition of Capric (C10:0) across the evaluated samples ranged from 0.21 ± 0.01 to 0.54 ± 0.00 with Tea seed oil and African oil bean seed having the lowest and highest compositions respectively. Lauric acid (C12:0) concentration ranged from 1.12 ± 0.01 and 2.63 ± 0.00 with Tomato seed oil and African oil bean seed respectively. The composition of Myristic (C14:0) ranged from 0.34 ± 0.01 to 0.54 ± 0.00 with Tomato seed oil and African oil bean seed respectively. Palmitic (C16:0) composition across the samples ranged from 0.33 ± 0.01 to 0.69 ± 0.01 with Cotton seed oil and African oil bean seed having the lowest and highest respectively. Stearic (C18:0) composition in the samples evaluated ranged from 0.21 ± 0.01 to 0.97 ± 0.00 with Castor seed oil and African oil bean seed having the lowest and highest composition respectively. the composition of Oleic (C18:1) ranged from 7.21 ± 0.01 to 8.49 ± 0.01 with Tea seed oil and African oil bean seed having the lowest and highest compositions. The composition of Linoleic (C18:2) ranged from 32.05 ± 0.01 to 50.32 ± 0.00 with Tomato seed oil and African oil bean seed having the lowest and highest concentrations respectively. The composition of Linolenic (C18:3) across samples ranged from 22.72 ± 0.01 to 33.66 ± 0.01 with African oil bean seed and Tea seed oil having the lowest and highest respectively. The composition of Arachidonic acid (C20:1) ranged from7.50±0.00 to 9.62±0.01 with sample Tomato seed oil and African oil bean seed having the lowest and highest respectively.

Table 4: Fatty Acids Profile of Oils from Oilseeds Samples

Sample	C10:0 (Capric)	C12:0 (Lauric)	C14:0 (Myristic)	C16:0 (Palmitic)	C18:0 (Stearic)	C18:1 (Oleic)	C18:2 (Linoleic)	C18:3 (Linolenic)	C20:1 (Arachidonic acid)
African Bean Seed	0.54± 0.00^{c}	2.63± 0.00^{c}	0.54± 0.00^{c}	0.69± 0.01^{c}	0.97± 0.00^{e}	8.49± 0.01^{c}	50.32± 0.00^{e}	22.72± 0.01^{a}	9.62± 0.01^{b}
Tea Seed	0.21± 0.01^{a}	1.23± 0.01^{ab}	0.47± 0.01^{b}	0.35± 0.01^{a}	0.31± 0.00^{b}	7.21± 0.01^{ab}	37.87± 0.01^{d}	33.66± 0.01^{d}	7.51± 0.00^{a}
African Locust Bean Seed	0.32± 0.01^{b}	1.45± 0.01^{b}	0.35± 0.01^{a}	0.45± 0.01^{b}	0.28± 0.01^{ab}	6.95± 0.01^{a}	35.25± 0.00^{c}	31.55± 0.00^{c}	7.95± 0.01^{a}
Castor Seed	0.24± 0.00^{a}	1.25± 0.02^{ab}	0.37± 0.01^{a}	0.36± 0.00^{ab}	0.21± 0.01^{a}	7.86± 0.00^{b}	35.15± 0.01^{c}	31.28± 0.00^{c}	7.94± 0.01^{a}

Cotton Seed	0.25± 0.01^{a}	1.35± 0.01^{ab}	0.35± 0.00^{a}	0.33±0. 00^{a}	0.45± 0.01^{d}	7.45± 0.01^{b}	33.96± 0.02^{b}	30.78± 0.01^{b}	7.85± 0.01^{a}
Tomato Seed	0.22± 0.00^{a}	1.12± 0.01^{a}	0.34± 0.01^{a}	0.33± 0.01^{a}	0.40± 0.00^{c}	7.22± 0.00^{b}	32.05± 0.01^{a}	30.19± 0.00^{b}	7.50± 0.00^{a}

Results are presented as mean ± standard deviation. Results within the same column with the same superscript indicate no significance differences while result with the different superscript within a column indicate significant difference ($p<0.05$).

Amino Acids

The results of the amino acids in the evaluated seed samples are presented in Table 5. The analysis showed the following amino acids: Lysine, Methionine, Threonine, Isoleucine, Leucine, Phenylalanine, Valine, Tryptophan, Histidine, Arginine, Serine, Cysteine, Tyrosine, Alanine, Aspartic acid, Glutamic acid, Glycine and Proline. The amino acid composition of lysine across the samples ranged from 1.21 ± 0.01 to 4.83 ± 0.01 mg/100g with African locust bean oil and Tea seed oil having the lowest and highest respectively. The concentration of Methionine ranged from 1.07 ± 0.01 to 1.65 ± 0.00 mg/100g with African locust bean oil and Tea seed oil having the lowest and highest respectively. The composition of Threonine ranged from 1.25 ± 0.01 mg/100g to 3.13 ± 0.01 mg/100g with Castor seed oil and Tea seed oil having the lowest and highest respectively. The composition of Isoleucine across the samples ranged from 2.85 ± 0.01 mg/100g to 7.00 ± 0.00 mg/100g with African oil bean seed and African locust bean seed oil having the lowest and highest respectively. The composition of leucine across the samples ranged from 4.95 ± 0.01 mg/100g to 9.32 ± 0.02 mg/100g with African locust bean seed oil and Tea seed oil having the lowest and highest respectively. The composition of Phenylalanine across the evaluated samples ranged from 3.84 ± 0.00 mg/100g and 5.87 ± 0.01mg/100g with sample African oil bean seed and cotton seed oil having the lowest and highest respectively. The composition of Valine ranged from 3.89 ± 0.02 mg/100g to 4.72 ± 0.02 mg/100g with African locust bean seed oil and tomato seed oil having the lowest and highest values respectively. The composition of Tryptophan across the evaluated samples ranged from 3.22 ± 0.01 mg/100g to 5.63 ± 0.01 mg/100g with African locust bean seed oil and Tea seed oil having the lowest and highest respectively. The composition of Histidine across the evaluated seed samples ranged from 1.87 ± 0.01 mg/100g to 4.43 ± 0.01 mg/100g with sample of African oil bean seed and Tomato seed oil having the lowest and highest respectively. The composition of Arginine across the evaluated samples ranged from 4.22 ± 0.02 mg/100g to 6.24 ± 0.01 mg/100g with African locust bean seed oil and Tea seed oil having the lowest and highest respectively. The composition of Serine across the evaluated samples ranged from 3.13 ± 0.01 mg/100g to 4.28 ± 0.01mg/100g with African oil bean seed and Tea seed having the lowest and highest respectively. The composition of Cysteine across the evaluated samples ranged from 0.70 ± 0.01 mg/100g to 4.33 ± 0.00 mg/100g with African oil bean seed and Tomato seed oil having the lowest and highest respectively. The composition of Tyrosine across the analysed samples ranged from 4.62 ± 0.01 mg/100g to 7.46 ± 0.00 mg/100g with African oil bean seed and Tomato seed oil having the lowest and highest respectively. The composition of Alanine ranged from 2.72 ± 0.01 mg/100g to 8.52 ± 0.02 mg/100g with African oil bean seed and Tomato seed oil having the lowest and highest respectively. The composition of Aspartic acid across the evaluated samples ranged from 5.85 ± 0.01 mg/100g to 8.22 ± 0.01mg/100g with sample Tomato seed oil and Tea seed oil having the lowest and highest respectively. The composition of Glutamic acid across the analysed samples ranged from 3.14 ± 0.01 mg/100g to 7.14 ± 0.00mg/100g with African oil bean seed and Castor seed oil having the lowest and highest respectively. The composition of Glycine in the evaluated samples ranged from 2.12 ± 0.01 mg/100g to 5.99 ± 0.01mg/100g with Tomato seed oil and Tea seed oil having the lowest and highest respectively. The composition of proline in the analysed seed samples ranged from 1.83 ± 0.01 mg/100g to 3.77 ± 0.00 mg/100g with African oil bean seed and Castor seed oil having the lowest and highest respectively.

Table 5 (a): Amino Acids Composition of the Oils from Oilseeds (mg/100g)

Sample	Lysine	Methionine	Threonine	Isoleucine	Leucine	Phenylalanine	Valine	Tryptophan	Histidine
African Bean Seed	2.62 ±0.00^{b}	1.13±0.01^{a}	2.25 ±0.01^{b}	2.85 ±0.01^{a}	7.34 ±0.00^{d}	3.84±0.00^{a}	4.01 ±0.01^{ab}	3.78±0.00^{ab}	1.87 ±0.01^{a}
Tea Seed	4.83 ±0.01^{c}	1.65±0.00^{b}	3.13 ±0.01^{c}	5.13 ±0.01^{b}	9.32 ±0.02^{e}	5.00±0.00^{c}	4.52 ±0.02^{b}	5.63±0.01^{d}	4.04 ±0.01^{c}
African Locust Bean seed	1.21 ±0.01^{a}	1.07±0.01^{a}	1.75 ±0.02^{a}	7.00 ±0.00^{d}	4.95 ±0.01^{a}	3.85±0.01^{a}	3.89 ±0.02^{a}	3.22±0.01^{a}	3.53 ±0.02^{b}
Castor Seed	1.82 ±0.02^{ab}	1.13±0.01^{a}	1.25 ±0.01^{a}	6.92 ±0.00^{d}	5.34 ±0.01^{b}	4.34±0.00^{b}	4.01 ±0.01^{ab}	4.18±0.00^{b}	3.87 ±0.01^{bc}

Cotton Seed	2.15 ±0.01^{b}	1.34±0.02^{a}	2.84 ±0.01^{bc}	6.94 ±0.00^{d}	6.78 ±0.00^{c}	5.87±0.01^{d}	4.64 ±0.01^{b}	4.21±0.01^{b}	3.70 ±0.00^{bc}
Tomato Seed	1.95 ±0.00^{ab}	1.56±0.01^{b}	2.83 ±0.02^{bc}	6.08 ±0.00^{c}	7.81 ±0.01^{de}	5.84±0.00^{d}	4.72 ±0.02^{b}	5.01±0.01^{c}	4.43 ±0.01^{d}

Results are presented as mean ± standard deviation. Results within the same column with the same superscripts indicate no significant differences ($p>0.05$), while results with the different superscripts within a column indicate significant differences ($p<0.05$).

Table 5 (b): Amino Acids Composition of the Oils from Oilseeds (mg/100g)

Sample	Arginine	Serine	Cysteine	Tyrosine	Alanine	Aspartic acid	Glutamic acid	Glycine	Proline
African Bean Seed	4.24±0.01^{a}	3.13±0.01^{a}	0.70±0.01^{a}	4.62±0.01^{a}	2.72±0.01^{a}	6.52±0.01^{b}	3.14±0.01^{a}	3.42±0.01^{c}	1.83±0.01^{a}
Tea Seed	6.24±0.01^{c}	4.28±0.01^{b}	1.77±0.01^{b}	5.37±0.01^{b}	6.54±0.01^{c}	8.22±0.01^{d}	4.39±0.01^{b}	5.99±0.01^{d}	2.35±0.02^{c}
African Locust Bean seed	4.22±0.02^{a}	3.50±0.00^{ab}	2.87±0.02^{c}	4.83±0.01^{a}	5.76±0.00^{b}	6.56±0.00^{b}	7.12±0.01^{e}	3.02±0.02^{b}	3.16±0.01^{d}
Castor Seed	4.24±0.00^{a}	3.63±0.01^{ab}	2.90±0.01^{c}	5.62±0.01^{b}	6.72±0.01^{c}	7.12±0.01^{c}	7.14±0.00^{e}	3.42±0.00^{c}	3.77±0.00^{e}
Cotton Seed	5.32±0.01^{b}	3.72±0.02^{ab}	3.12±0.00^{d}	6.84±0.00^{c}	6.82±0.02^{c}	6.33±0.00^{ab}	6.12±0.02^{d}	3.03±0.01^{b}	2.85±0.00^{dc}
Tomato Seed	5.47±0.01^{b}	4.16±0.00^{b}	4.33±0.00^{e}	7.46±0.00^{d}	8.52±0.02^{d}	5.85±0.01^{a}	5.73±0.01^{c}	2.12±0.01^{a}	2.05±0.01^{b}

Results are presented as mean ± standard deviation. Results within the same column with the same superscripts indicate no significant differences ($p>0.05$), while results with the different superscripts within a column indicate significant differences ($p<0.05$).

Crude Protein Composition

The crude protein composition in the evaluated oilseed samples are presented in Table 6. The anaylsis revealed that African oil bean seed to Tomato seed oil ranged from 6.95 ± 0.01 to 8.77 ± 0.00 with African oil bean seed and Tea seed oil having the lowest and highest crude composition respectively. There is no significant difference between sample of African locust bean seed oil, Castor seed oil and Cotton seed oil, while on the other hand, African oil bean seed, Tea seed oil and Tomato seed oil are statistically significant ($p<0.05$) in terms of the crude protein composition.

Protein levels of the oilseeds analysed

Table 6 Crude Protein Composition

Samples	Crude Protein (%)
African Oil Bean seed	6.95 ± 0.01^{a}
Tea Seed	8.77 ± 0.00^{c}
African Locust Bean Seed	7.19 ± 0.00^{b}
Castor Seed	7.95 ± 0.01^{b}
Cotton Seed	7.56 ± 0.01^{b}
Tomato Seed	8.12 ± 0.01^{bc}

Results are presented as mean ± standard deviation. Results within the same column with the same superscripts indicate no significant difference ($p>0.05$), while result with the different superscripts within a column indicate significant differences ($p<0.05$).

DISCUSSION

The iodine value, indicating lipid unsaturation, varied among the oilseeds. Tomato seed oil exhibited the lowest value of 73.89 ± 0.01 g/100g oil, while African locust bean seed oil had the highest iodine value of 85.22 ± 0.00 g/100g oil. This suggests that African locust bean seed oil had the highest unsaturation degree, thus a higher likelihood to remain in liquid state at room temperature. Elevated iodine values may imply a greater presence of unsaturated bonds and heightened susceptibility to oxidative rancidity. Previous research found an iodine value of 82.40 g/100g in Parkia biglobosa oil, indicating it is not a drying oil since its iodine values are below 100g/100g. However, Parkia biglobosa seed oil still exhibited a relatively high mean iodine value, indicating the presence of C=C double bonds. Moreover, iodine values exceeding 100 g/100g suggest potential industrial applications such as leather production, candle lubricants, and cosmetics manufacturing, aligning with findings for Cucumis melo seeds oil.

The saponification value serves as an indicator of the proportion of low molecular weight triacylglycerols in oils (Oladiji *et al.*, 2010). Tea seed oil exhibited the lowest value at 155.90 ± 0.00 mEq KOH/kg oil, while castor seed oil displayed the highest value at 172.92 ± 0.02 mEq KOH/kg oil, reflecting their respective foaming abilities. Additionally, the saponification value provides insights into the average molecular mass of fatty acids in the oil sample. Despite its lower value compared to *Terminalia catappa* seed oil, which is recommended for the production of liquid soap, shampoos, and leather shaving creams, the observed saponification value falls within the range suitable for soap making, as indicated by previous studies (Warra, 2013). Higher saponification values justify the utilization of fat or oil in soap production.

The peroxide value, expressed in milliequivalents (meq) of free iodine per kilogram of fat, denotes the reactive oxygen content and indicates oxidation during the early stages of lipid deterioration. However, its reliability diminishes as peroxide degradation increases during later stages of deterioration. A lower peroxide value signifies the oil's resistance to peroxidation during storage. African locust bean seed oil exhibited the highest peroxide value at 6.14 ± 0.01 mEq/kg oil, while tea seed oil displayed the lowest value at 3.25 ± 0.00 mEq/kg oil. Oils with peroxide values below 10 meq/kg are considered fresh, and the detection of a rancid taste typically occurs when the peroxide value ranged from 20 and 40 meq/kg, indicating that the seed oils examined in this study were fresh.

The acid value, commonly used in fats and oils specifications, measures the presence of free fatty acids (FFA) (Popoola and Yangomodo, 2006). It indicates the breakdown of triacylglycerols into free fatty acids, affecting lipid quality. The acid value reflects the edibility of the lipid and its suitability for use in the paint industry (Olaniyi *et al.*, 2014). African oil bean seed exhibited the highest acid value at 6.53 ± 0.01 mg KOH/g oil, while Tomato seed oil showed the lowest value at 2.95 ± 0.02 mg KOH/g oil. Despite this, all oils analyzed had acid values below 10 mg KOH/g oil, suggesting their overall good quality. Low acid values imply long-term stability, protecting against rancidity and peroxidation, possibly due to the presence of natural antioxidants such as vitamins C and A and other phytochemicals like flavonoids (Abubakar *et al*., 2020).

Free fatty acids, expressed as a percentage by weight of a specified fatty acid, indicate oil quality (Nielson, 1994). They may form through hydrolysis or oxidation. The range of free fatty acids observed varied, with Tomato seed exhibiting the lowest value at 1.48 ± 0.01 and African oil bean seed showing the highest at 3.26 ± 0.02. High-quality oils typically have low free fatty acid content (Overhults *et al*., 1975), contributing to enhanced palatability, especially in refined vegetable oils (Aremu *et al*., 2015).

The refractive index is crucial in quality control, assessing material purity, and monitoring hydrogenation and isomerization processes (Aremu *et al*., 2015). The refractive index values of most seed oils reviewed fell within the acceptable range according to Codex Standards, indicating their quality. The mean refractive index recorded for all oils analyzed aligned closely with conventional oils from soybean (Akubugwo *et al*., 2008).

The specific gravity of oils ranged from 0.85 to 0.91, consistent with reported values for fats and waxes (Ajayi and Oderinde, 2002). Previous research indicated that the specific gravity of locust bean seed oil was less dense than water (Olowokere *et al*., 2018), suggesting that the oils studied were lighter than water.

The pH, indicating the concentration of hydrogen ions in a substance or solution, ranged from 4.58 ± 0.01 for African oil bean seed to 5.20 ± 0.00 for tea seed oil, indicating that all oilseeds analyzed were slightly acidic.

The essential amino acids analyzed included lysine, methionine, threonine, isoleucine, leucine, phenylalanine, valine, and tryptophan, while the semi-essential and non-essential amino acids comprised histidine, arginine, serine, cysteine, tyrosine, alanine, aspartic acid, glutamic acid, glycine, and proline. Tea seed oil exhibited the highest levels of essential and semi-essential amino acids, particularly in lysine, methionine, threonine, leucine, tryptophan, and arginine. Additionally, tea seed oil showed elevated levels of non-essential amino acids like serine, aspartic acid, and glycine, whereas tomato seed oil displayed higher levels of cysteine, tyrosine, and alanine. These findings suggest that tea seed oil may promote better growth compared to other oilseed samples, as essential amino acids are crucial for overall health and well-being. Lysine deficiency, for instance, can lead to physical and mental impairment (Papes *et al*., 2001). The amino acid values observed in these seed oils were notably higher than those reported for other varieties and oilseeds (Satish and Shrivastava, 2011).

Regarding protein levels, tea seed oil exhibited the highest concentration at 8.77 ± 0.00%, whereas African oil bean seeds had the lowest at 6.95 ± 0.01%. This aligns closely with findings reported by Okoye and Okobi (1984), who analyzed the physical and chemical parameters of oils in lesser-known Nigerian oilseeds.

Minerals such as iron, magnesium, sodium, potassium, manganese, and zinc are essential for good health. Tomato seed oil displayed the highest iron level, while African oil bean seed had the lowest. Magnesium content was highest in African locust bean seed oil and lowest in castor seed oil. Sodium levels were highest in African oil bean seed oil and lowest in cotton seed oil. Potassium content was highest in African oil bean seed oil and lowest in castor seed oil. Tomato seed oil exhibited the highest manganese level, while African oil bean seed had the lowest. Zinc levels were highest in tomato seed oil and lowest in African oil bean seed. These minerals present in the analyzed oils serve as variable sources in the body. However, the zinc and iron levels obtained from the oil analysis were relatively low. The variation in mineral elements may stem from differences in uptake rates from the soil by plants and subsequent incorporation into their constituents. Previous studies have indicated higher mineral values in this study compared to citrullus vulgaris seed oil (Zaharaddeen *et al*., 2014). In another study by Besong *et al.* (2011), the Fe content in African melon oil seed was 6.45 mg/100g which is way lower than all the Fe contents in this study.

According to Bhukya *et al.* (2019), Oilseeds are a good source of the vitamin; niacin, tocopherols, pantothenic acid, riboflavin and thiamine. Vitamins are vital component that helps the body immune system build strong defense against diseases and infections. The oils obtained from oilseed samples analysed contained both water and fat soluble vitamins were present in all the oilseeds samples; (A, D, E, K, C and B_2). Vitamin A had the highest in African oil bean seed while tomato seed oil had the lowest ranged from 19.45 ± 0.01 to 7.99 ± 0.01 mg/100g. Vitamin D with cotton seed oil and tomato seed oil had same value as the highest while African oil bean seed and tea had the same value as the lowest ranged from 0.15 ± 0.00 to 0.07 ± 0.00 mg/100g. Vitamin E with tomato seed oil has the highest while African oil bean seed had the lowest ranged from 1.88 ± 0.00 to 0.57 ± 0.01 mg/100g. Vitamin K with African oil bean seed had the highest while tomato seed oil had the lowest ranged from 0.06 ± 0.00 to 0.03 ± 0.00 mg/100g. Vitamin C with African oil bean seed had the highest while tomato seed oil had the lowest ranged from 17.33 ± 0.01 to 8.15 ± 0.01 mg/100g. Vitamin B_2 with African oil bean seed had the highest while tomato seed oil has the lowest, ranged from 1.88 ± 0.00 to 0.56 ± 0.00 mg/100g. In this study the vitamin content was tremendously higher than those from the research of Eller *et al.* (2010) in which the vitamin E contents ranged from 0.94 mg/g to 1.11 mg/g.

Fatty acids profile of the oilseed samples determined were as follows: capric acid, lauric acid myristic acid, palmitic acid, stearic acid, oleic acid, linoleic acid linolenic acid and arachidonic acid. African oil bean seed had the highest value in capric acid, lauric acid, myristic acid, palmitic acid, stearic acid, oleic acid, linoleic acid, and arachidonic acid 0.54 ± 0.00, 2.63 ± 0.00, 0.54 ± 0.00, 0.69 ± 0.01, 0.97 ± 0.00, 8.49 ± 0.01, 50.32 ± 0.00, 9.62 ± 0.01 respectively, while African oil bean seed had the lowest value in linolenic acid 22.72 ± 0.01. Tomato seed oil had the lowest value in lauric acid, myristic acid, linoleic acid and arachidonic acid 1.12 ± 0.01, 0.34 ± 0.01, 32.05 ± 0.01 and 7.50 ± 0.00 respectively. Tea seed oil had the highest and lowest value in linolenic acid and capric acid 33.66 ± 0.00 and 0.21 ± 0.01 respectively. Castor seed oil had the lowest value in stearic acid 0.12 ± 0.01. Cotton seed oil and tomato seed oil had the lowest values in palmitic acid with value 0.33 ± 0.00. In previous study it was revealed that Oleic acid (C18:1,9) was predominant in sunflower oil 88.84% and sesame oil 65.43%. The oleic acid content in the sesame oil is above the range specified in the Codex standard 35.90-42.30% but the content in the sunflower oil (SN1) sample analyzed was within the range for high oleic sunflower seed oil 75- 90.7% (Admassie *et al.,* 2021).

CONCLUSION

The findings in this study revealed the physicochemical and the nutritional levels of the oils in the oilseed samples analysed which showed that they all have appreciable nutrient levels which are good for human consumption. The level of protein and essential amino acids are generally higher in Tea seeds oil than other samples analysed. It was further revealed that tea seed oil had highest amount of essential amino acids such as lysine, methionine, leucine tryptophan, threonine and arginine. However African oil bean seed had the highest amount of vitamins A, B2, C, and K and also had the highest level of sodium and potassium.

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