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Physical Properties, Chemical Composition and Nutritional Quality Potentials of *Lonchocarpus sericeus* (Cube root) Seeds and Seed Oil

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Abstract

Physical properties, chemical composition, and nutritional quality potentials of the seeds of *Lonchocarpus sericeus* (cube root) were investigated. The water absorption properties of the seeds were measured both gravimetrically as hydration capacity (0.02±0.005 g/seed), and hydration index (0.06±0.01) and volumetrically as swelling capacity (0.01±0.00 mL/seed) and the swelling index ($1.2x10^{-4}$±0.00). A 100 g of seeds contained 17.53±2.08, 38.83±4.16, 3.18±0.19, 24.93±3.21, 29.96±3.82, and 3.10±0.89 g moisture, crude fiber, ash, crude fat, crude protein, and nitrogen-free extract (NFE), respectively; Further, the sample had per 100 g 149.20±0.24 kJ gross energy, 848±16.1, 722±10.0, 720±9.1, 230±8.2, and 224±8.1 mg Fe, Mn, Zn, Cu, and Na, respectively. The seed also contained 3.14±0.12, 2.18±0.32 and 4.30±0.06 mg/g tannin, oxalate, and saponin, respectively. The essential-to-total amino acid ratio (E/T, %) was 44.10 %; the average predicted protein efficiency ratio (PER) was 2.70, while the predicted biological value (BV) was 34.85. Elaidic acid was the most significant fatty acid (46.32 %) found in the seeds with a total saturated and unsaturated fatty acids of 46.14 and 50.50 %, respectively. The oil of *L. sericeus* was equally rich in bioactive compounds, including tocopherols, sterols, phospholipids, tocotrienols, and terpenoids with a concentration of 50.09, 479.13, 333.14, 1.34, and 3.33 x 10^{-4} mg/100g, respectively. *L. sericeus* seed can be a potential source of dietary energy, industrial oil, bioactive compounds, and vegetable protein.

Keywords: Bioactive compounds, Elaidic acid, *Lonchocarpus sericeus,* Micronutrients, Underexploited legume vegetable oil

Introduction

The problem of inadequate animal protein intake particularly in developing countries in the tropics due to the high cost and short supply is frequent [1,2], and this is expected to escalate in the coming years due to unplanned population growth and insecurity fueled by the insurgency. Nigeria currently has spent over $44 million annually on the importation of cowpea to bridge the gap between domestic production and cowpea consumption deficit of five hundred thousand tons. Research into new seed crops for protein and oils for human and animals will conserve scarce foreign exchange, providing adequate nutrition that could alleviate the consequences of inadequate protein in diets, and also the various civilization-related diseases, e.g. diabetes, cardiac diseases and obesity since many health-promoting roles have been ascribed to bioactive food components [3,4]. Consequently, attention has been directed at sourcing alternative cheaper plant protein and seed oil to alleviate the problem of malnutrition in children and pregnant women, and also provide feeds for animals particularly in the areas ravaged by drought and conflicts

[5-8]. Several workers had acknowledged the suitability of *Cajanus cajan* (pigeon pea), *Vigna unguiculata* (cowpea), and *Glycine max* (soybean) as cheaper vegetable protein sources and alternatives to the expensive animal proteins [9,10] while *Lannea kerstingii* [11], pomegranate, cherry, pumpkin [3,12], chia [4], and garden cress (*Lepidium sativum* L.) seeds have also been documented for their excellent seed oils and bioactive components [13]. The present study reports the physical properties, chemical composition, and nutritional quality potentials of *L. sericeus* (Cube root) seed. *L. sericeus* (Poir.) is a Leguminosae belonging to the subfamily *Papilionaceae*. It is commonly called cube root or Senegal lilac. Its seeds are usually oblong-kidney-shaped, reddish-brown, about 7 and 5 mm long and wide, respectively. It is native to several West African countries, including Nigeria, where its bark and roots have been explored for medicinal uses [14]. The plant grows wildly, and its cultivation is supported by the climate and soil of the West African region [14,15]. The seeds of *L. sericeus* had been reported to be abundant in flavonoids, particularly flavonol, quercetin, sugars, vitamins, and bioactive principles including carotenoids and anthocyanins [16]; it is also rich in insecticide rotenone [15]. The seed of *L. sericeus* remains unexploited, and if found nutritionally suitable, it could serve as a partial replacement for cowpea as dietary protein and oil supply.

Materials and methods

Seed samples

In this study, *L. sericeus* seeds were obtained from the biological garden of the Federal Polytechnic, Ilaro in South West Nigeria, (6.89 °N, and 3.02 °E) between March and April 2019. They were identified at the Forestry Research Institute of Nigeria (FRIN), Ibadan with herbarium number FHI 110133. A clean bulk, matured, healthy and unbroken seeds were used. A portion of the bulk was removed for the determination of physical properties, while the remaining was reserved for chemical analysis. The latter portion was washed with deionized-distilled water, drained, and dried in oven at 60 °C; the seeds were pulverized in a Waring laboratory blender (MX-LBC15), sieved, and kept in an airtight polythene bag for chemical analysis.

Physical properties of *L. sericeus* seeds

Seed weight, seed volume, seed density, hydration capacity, hydration index, swelling capacity, and swelling index were determined as previously described [9,17-19]. Briefly, the weight of 100 seeds was determined on an analytical balance and was recorded in grams (g). Seed volume was measured by transferring the previously weighed 100 seeds sample into a 100 mL measuring cylinder and 50 mL distilled water was added. Seed volume was expressed as an increase in volume per 100 seeds (mL/100 seeds). Seed density was calculated by dividing the weight of 100 seeds sample by their volume measured with a 100 mL measuring cylinder. Hydration capacity was recorded as the gain in weight after an overnight soaking of 100 seed samples in distilled water; while hydration index was calculated as hydration capacity divided by the initial 100 seeds weight. Swelling capacity was the increase in the volume of 100 seeds sample after an overnight soaking in distilled water, and the swelling index was determined by dividing the swelling capacity with the initial seed volume and expressed as mL/seed. All the determinations were carried out in triplicates.

Proximate, mineral, and anti-nutritional composition

Powdered seeds sample was used for the determination of moisture, Kjeldahl nitrogen, ether extract, and crude fiber and ash contents following the standard official methods [20]. Crude protein was estimated as %N multiplied by 6.25. Nitrogen free extractives (NFE) was determined by the following Eq. (1).

$$\%NFE = 100 – (\%crude\ protein + \%crude\ fibre + \%crude\ fat + \%ash + \%moisture. \quad (1)$$

The gross energy value of the seed was estimated in kilojoules by multiplying the crude protein, ether extract, and NFE by the factors of 16.7, 37.7 and 16.7, respectively [21]. Triplicate determinations were done for all the experiments. Seed flour samples were also analyzed for potassium, magnesium, calcium, sodium, manganese, iron, copper, and zinc using Atomic Absorption Spectrophotometer (Buck 210 VGP) while phosphorus content was determined by colorimetric technique (Ammonium molybdovanadate) following standard official methods [20]. The oxalate, tannin, and saponin contents of seed flour were also determined by official methods [20].

Extraction of seed oil and determination of fatty acid composition

Soxhlet extraction of *L. sericeus* seed flour for oil was done with 400 mL n-hexane for 8 h. Solvent recovery was carried out by using a vacuum rotary evaporator (RE300 Bibby) at 40 - 50 °C. Determination of fatty acid composition was carried out using the official method [20] and a modified method of Omar and Salimon [22]. One microliter of fatty acid methyl ester (FAME) was injected into a GC-FID (HP 6890) with an HP column (30 m × 0.25 mm × 0.25 µm particle size) with a helium carrier gas. The injector temperature was 250 °C with split-less modes. The initial column temperature was set at 80 °C, and held for 1 min, and ramped at 10 °C/min to 200 °C for 2 min then 20 °C/min to 300 °C for 8 min. Six internal standards of saturated fatty acids (Palmitic, stearic, arachidic, and lignoceric acids) and unsaturated fatty acids (Elaidic and oleic acids) were processed with n-hexane then their methyl esters were prepared, and analyzed under the same conditions.

Bioactive components in the seed oil of *L. sericeus*

Tocopherols and tocotrienols in the seed oil were determined as described by Du and Ahn [23]. Sterols and terpenoids contents of the oils were evaluated using the modified methods of AOAC [24,25]. The method of Raheja *et al.* [26] was used for analysis of phospholipids. An HP 6890 GC-FID system was used for the analyses with split injection in the ratio of 20:1 and a detector temperature of 300 °C. The inlet temperature was maintained at 290 °C with helium as the carrier gas for tocopherols and tocotrienols while nitrogen was the carrier gas for sterols, terpenoids and phospholipids. HPINNOWax column (30 m × 0.25 mm × 0.25 µm, particle size) was used for sterols and terpenoids analyses while HP-5ms UI with the same dimension was used for the studies of tocopherols, tocotrienols and phospholipids. The oven program had an initial temperature of 180 °C for 0 min. The first ramp at 8 °C/min to 260 °C and second ramp at 2 °C/min to 280 °C was held constant for 13 min. The flow rate and hydrogen pressure were 2.5 mL/min and 22 psi, respectively, while data acquisition was achieved with HP ChemStation Rev. A 09.01 [1206] software.

Amino acid derivatization, analysis, and protein quality evaluation

Determination of the amino acid content of *L. sericeus* was performed following modified AOAC and Danka *et al*. methods [20,27]. A half gram of sample was weighed and added into 250 mL conical flask and defatted with 30 mL petroleum ether using Soxhlet extractor. The defatted sample was soaked in 30 mL of 1 M KOH solution and incubated for 48 h at 110 °C in hermetically closed borosilicate glass container. After the alkaline hydrolysis, the pH of hydrolysate was adjusted to a pH range of 2.5 - 5.0. This was thereafter purified by cation-exchange solid-phase extraction. The amino acids in purified solution were derivatized with ethyl chloroformate that was, afterward, removed by passing streams of nitrogen gas. Aliquots of amino acid derivatives dissolved in dichloromethane were analyzed by gas chromatography equipped with a pulsed flame photometric detector (GC-PFPD). One microliter of concentrate was injected into the gas chromatograph (HP 6890) with HP-5MS column (30 m × 0.25 mm, 0.25 µm particle size) for individual amino acid peaks. The initial temperature of the hydrogen carrier gas and column was 60 °C. It was ramped at 8 °C for 20 min and held constant for 2 min and then increased to 12 °C/min for 6 min. Amino acids standard solutions were repeatedly analyzed for five times and the calibration curves obtained had correlation coefficients ≥ 0.9992.

Subsequently, the quality of seed protein was evaluated by:

a) Calculating the proportion of essential amino acids (E) to the total amino acids;
(T)×100, $\left(\frac{E}{T} x100\right)$ (2)

b) Computing essential amino acids index (EAAI) using equation (3);

$$EAAI = 10^{logEAA} \quad (3)$$

where $logEAA = 0.1[\log(\frac{a_1}{a_s} x\ 100) + \log(\frac{a_2}{a_s} x\ 100) \ldots.. + \log(\frac{a_n}{a_{ns}} x\ 100)]$
$a_1 \ldots \ldots. a_n$ = Amino acids content of the sample
$a_s \ldots \ldots. a_{ns}$ = Amino acids values from the reference i.e., whole egg

Herein, amino acids values from the reference are: Ile = 4.00; Leu = 7.04; Lys = 5.44; Met + Cys = 3.52; Trp = 0.56; Val = 4.76; Phe + Tyr = 6.08; Thr = 4.00; and His = 2.40.

c) Biological Value (BV), was estimated from EAAI

$$BV = 1.09(EAAI) - 11.73 \quad (4)$$

d) The protein efficiency ratio (PER) was predicted from the amino acid content according to the equation

$$PER = -0.468 + 0.454(Leu`) - 0.105(Tyr) \quad [28] \quad (5)$$

Results and discussion

Physical properties

The physical properties of *L. sericeus* seeds are presented in **Table 1**. The weight of 100 seeds of *L. sericeus* is similar to that of *Lupinus Albinus* (28.65±0.28 g [18] but slightly heavier than *Lathyrus maritimus* seeds (25.27±0.05 g) [17]. It is about three times heavier than the seeds of *C. cajan* (10.57±1.029 g) [9]; but lighter than the seeds of *Parkia roxburghii* (53.00±4.00 g [19]. The weight of *L. sericeus* as determined in this study could be classified alongside the medium market class of 25 - 40 g/100 seeds, where the most common bean (*Phaseolus vulgaris* L.) species are grouped. The market classes are grouped as small ≤ 25, medium 25 - 40, and large ≥ 40 g/100 seeds [29]. The seed volume (mL/100 seeds) of 24.75±0.96 followed a similar pattern with the seeds earlier stated. This is reflected in the density of the seed as it is similar to the density of all the seeds mentioned previously except that of *P. roxburghii* (0.45±0.05). The hydration capacity (0.02±0.00 g/100 seeds), hydration index (0.06±0.008), swelling capacity (0.011±0.00 mL/seed), and swelling index (1.2×10^{-4}±0.00) as presented in **Table 1** showed comparable values with those of matured *L. maritimus* [7] and *C. cajan* [9]. Arising from their low physical characteristic values, *L. sericeus* seeds would have poor swelling properties that could make them unsuitable for some domestic applications that include the preparation of puddings, soups, and sauces [29]. These characteristics may not be unconnected with the fact that *L. sericeus* seeds have a glossy and hard coat, therefore, making them impermeable and not easily hydrated. Consequently, it may take a longer time for the seeds to germinate or cook as cooking time positively correlates to seed physical properties such as density, swelling index, hydration capacity and swelling capacity and seed coat characteristic; these qualities influence the inclination of consumers and processors of seed legumes [17,30].

Table 1 Physical Properties of the seed of *L. sericeus*.

Parameter	Mean ± SD
Seeds weight (g/100 seeds)	28.08±0.45
Seed volume (mL/100 seeds)	24.75±0.96
Seed density (g/mL)	1.14±0.04
Hydration capacity (g/100seeds)	0.02±0.00
Hydration index	0.06±0.01
Swelling capacity (mL/seed)	0.011±0.00
Swelling index	1.2×10^{-4}±0.00

Proximate, mineral and antinutrient composition of *L. sericeus*

The chemical composition of *L. sericeus*, as shown in **Figure1** compares well with those of cowpea (*V. unguiculata*) and scarlet runner bean (*Phaseolus coccineus*) [31]. The composition of different varieties of cowpea and scarlet runner bean previously reported in g/100 g contained moisture (0.4 - 1.8), ash (3.61 - 4.11), crude fat (2.13 - 7.53), and crude protein (7.53 - 52.61) while the results from our present study showed *L. sericeus* to be higher in crude protein than cowpea (7.53±0.02) but less than scarlet runner bean (51.14±0.0); however, crude protein value from the present work is greater than the 28.03 % reported for *L. sericeus* in a previous study [32]. Besides, the results from this study also showed higher values than crude fat (3.45±0.06 %), crude fiber (6.85±0.07 %), crude protein (23.45±0.62 %), ash (3.55±0.04 %), but lower in carbohydrate (58.89±0.44 %) reported for cowpea cultivars from Sri Lanka [33] and still lesser than the average of 62.32±2.18 g/100 g for different accessions of *Mucuna* beans [34]. The crude protein and ash contents of *L. sericeus* compare with 29.83±1.15 and 3.44±0.3 g/100 g, respectively, reported by Mohan and Kala, 2010 [35] for *M. pruriens* (Velvet bean) but richer in lipid and crude fibre contents. *L. sericeus* has higher protein, fiber, and fat content than black turtle bean (*P. vulgaris*) that had 23.7±0.15 protein, 3.3±0.01 crude fibre and 15.2±0.05 fat [36]. The crude ether extract of 24.93±3.21 g/100 g for *L. sericeus* is very high compared to the 22.5 and 1.3 g/100 g documented by El-Shemy *et al.* [37] for soybean and faba beans, respectively; it is, however, about half the 45.41-48.14 g/100 g reported by many workers for *Arachis hypogea* [38,39]. *L. sericeus* can invariably be classified as an oil-bearing seed since it contains oil in the range of those classified as oil-rich seeds. Comparing the results obtained in this study with soya beans seeds, *L. sericeus* had higher crude fiber but lower crude protein, ash, and nitrogen-free extract than soya bean seeds [40]. The gross energy value of 149.2±0.2 kJ/100 g (**Table 2**) obtained in the present study is not unexpected because of its high crude ether extract. The value compares well with 168.4±0.2 kJ/100 g reported for different accessions of *Mucuna* beans [34] but less than 1597.6 - 1654.0 and 1600.6 kJ /100 g for *V. aconitifolia* and *V. unguiculata*, and *C. catharica*, respectively [41,42].

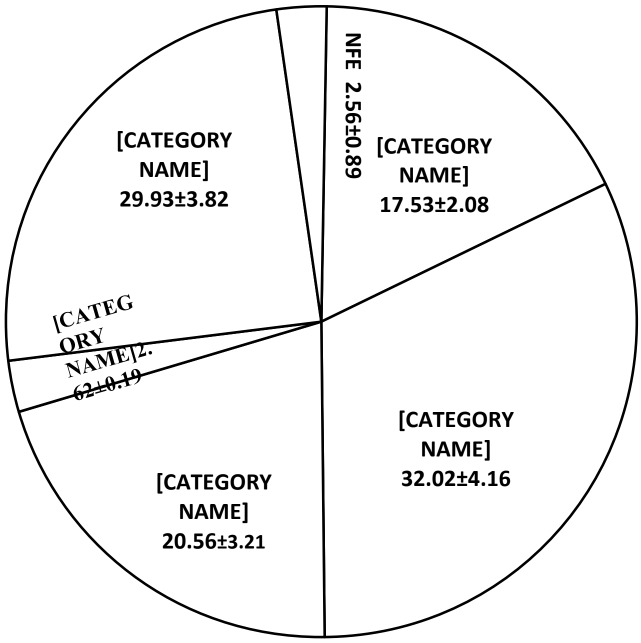

Figure 1 Proximate composition (g/100g) of the seeds of *L.sericeus*

The results of the mineral composition of *L. sericeus* in mg/100 g is as shown in **Figure 2**. *Lonchocarpus sericeus* is very rich in Na (224.8±8.10 mg/100 g) but poor on other macroelements when compared to cowpea that had 1062, 745.4, and 416.4 mg/100 g Ca, K, and Mg, respectively [6]; and 443.0±12.17, 1417.5±21.65, 101.7±7.20, and 109.8±3.81 for P, K, Ca, and Mg, in that order for *M. pruriens* [35]. Equally abundant in *L. sericeus* seeds are micronutrients including copper (230.0±8.21), zinc (720.0±9.06), manganese (722.0±10.04), and iron (848.0±16.09 mg/100 g). The amount of sodium in *L. sericeus* and the other micronutrients as mentioned earlier far exceeded what had been reported for most legumes. The seed also contained more iron and zinc than newly developed chickpea (*Cicer arietinum* L) varieties [43], and more sodium than in the chickpea reported by Simsek *et al.* [44] thus making *L. sericeus* seeds an excellent source for sodium and the micronutrients it contained. The Ca/P, and Na/K ratios obtained in this study (**Table 2**) may promote loss of calcium and high blood pressure [31]; and also, since the excess of one mineral has been reported to decrease the absorptivity and proper utilization of another for good nutrition [45], potassium supplementation may be required to correct the Na:K imbalance in the seeds of *L. sericeus* while the Ca:P revealed the high value of phosphorus, therefore there may be a need to complement *L. sericeus* with seed grains rich in calcium.

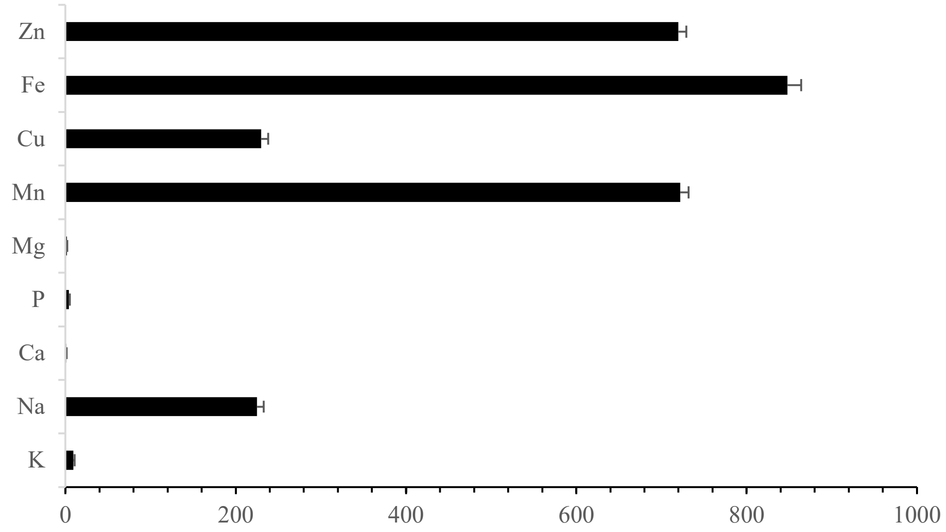

Figure 2 Mineral composition (mg/100 g) of the seed of *L. sericeus*.

The results of tannins, oxalates, and saponin contents of *L. sericeus* are as shown in **Table 2**. They are 3.14±0.12, 2.18±0.32, and 4.30±0.06 in mg/g, respectively. These values are higher compare to those reported by Soetan *et al*. [46] for the seeds of *P. biglobosa* (tannin, 0.51±0.00; oxalate, 0.47±0.01; and saponin, 0.92±0.00 mg/g) and approximately two times the values of the same parameters reported by Carew *et al*. [47] for *M. puriens* seeds. However, the values presented in this study are generally lower than those reported for most consumed legumes including red kidney beans, lentils, white beans, Anasazi beans, and blackeyed pea [48]. From the concentrations of saponin, tannin, and oxalate obtained in this study, it is not likely they will affect the nutritional potentials of *L. sericeus* to any significant extent and neither will they pose any undesirable effects on its utilization.

Table 2 Gross energy, minerals ratio and anti-nutritional composition of the seed of *L. sericeus*.

Gross energy kJ/100 g	**149.20±0.24**
Na/K	23.86
Ca/P	0.26
Anti-nutritional constituents (mg/g)	
Tannins	3.14±0.12
Oxalate	2.18±0.32
Saponin	4.30±0.06

Fatty acid composition of *L. sericeus*

The fatty acid composition of *L. sericeus* seed is indicated in **Table 3** with more unsaturated fatty acids than saturated. The seed is very rich in dietary saturated fatty acids with palmitic acid (22.88 g/100 g) been the most abundant. Elaidic acid (46.32 g/100 g), a trans - ω^9 fatty acid is the most abundant in *L. sericeus;* though not an essential fatty acid like ω^3 and ω^6 fatty acids, ω^9 fatty acids protect against the possibility of metabolic syndrome and cardiovascular disease risk factors. They have been shown to increase high-density lipoprotein cholesterol and decrease low-density lipoprotein cholesterol; they also help reduce plaque buildup in the arteries that could pre-dispose an individual to a heart attack or a stroke [49]. ω^9 fatty acids provide energy, besides, they are structural components of cell membranes, and contribute desirable texture and tastiness to foods [50]. The ratio of unsaturated to saturated fatty acids (1.1) obtained in this study reveals that consumption of *L. sericeus* oil will supply healthy fatty acids and can also overcome the negative effects associated with fatty acids [19].

Table 3 Fatty acid composition* of *L. sericeus* seed oil in g /100 g lipid.

Saturated fatty acids	
Palmitic acid	22.88
Stearic acid	9.04
Behenic acid	7.84
Arachidic acid	2.65
Lignoceric acid	2.50
Margaric acid	1.23
Unsaturated fatty acids	
Elaidic acid (18:1)	46.32
Oleic acid	4.03
Cinnamic acid	0.15
Others	
Warfarin	0.78
Megastigmatrienone	0.56
Cuparene	0.20
Alpha-phenyl-o-xylene	1.81
Total saturated	46.14
Total unsaturated	50.50
Unsaturated / Saturated	1.10

Bioactive components in the seed oil of *L. sericeus*

The seed oil of *L. sericeus* contained all the eight different isomers of vitamin *E* with γ-tocopherol been the most abundant at about 89 % similar to that of soya bean oil (88 %) and higher than 10.5, 58, and 46 % for Brazil nut (*Bertholletia excelsa*), olive and walnut oils, respectively [51,52]. The total concentration of *α*- and γ-tocopherols in the oil was 50.09 mg/100 g, while the total tocol (tocopherols + tocotrienols) composition was 51.43 mg/100 g as shown in **Table 4**. The value is higher than the 42.54 mg/100 g total tocopherol reported by Nehdi [51] for cold-pressed olive oil; while it compared with the 55 mg/100 g total tocopherol in coconut oil; and, however, higher than 33 mg/100 g for palm kernel oil [53]. Tocotrienols, though more potent in antioxidant activity [54] are reportedly less abundant in plant products compared to tocopherols [55], and this is demonstrated in the present study. Due to its high levels of γ-tocopherol, the oil can find use in cosmetic and pharmaceutical formulations by adding value and stability to those products because of their inherent antioxidant capacity; and in some instances, improve their emollient effects. Taraxerol, α-amyrin, β-amyrin, luperol, and bauerenol acetate were confirmed in the seed oil in trace amounts of 0.333 mg/100 g as shown in **Table 4**. α- and β-amyrin isolated from *Alstonia boone*i stem bark reportedly had profound anti-inflammatory activities in rodents [56]. Ebajo *et al.* [57] also isolated these terpenoids from *Hoya multiflora* (shooting-star hoya) stem and leaves but did not report any biological activity on the isolates. De Amorim and co-workers, however, isolated the same principle from the leaves of *Pseudobrickellia brasiliensis* used as painkillers and in the treatment of inflammation [58]. The presence of terpenoids in the oil sample suggests that it could be useful as an analgesic and anti-inflammatory agent. *Lonchocarpus sericeus* seed oil is rich in phosphatidylcholine (230.37 mg/100 g) accounting for 69.15 % of total phospholipids. Phosphatidylinsitol and phosphatidylethanolamine were the next most abundant as indicated in **Table 4**. The total phospholipids in *L. sericeus* were 333.14 mg/100 g. Phospholipids have been established to improve the antioxidant properties of oils because of the synergism between them and tocopherols [59]. They also through their phosphate groups, chelate pro-oxidant metals and act as an oxygen barrier between oil and air interfaces [60]. Hidalgo *et al*. [61] used the Rancimat method to demonstrate that the addition of mixtures of amino acids to phospholipids further enhanced their antioxidant properties. Phosphatidylcholine and phosphatidylserine have respectively been reported in the treatment of liver conditions and the prevention of brain deterioration [62]. Sterols in the present study were found in amounts ranging from 302 - 310, 105 - 107, 52 - 78, and 12 - 16 mg/100 g in that order for sitosterol, campesterol, stig-masterol, and Δ^5-avenasterol, respectively with sitosterol been the most prevalent and accounted for over 60 %. Other steroids determined in trace quantities include cholesterol, cholestanol and ergosterol. The total sterol contents for *L. sericeus* were 479. 13 mg/100 g. The campesterol content exceeded the 4 % maximum acceptable limit against the total sterol content for olive oils with stigmasterol also exceeding limits [63]. The sterol composition of the seed oil is higher than the 146.75 - 247.68 mg/100 g reported for different Tunisian olive oils shown to have good nutritional characteristics [64], and also the 204.0 - 248.0 mg/100 g for acorn fruit oils [65]. Sterols from plants, like other sterols are critical constituents of cellular membranes where they regulate fluidity and permeability [66, 67]. They have been reported to have the ability to lower blood serum cholesterol in hypercholesterolemic and diabetic patients and healthy human volunteers [68]; they are also as effective as many cholesterol-lowering drugs [69]. The consumption of vegetable sterols has been associated with a lower risk of myocardial infarction, lowering LDL cholesterol even when combined with non-fat matrices. Additionally, they may moderate biomarkers of oxidative stress and inflammation and modulate the development of atherosclerosis.

Table 4 Bioactive components in the seed oil of *L. sericeus*.

Bioactive compounds (mg/100 g)		***L. sericeus***
Tocopherols	α-tocopherol	3.83
	γ-tocopherol	45.94
	β-tocopherol	$5.98*10^{-5}$
	δ-tocopherol	$3.19*10^{-1}$
		50.09
Tocotrienols	α- tocotrienols	$4.33*10^{-1}$
	γ-tocotrienol	$8.34*10^{-1}$
	β-tocotrienol	$7.36*10^{-2}$
	δ-tocotrienol	$1.48*10^{-4}$
		1.34
Terpenoids	Taraxerol	$3.18*10^{-4}$
	α-amyrin	$1.35*10^{-2}$
	β-amyrin	$3.09*10^{-1}$
	Luperol	$1.74*10^{-3}$
	Bauerenol acetate	$8.59*10^{-3}$
		$\mathbf{3.33*10^{-1}}$
Phospholipids	Phosphatidylethanolamine	26.31
	Phosphatidylcholine	230.37

Bioactive compounds (mg/100 g)		***L. sericeus***
	Phosphatidyserine	4.59
	Lysophosphatidylcholine	2.29
	Phosphatidylinsitol	69.58
		333.14
Sterols	Cholesterol	$5.05*10^{-6}$
	Cholestanol	$4.67*10^{-4}$
	Ergosterol	$1.57*10^{-5}$
	Campesterol	107.48
	Stig-masterol	52.30
	Δ^5-avenasterol	16.80
	Sitosterol	302.55
		479.13

Amino acid composition of *L. sericeus*

The amino acid profile of *L. sericeus* in g/100 g of protein is presented in **Table 5.** The concentrations of glutamic acid (18.22), leucine (7.68), aspartic acid (7.14), proline (6.10), arginine (5.99), valine (5.47), and lysine (5.35) were high while the concentrations of methionine and cystine were the lowest (2.13 and 1.84 g/100 g)˙, however, tryptophan was not detected; while leucine and arginine at 7.68 and 5.99 g/100 g, respectively were the most abundant essential amino acids. The ratio of essential amino acids to total obtained for *L. sericeus* was 44.10 % and is above the 36 % considered adequate for an ideal protein [70]. The protein efficiency ratio (PER) of 2.70 obtained in this study is higher than 1.87, 1.21, and 1.82 reported for *P. biglobosa*, *V. unguiculanta*, and *C. cajan*, respectively [71,72]. The essential amino acid index (EAAI) of the seeds was 42.73, and the biological value (BV) of 34.85 was computed from it. The BV of 46.68 and 48.31 reported for roasted and pressure-cooked seeds of *Canavalia cathartica,* [7] and 63.35 for Bambara bean (*V. subterranea*) [73] are greater than 34.85 obtained in the present study; however, this value is more than the 22.56 for *P. biglobosa* flour [71]. The contents of essential amino acids of *L. sericeus* especially leucine, valine, threonine, and histidine were higher than those of the FAO/WHO that was found to be sufficient for an ideal protein while lysine is at a comparable level with the recommended pattern [74]. The values of essential amino acids such as Leu, Val, Arg, and Lys reported in this study are higher when compared to those found in soybean seeds [75].

Table 5 Amino acid content in g/100 g seed of *L. sericeus*.

Essential amino acids	
Leucine	7.68
Valine	5.47
Isoleucine	3.73
Threonine	4.49
Histidine	3.02
Lysine	5.35
Methionine	2.13
Cystine	1.84
Phenylalanine	4.00
Arginine	5.99
Non-essential amino acids	
Glycine	4.88
Alanine	4.28
Serine	4.28

Essential amino acids	
Proline	6.10
Aspartate	7.14
Glutamate	18.22
Tyrosine	3.09
Total	91.66
Protein quality evaluation	
E/T, %	44.49
PER	2.70
BV	34.85
EAAI	42.73

Conclusions

This study has reported chemical composition, physical properties, and nutritional potentials of *L. sericeus*. The seeds were shown to be high in crude protein and fat contents but low in carbohydrate content. The amounts and quality of its oil and protein compared well to those for soybean and other common staples, it therefore clearly shows promise as a protein supplement for low-protein foods and feeds such as cereal grains. As an oil-rich seed with a good fatty acid profile, its oil can be exploited for human and animal nutrition after further investigation into its characteristics, and the oil could be exploited for industrial purposes. The seed has an interesting composition in macro and micronutrients, and also minimal in antinutrients thus having the potential to cover human nutritional requirements. With increasing population growth and continuous depletion of available food resources, *L. sericeus* represents a potential food source, which could reduce protein shortages and expand available food options and varieties, generate income, and allow farmers to spread risk in times of crop failure. However, further studies into its possible toxic and antinutrient factors such as L-Dopa and trypsin inhibitors, and digestibility is still required.

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