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Evaluating the Nutritional and Chemical Composition of *Treculia Africana* and *Vigna Subterranea* L. Seeds Collected from Kogi State, Nigeria

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ABSTRACT

This study aims to investigate the nutritional composition of two underutilized leguminous crops, namely *Treculia africana* and *Vigna subterranea* seeds, collected from Kogi state, Nigeria. The study analysed their proximate composition, mineral content, and amino acid profile using standard analytical methods. Additionally, the chemical composition of the sample was determined using gas chromatography-mass spectroscopy. The results showed that there were significant differences ($P \leq 0.05$) in the legume samples. However, *V. subterranea* seeds had the least moisture content (12.90±0.81 %) as well as the highest crude fat content, crude fiber content, crude protein and ash content at 15.70±0.41 %, 5.06±0.16 %, 27.86±0.25 % and 3.23±0.50 %, respectively. The elemental analysis in mg/100g indicated that the samples contained appreciable levels of essential minerals. *T. africana* had the highest magnesium, phosphorus, sodium, potassium and iron concentrations of 190.03±1.70 mg/100g, 315.95±1.60 mg/100g, 32.61±1.82 mg/100g, 1941.53±2.61 mg/100g and 39.50±1.73 mg/100g, respectively, while calcium (58.46±1.63) was most abundant in *V. subterranea* The samples were also rich in amino acids, which are the building blocks of protein. However, *V. subterranea* was the richest in amino acid content, as it had 33.07±2.22 g/100g and 46.01±4.24 g/100g, for essential and non-essential amino acids, respectively. The GC-MS characterization of the chemical composition of the samples showed that myristic acid (48.1) was the most abundant in *T. africana*, while ethyl palmitate (31.17) was the most abundant in *V. subterranea.* Overall, the results suggest that these legume samples are rich sources of both nutritional and pharmaceutical properties beneficial for human consumption.

Keywords: Amino acid profile, chemical composition, mineral concentration, proximate composition, *Treculia africana*, *Vigna subterranean*.

1. INTRODUCTION

Africa still faces a major issue with food and nutritional insecurity, with two hundred and thirty-two million individuals suffering from micronutrient deficiencies and around two hundred and thirty-nine million suffering from protein-calorie malnutrition [1]. Meat, dairy and seafood are costly for low-income households in rural Africa, even though they can help prevent protein-calorie malnutrition. Therefore, protein-rich plant foods have been the primary choice for many underprivileged African populations [1]. Legumes are a great source of inexpensive plant proteins and minerals compared to animal products and are the second most significant food crop in the tropics, after cereals [2]. Hence, natural legumes offer a valuable and affordable alternative source of protein for low-income populations in many developing nations, particularly in

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Asia and Africa where grains are a staple food [2].

The seeds of two native leguminous crops, *T. africana* (African breadfruit) and *V. subterranea* (Bambara nut) have great promise as sources of nutrients and useful chemicals. These crops are still underutilized and poorly researched despite their high nutritional content and capacity to adapt to local environmental conditions [3]. Thus, assessing their chemical and nutritional composition is crucial to encouraging their use as food resources and improving food security in areas where they are grown, like Kogi State, Nigeria. Through the use of a multidisciplinary approach to evaluate the nutritional and chemical composition of samples primarily from Kogi State, Nigeria, this study provides new insights into the potential benefits of *T. africana* and *V. subterranea* seeds for food security, nutrition and regional economic development.

Bambara nut is native to Africa. It is highly suited to the sub-Saharan African agroclimatic conditions, which are often harsh [3]. Bambara nuts have a desirable nutritional composition comprising minimal fat, a decent amino acid profile, a high protein and carbohydrate content [4]. The high nutritional value of Bambara nut, especially its essential amino acid content, including methionine, lysine and leucine as well as its adaptation to harsh environmental conditions makes it a valuable crop for food and nutrition security, especially in sub-Saharan Africa, where nutrient deficiencies affect the majority of the population [4]. Furthermore, it has been discovered that Bambara nuts have significant antioxidant qualities, which suggests they may have positive health effects [5].

The African breadfruit is one of the four genera and members of the family Moraceae. It is home to numerous tropical nations, including the West Indies, Ghana, Sierra Leone, Nigeria and Jamaica. *T. africana* is a delicacy among the Igbo people of southeast Nigeria. The plant is well known in southeast Nigeria as "ukwa." The biological value of the seeds is higher than even that of soybeans, and they have a remarkable polyvalent dietetic value [6]. It is one of the most prized commercial plants and a highly regarded medicinal plant used in most traditional herbal medicine treatments. It's considered high in fiber, vitamins, minerals, fat, carbs and high-quality protein. Significant concentrations of phytochemicals, including flavonoids, polyphenols, anthraquinones, saponins, and cardiac glycosides, are also present in it [6]. In traditional medicine, the plant's crude extracts alone or in conjunction with other herbs, have been used to cure various illnesses.

In a world where dietary habits are changing and people are becoming more aware of how food choices affect their health, the nutritional analysis of African breadfruit and Bambara nuts becomes germane. Therefore, by investigating the nutritional and chemical composition of *T. africana* and *V. subterranea* collected from Kogi State, Nigeria, this research harmonises traditional knowledge with contemporary nutritional science, thus closing the divide between traditional knowledge and modern understanding. This study investigates the proximate composition, mineral concentration, amino acid profile and chemical composition of *T. africana* and *V. subterranea* collected from Kogi State, Nigeria.

2. MATERIALS AND METHODS

2.1 Materials

Every chemical compound, reagent and solvent used in the experiment was acquired from Sigma-Aldrich (St. Louis, MO, U.S.A.). These included petroleum ether, sulfuric acid, boric acid, hydrolysate, hydrochloric acid, nitric acid and perchloric acid. All of the reagents were of analytical reagent grade.

2.2 Instruments

A Scitek Atomic Absorption Spectrometer, Model SP-AA3618, was used to analyse the samples for mineral content. This equipment has an air/acetylene burner, eight lamp supports, and a double beam. It also features a 350 mm focal length Czerny-Turner type monochromator. This spectrometer has a wavelength range of 185-900 nm, a wavelength repeatability of $\leq$ 0.05 nm and a wavelength precision of 0.15 nm. The exterior dimensions are 830 x 650 x 60 (W x D x H), and the spectral bandwidth variation is ±0.02 nm. The device makes use of deuterium background correction to guarantee accuracy. The photometer's optics are also shielded from corrosive fumes and dust.

A Technicon Sequential Multi-Sample (TSM) amino acid analyzer (Technicon Instrument Corporation, New York) was used to measure the amino acids, and the analytical techniques used followed the manufacturer's recommendations. The Technicon Sequential Multi-Sample (TSM) is fitted with two short columns, 35 × 0.6 cm, with adjustable bottom fittings. The resins (C-4 chromobeads) have an average particle size of 12 µm. The resin bed is 21 × 0.6 cm and operates at a temperature of 61ºC. It has a flow rate of 0.80ml/min and an operating pressure of 200-250 psi (1379-1724 kN/m^2).

The GC-MS Agilent Technologies, Model-7890A, the Gallenkamp oven (Model: 800-NE1V.32E-00), the Lenton furnaces, England, the water bath (Memmert model WTB24), the soxhlet extractor, and the Kjeldahl flask were additional instruments utilised.

2.3 Sample collection

Randomly selected matured accessions of *T. africana* and *V. subterranea* were collected from nearby farms in Lokoja, Kogi State, communities of Adankolo and Zangondaji, from September 4th to 8th 2023. The samples were cleared of soil particles and transported to the laboratory for analysis at a tropical ambient temperature.

2.4 Sample preparation

The Bambara nut (*V. subterranea*) and African breadfruit (*T. africana*) seeds were sorted, and foreign objects and rotten grains were eliminated. The seeds were hand-separated from their shells and allowed to air dry for three days. The dried African breadfruit and Bambara nut grains were then crushed into a powder using a pestle and mortar and sieved into fine flour using a 250 µm sieve.

2.5 Determination of Proximate Composition

Standard analytical techniques as described by the Association of Official Analytical Chemists (AOAC) [7] were applied to ascertain the moisture content, ash content, crude protein, crude fiber and percentage of fat. The carbohydrate content was determined by difference. Using the formula: $\%\,Carbohydrate\ content = 100 - (\%\,moisture + \%\,ash + \%\,crude\ protein + \%\,crude\ fiber + \%\,crude\ fat)$

2.6 Determination of Mineral Concentration

Samples were digested according to the AOAC [7] protocol for mineral analysis. After the sample was pulverised and weighed, 1.00 g was added to a 250 mL beaker. The beaker was filled with a strong acid mixture of 15.00 mL HNO_3 and 5.00 mL perchloric acid. The mixture was thoroughly mixed to guarantee appropriate mixing and then heated on a hot plate until a clear digest emerged. After letting the digest cool, it was quantitatively filtered into a 100 mL volumetric flask. To aspirate the filtrate into the AAS machine (Scitek Atomic Absorption Spectrometer, Model SP-AA3618) for trace metal analysis, it had to be produced up to the 100 mL threshold.

2.7 Determination of Amino Acid Profiles

To evaluate the sample, a Soxhlet extractor was used to extract 3.00 g of the sample for six hours at 40–60°C in petroleum ether, following the method described by Cooper *et al.* [8]. After extraction, a glass ampoule was filled with 30.00 mg of defatted samples and 7.00 mL of 6.00 mol/dm^3 hydrochloric acid. Nitrogen was released from the ampoule after oxygen was supplied to avoid the oxidation of some amino acids during hydrolysis. The ampoule was then sealed with a Bunsen flame and placed in a preheated oven at 105°C for 22 hours. After cooling, the tip of the ampoule was broken and its contents were filtered. The filtrate was then evaporated to dry at 40°C while vacuuming in a rotating evaporator. The residue was later dissolved in 5.00 mL of pH 2.0 acetate buffer and stored for 24 hours in a plastic bottle in the deep freezer. Finally, 5-10 microliters of the hydrolysate were added to the Technicon Sequential Multi-Sample (TSM) amino acid analyzer (Technicon Instrument Corporation, New York). The analysis took 76 minutes to complete once the sample was placed into the analyzer's cartridge.

2.8 Chemical composition of the samples using Gas chromatography-mass spectrometry (GC-MS) analysis

T. africana and *V. subterranea* were subjected to chemical composition analysis using the methodology outlined by Karki *et al.* [9]. The GC-MS analysis was conducted using Agilent Technologies Model-7890A gas chromatograph and 5975C mass spectrometer. For the gas chromatography analysis, an HP-5MS capillary column was used, which was 30 meters long, 0.320 mm in diameter internally, and had a 0.25 µm film thickness. Helium was used as the carrier gas with a pressure of 1.5 PSI, a constant flow rate of 1.4123 mL/min and an average velocity of 43.311 cm/sec. The temperature was programmed to start at 80 degrees Celsius for two minutes, then increase to 240 degrees Celsius at 10 degrees Celsius per minute. The injected samples had a volume of 1 µL, a split ratio of 50:1 and a split flow rate of 70.615 mL/min. The constituents were identified by comparing the published mass spectrum database (NIST 11. L) and literature data with the auto-integrated whole chromatogram.

2.9 Statistical Analysis

To assess the degree of significance between various samples, the obtained findings were statistically analysed using mean standard deviation and analysis of variance (ANOVA), as explained by Duncan's multiple range test. Significance was determined at $p < 0.05$.

3. RESULTS AND DISCUSSION

3.1 Proximate composition of *V. subterranea* and *T. Africana* samples

Table 1 shows the results of the proximate composition analysis of *V. subterranea* and *T. africana. V. subterranea* and *T. africana's* moisture content are 12.90±0.81 % and 38.90±0.76 % respectively. There is a significant difference ($p \leq 0.05$) between the moisture content of both samples, with *V. subterranea* having lower moisture content. This result is consistent with James *et al.* [2] study, which found that the moisture content of some lesser-known native legumes in Nigeria ranged from 9.30±0.00 % to 12.75±0.00 %. Compared to *T. africana*, *V. subterranea* is more resistant to deterioration and has a longer shelf life [2].

The ash content of *T. africana* and *V. subterranean* are 0.50±0.05% and 3.23±0.50% respectively. There was a significant difference ($p \leq 0.05$) between the two samples, with *V. subterranea* having the highest ash content. This finding is approximately similar to the study conducted by Musah *et al.* [10], which reported a 3.40±0.09% ash content for Bambara groundnut in Lapai, Nigeria. According to Godfrey *et al.* [11], this suggests that *V. subterranea* has a higher mineral content than the other sample analysed.

The crude fat content for *T. africana* and *V. subterranea* are 1.93±0.12 % and 15.70±0.41 % respectively. A significant difference ($p \leq 0.05$) was observed between the samples, with *V. subterranea* exhibiting the highest fat content. Nonetheless, the outcome is comparable to the study conducted by Abejide *et al.* [12], which revealed that the crude fat content of several Bambara nut claims varied, ranging from 9.88±0.17 % to 15.83±0.01 %. The fact that dietary fat supplies most of the energy required by man suggests that *V. subterranea* is a better source of calories than *T. africana* [13].

The crude fiber content for *T. africana* and *V. subterranea* are 4.76±0.25 % and 5.06±0.16 % respectively. There was a significant difference ($p \leq 0.05$) across the samples, with the maximum fiber content found in *V. subterranea* The outcome, however, is approximal to the study by James *et al.* [2], which found that the crude fiber content of a few lesser-known native legumes from Nigeria ranged from 2.33±0.01 % to 6.11±0.01 %. This suggests that compared to the other sample examined, *V. subterranea* is more suited to reduce the risk of obesity, heart disease, diabetes and softens stool [14].

The crude protein content for *T. africana* and *V. subterranea* are 16.53±0.42 % and 27.86±0.25 % respectively. There was a significant difference ($p \leq 0.05$)

across the samples, with the maximum fibre content found in *V. subterranea*. However, the outcome is approximated to that of Mohammed and Mhya [15] analysis, which found that Bambara groundnut varieties cultivated in north-eastern Nigeria had yields ranging from 19.5 % to 21.1 %. This indicates that *V. subterranea* is the better sample among the two examined for tissue growth and healing [16].

The carbohydrate content for *V. subterranea* and *T. africana* are 35.24±1.56 % and 37.38±1.12 % respectively. There was a significant difference ($p \leq 0.05$) between the samples, with *T. africana* exhibiting a higher carbohydrate content. However, the outcome is comparable to that of the Frances and Johnson [17] study, which had 38.39 % for *T. africana* seeds. This suggests that, compared to the other samples examined, *T. africana* seeds are considered to be a superior source of energy for all species [17].

Table 1. Proximate composition of *T. africana* and *V. subterranea* samples

Sample	Moisture content (%)	Ash content (%)	Crude Fat content (%)	Crude Fibre content (%)	Crude Protein content (%)	Carbohydrate (%)
Treculia Africana	38.90±0.76	0.50±0.05	1.93±0.12	4.76±0.25	16.53±0.42	37.38±1.12
Vigna subterranea L.	12.90±0.81	3.23±0.50	15.70±0.41	5.06±0.16	27.86±0.25	35.24±1.56

Note: Values are means ± standard deviation of triplicate analysis

3.2 Mineral concentration of the *T. africana* and *V. subterranea* samples

The results of the mineral concentration of *T. africana* and *V. subterranea* are shown in Table 2. The calcium content for *T. africana* and *V. subterranea* are 42.90±1.60 mg/100g and 58.46±1.63 mg/100g respectively. There was a significant difference ($p \leq 0.05$) among the samples, with the maximum calcium concentration found in *V. subterranea*. The result, however, is approximately similar to the 37 mg/100 g to 64 mg/100 g calcium concentration of *V. subterranea* found from various landraces in Namibia reported by Amarteifio *et al*. [18]. Calcium is necessary for blood coagulation, tooth and bone growth, muscle contraction and neurological function [19]. It is recommended that adults take 1000 mg of calcium per day, while children should take 500–800 mg [20].

The magnesium content for *V. subterranea* and *T. africana* are 124.00±1.84 mg/100g and 190.03±1.70 mg/100g respectively. There was a significant difference ($p \leq 0.05$) between the samples, with *T. africana* exhibiting the highest magnesium concentration. However, the outcome is near that of Ojimelukwe and Ugwuona [21] analysis, which found that raw *T. africana* seeds contained 186.00 mg/100g. Magnesium is linked to immunologic dysfunction, poor spermatogenesis, alopecia, dermatitis, muscle degeneration, development retardation and fetal abnormalities [22]. The recommended daily intake of magnesium is 80–320 mg [20].

The phosphorous content for *V. subterranea* and *T. africana* is 78.64±1.80 mg/100g and 315.95±1.60 mg/100g respectively. There was a significant difference ($p \leq 0.05$) across the samples, with *T. africana* exhibiting the highest iron concentration. Nonetheless, the outcome is comparable to the 395.66±0.01 mg/100g phosphorus concentration of *T. africana* from Nigeria reported by James *et al*. [2]. Particularly in young children and nursing moms, phosphorus helps to strengthen bones and teeth [23]. The recommended daily intake of magnesium for both adults and children is 800 mg [20].

The sodium content for *V. subterranea* and *T. africana* are 21.39±1.40 mg/100g and 32.61±1.40 mg/100g respectively. There was a significant difference ($p \leq 0.05$)

between the samples, with *T. africana* exhibiting the highest sodium concentration. Nonetheless, the result is more than that of Frances and Johnson [17] research, which stated that *T. africana* seeds contained 15.50 mg/100g. Sodium, a macronutrient, plays a vital role in the body's metabolic activities by exciting and transmitting nerve impulses during action [24]. According to WHO [20], the recommended daily salt intake for adult males is 10 mg, while for females, it is less than 15 mg.

The potassium content for *V. subterranea* and *T. africana* are 622.60±1.61 mg/100g and 1941.53±1.80 mg/100g, respectively. There was a significant difference ($p \leq 0.05$) between the samples, with *T. africana* showing the highest potassium concentration. However, the result is higher than that of Ojimelukwe and Ugwuona [21] analysis, which found that raw *T. africana* seeds contained 186.00 mg/100g. Potassium is essential for maintaining the body's water balance, neurotransmission, immunological response, and signalling [25]. The WHO [20] recommends a daily intake of 2000 mg of potassium for adults and 1000 mg for children.

The iron content for *V. subterranea* and *T. africana* are 10.75±1.32 mg/100g and 39.50±1.50 mg/100g, respectively. There was a significant difference ($p \leq 0.05$) across the samples, with *T. africana* showing the highest iron concentration. Nonetheless, the result is approximately similar to the 4.06±0.01 mg/100g to 17.93±0.01 mg/100g reported by James *et al*.[2] for the iron content of a few lesser-known Nigerian native legumes. Iron is present in considerable amounts in haemoglobin, a protein found in red blood cells that carries oxygen from the lungs to every body part [26]. It is advised that adults take 17.0–18.9 mg of iron per day, while children should take 13.7–15.1 mg [20].

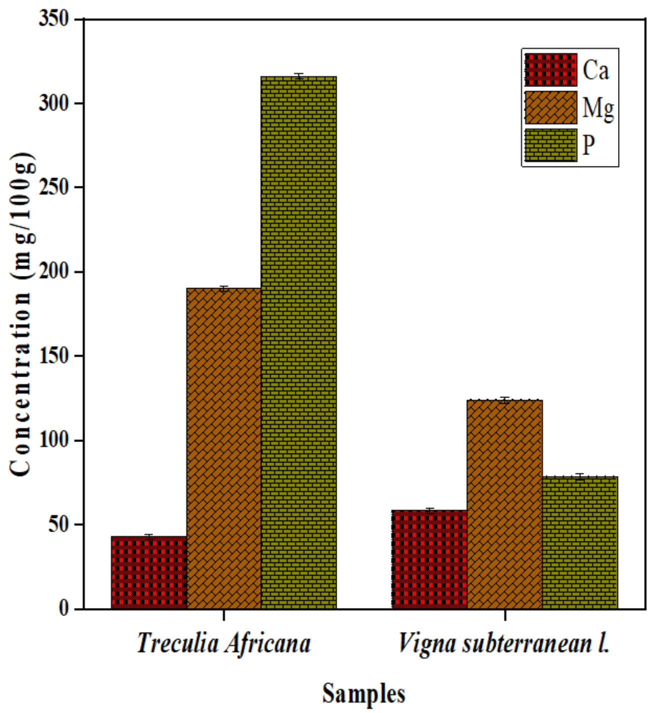

Fig 1. The mineral concentration (calcium, magnesium and phosphorous) of *T. africana* and *V. subterranean* seeds.

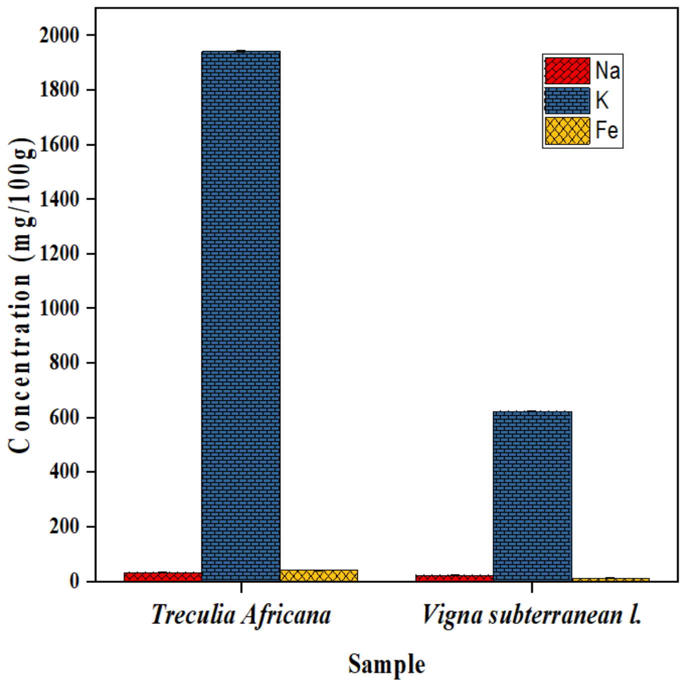

Fig 2. The mineral concentration (sodium, potassium and iron) of *T. africana* and *V. subterranea* seeds.

3.3 Amino acid profile of the *T. africana* and *V. subterranean* samples

The results of the amino acid profiles of *T. africana* and *V. subterranea* are shown in Table 2. Amino acids are the building blocks of proteins, which also have vital bodily functions. According to the research, legumes are a good source of essential and non-essential amino acids. Among the necessary amino acids are Lysine, phenylalanine, valine, threonine, isoleucine, methionine, histidine and leucine. The non-essential amino acids are alanine, arginine, aspartic acid, serine, tyrosine, proline, cysteine and glutamic acid. Nonetheless, results demonstrated that in *T. africana* and *V. subterranea* seed samples, the non-essential amino acids exceeded the essential amino acids. The total non-essential amino acid values for *T. africana* and *V. subterranea* seeds were 30.29±3.55 g/100g and 46.01±4.24 g/100g, respectively, representing 57.85 % and 58.18 %. The total essential amino acid levels for *T. Africana* and *V. subterranea* Seeds were 22.07±1.63 g/100g and 33.07±2.22 g/100g, respectively, representing 42.15 % and 41.82 %. This outcome is comparable to studies published by Musah *et al*. [10].

V. subterranean had the highest non-essential amino acid and essential amino acid content at 46.01±4.24 g/100g and 33.07±2.22 g/100g respectively. *T. Africana* had the least non-essential amino acid and essential amino acid content at 30.29±3.55 g/100g and 22.07±1.63 g/100g respectively. Furthermore, the percentage ratio of the essential amino acid (EAA) to the total amino acid (TAA) in the samples is 42.15 % and 41.82 %. These values are well above the 39%, which is considered adequate for ideal protein food for infants, 26% for children and 11% for adults.

Glutamic acid appeared to be the most abundant amino acid in *T. africana* and *V. subterranea* Seeds at 10.57±0.31 g/100g and 15.41±0.58 g/100g, respectively. By producing glutathione, a potent antioxidant essential for bolstering the immune system and shielding cells from oxidative stress, glutamic acid contributes to the immune system's support. In addition, it functions as a neurotransmitter and is necessary for detoxification, protein synthesis and preserving the body's acid-base equilibrium [27].

Tryptophan a precursor to the neurotransmitter serotonin, which controls mood, hunger and sleep, was found in meagre amounts in all the samples, with *T. africana* being the least abundant at 0.01±0.00 g/100g [28]. At 0.69±0.10 g/100 g, cystine was the least abundant amino acid in *V. subterranea*, yet it is important for protein synthesis and redox balance maintenance [29]. Additionally, it helps with wound healing, immune system function, healthy skin and hair, wound healing and the metabolism of fatty acids. It is beneficial in detoxifying hazardous compounds such as heavy metals and environmental pollutants [30].

The minimum amino acid intake of 1.5 g/kg/day is reported to be necessary for preventing negative nitrogen balance, while 2.5 g/kg/day is not advisable [31].

Table 2. Amino acid profile of *T. africana* and *V. subterranea* seeds

Amino acids	*T. Africana* (g/100g)	*V. subterranea* (g/100g)
Leucine	4.87±0.15	7.25±0.19
Lysine	3.79±0.22	4.13±0.25
Isoleucine	1.70±0.18	1.82±0.07
Phenylalanine	1.72±0.11	5.24±0.32
Tryptophan	0.01±0.00	0.91±0.08
Valine	1.85±0.31	5.96±0.10
Methionine	1.50±0.24	0.92±0.05
Histidine	1.92±0.13	3.30±0.11
Threonine	4.71±0.14	3.54±0.12
*Proline	5.52±0.10	6.48±0.27
*Arginine	3.87±0.15	4.69±0.11
*Tyrosine	0.62±0.11	2.09±0.15
*Cystine	0.85±0.14	0.69±0.10
*Alanine	0.58±0.33	4.89±0.13
*Glutamic acid	10.57±0.31	15.41±0.58
*Glycine	0.92±0.18	2.75±0.28
*Serine	0.85±0.13	4.05±0.33
*Aspartic acid	6.51±0.25	4.96±0.24
TEAA	22.07±1.63 (42.15%)	33.07±2.22 (41.82%)
TNEAA	30.29±3.55 (57.85%)	46.01±4.24 (58.18%)

Note: Values are means ± standard deviation of triplicate analysis, TEAA - Total essential amino acid, TNEAA - Total non-essential amino acid, *Non-essential amino acid

3.4 The chemical composition of *T. africana* and *V. subterranea* sample

The results of the chemical composition analysis of *T. africana* and *V. subterranea* seeds using GC-MS are presented in Tables 3 and 5 while, the chemical composition summary is shown in Tables 4 and 6. In *T. africana* seeds, 24 compounds were identified, accounting for 99.43% of the total composition, while in *V. subterranea* seeds, 18 compounds were identified, accounting for 95.90% of the total composition. The most abundant compounds in *T. africana* seeds were Myristic acid (48.01%), linoleic acid (28.27%), and palmitic acid (13.94%), while in *V. subterranea* seeds, the most abundant compounds were ethyl palmitate (31.17%) and ethyl stearate (13.08%). *T. africana* and *V. subterranea* seeds contained different classes of compounds, with *T. africana* seeds dominated by fatty acid and fatty acid esters (92.21%), alkanes and alkenes (4.18%), and monoterpenes (1.35%), while *V. subterranea* seeds were dominated by fatty acid and fatty acid esters (60.55%), alkanes (27.20%), ketones (5.64%), and esters (2.51%). Comparing the composition of *T. africana* and *V. subterranea* seeds, myristic acid and ethyl palmitate were found to be the major components in both samples, with a higher content of 48.01% and 31.17%, respectively. The comparison of the composition pattern of *T. africana* and *V. subterranea* seeds showed notable qualitative and quantitative differences. The *T. africana* seeds have nutraceutical uses in improving cholesterol levels, heart health, and digestion, reducing inflammation, improving skin health, boosting the immune system, and reducing the risk of certain types of cancer, such as breast cancer, which may be attributed to the presence of myristic acid, the major chemical constituent in *T. africana* seeds [32]. Myristic acid is a saturated fatty acid found in many foods, including dairy products, nutmeg, and coconut oil [33]. Ethyl palmitate, the most abundant chemical constituent found in *V. subterranea* seeds is often used in cosmetic and skincare products for their emollient properties. It helps soften and smooth the skin, enhancing the texture and feel of skincare formulations [34]. Ethyl palmitate is sometimes used as a fragrance carrier in cosmetic products [35]. Contrary to popular opinion, ethyl palmitate has pharmaceutical importance as it has anti-inflammatory properties [36]. Apart from its applications in pharmaceuticals, ethyl palmitate is used in the wine industry to enhance flavours, as an additive in tobacco for cigarette making and in the food industry for processing nut products [37].

Table 3. Chemical composition of African breadfruit (*T. africana*)

S/N	RT (min)	Compounds	Composition (%)	Formula	Class of compound
1	3.751	Limonene	1.02	$C_{10}H_{16}$	Monoterpenes
2	8.052	d-α-Pinene	0.33	$C_{10}H_{16}$	Monoterpenes
3	8.561	trans-4-Tetradecene	0.32	$C_{14}H_{28}$	Alkenes
4	8.660	Undecane	0.22	$C_{11}H_{24}$	Alkane
5	9.282	1-Cyclohexyloctane	0.15	$C_{14}H_{28}$	Cycloalkane
6	10.118	2,4-Di-tert-butylphenol	0.43	$C_{14}H_{22}O$	Phenol
7	11.036	Cyclohexadecane	1.07	$C_{16}H_{32}$	Cycloalkane
8	11.114	Hexadecane	0.22	$C_{16}H_{34}$	Alkane
9	11.768	1-Decylcyclohexane	0.18	$C_{16}H_{32}$	Cycloalkane
10	13.013	Myristic acid	0.42	$C_{14}H_{28}O_2$	Fatty acid
11	13.267	1-Octadecene	1.44	$C_{18}H_{36}$	Alkene
12	13.329	10-Methylnonadecane	0.31	$C_{20}H_{42}$	Alkanes
13	14.009	Hexane, 1,6-dicyclohexyl	0.27	$C_{18}H_{34}$	Cycloalkane
14	14.056	Pentadecylic acid	0.30	$C_{15}H_{30}O_2$	Fatty acid
15	14.108	Octyl ketone	0.37	$C_{17}H_{34}O$	Ketone
16	14.626	Methyl palmitate	0.31	$C_{17}H_{34}O_2$	Fatty acid methyl ester
17	15.311	Palmitic acid	13.94	$C_{16}H_{32}O_2$	Fatty acid
18	15.524	Myristic acid	48.01	$C_{14}H_{28}O_2$	Fatty acid
19	16.308	Methyl linoleate	0.36	$C_{19}H_{34}O_2$	Fatty acid methyl ester
20	16.359	trans-13-Octadecenoic acid, methyl ester	0.45	$C_{19}H_{36}O_2$	Fatty acid methyl ester
21	16.583	Hexadecylic acid	0.15	$C_{16}H_{32}O_2$	Fatty acid
22	17.174	Linoleic acid	28.27	$C_{18}H_{32}O_2$	Fatty acid
23	20.106	4-Methylindole	0.31	C_9H_9N	Indole
24	22.747	Naphthalene, 1,2,3,4-tetrahydro-1- octyl-	0.58	$C_{18}H_{28}$	PAHs

Key: RT = Retention time

Table 4. Summary of chemical composition of African breadfruit (*T. africana*)

S/N	Class of compounds	% Composition
1	Monoterpenes	1.35
2	Alkanes and alkenes	4.18
3	Phenols	0.43
4	Fatty acid and fatty acid esters	92.21
5	Ketones	0.37
6	Indole	0.31
7	Polycyclic aromatic hydrocarbons (PAHs)	0.58
8	Total	99.43

Table 5. Chemical composition of Bambara nut (*V. subterranea*)

S/N	RT (min)	Compounds	Composition (%)	Formula	Class of compounds
1	12.307	5-Methyloctadecane	2.38	$C_{19}H_{40}$	Alkane
2	13.277	Ethyl undecanoate	2.51	$C_{13}H_{26}O_2$	Esters
3	13.324	Octadecane	1.77	$C_{18}H_{38}$	Alkane
4	13.822	6,10,14-Trimethyl-2-pentadecanone	5.64	$C_{18}H_{36}O$	Ketone
5	14.351	Hexadecane	2.30	$C_{16}H_{34}$	Alkane
6	14.626	Methyl palmitate	3.23	$C_{17}H_{34}O_2$	Fatty acid methyl ester
7	15.109	Palmitic acid	4.41	$C_{16}H_{32}O_2$	Fatty acid
8	15.348	Ethyl palmitate	31.17	$C_{18}H_{36}O_2$	Fatty acid ethyl ester
11	16.282	Heneicosane	4.47	$C_{21}H_{44}$	Alkane
12	16.915	Palmitoleic acid	4.28	$C_{16}H_{30}O_2$	Fatty acid
13	16.982	Ethyl elaidate	4.38	$C_{20}H_{38}O_2$	Fatty acid ethyl ester
14	17.169	Ethyl stearate	13.08	$C_{20}H_{40}O_2$	Fatty acid ethyl ester
15	17.195	Hexadecane	3.50	$C_{16}H_{34}$	Alkane
16	18.041	Heptadecane	4.10	$C_{17}H_{36}$	Alkane
17	18.980	9-Methylnonadecane	5.30	$C_{20}H_{42}$	Alkane
18	20.126	Tricosane	3.38	$C_{23}H_{48}$	Alkane

Key: RT = Retention time

Table 6. Summary of chemical composition of Bambara nut (*V. subterranea*) seeds

S/N	Class of compounds	% Composition
1	Alkanes	27.20
2	Esters	2.51
3	Ketones	5.64
4	Fatty acid and fatty acid esters	60.55
5	Total	95.90

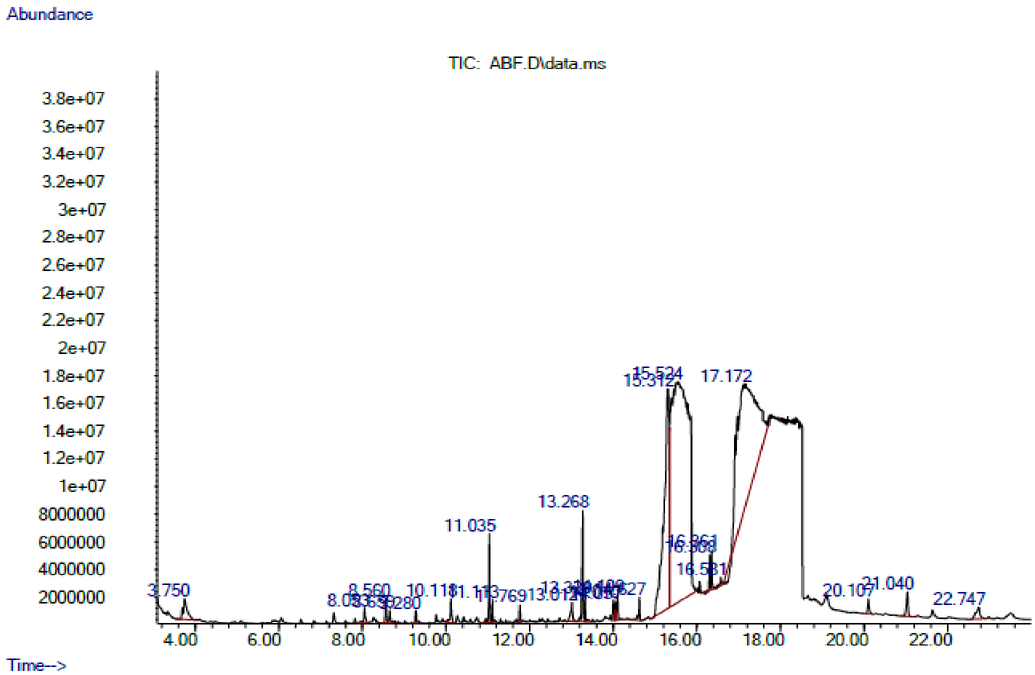

Fig 3. GC-MS spectra showing the chemical composition of African breadfruit (*T. Africana*) seeds

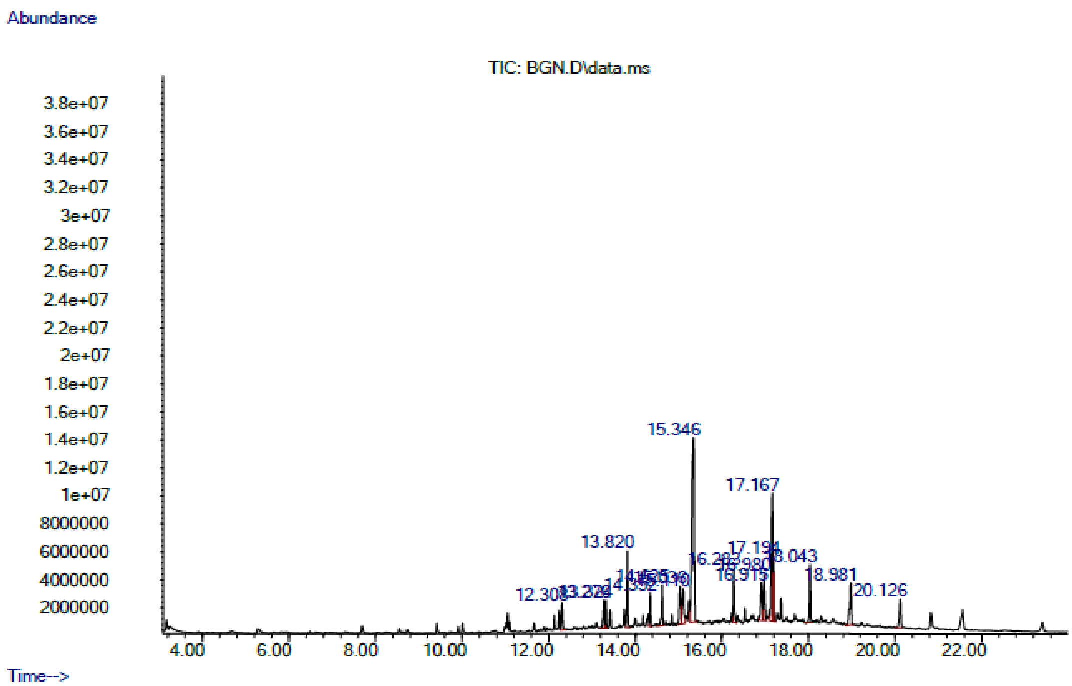

Fig 4. GC-MS spectra showing the chemical composition of Bambara nut (*V. subterranea*) seeds.

4. CONCLUSION

This study aimed to investigate two types of legumes, *T. africana* and *V. subterranea*, for their nutritional and chemical composition. The proximate composition analysis was used to determine the distribution of macronutrients in the legumes, shedding light on their potential as dietary sources. The results showed that *V. subterranea* seeds had the highest levels of ash, crude fat, crude fiber and crude protein content, while *T. africana* seeds had the highest carbohydrate content. Regarding mineral content, *T. africana* had the highest concentration of magnesium, phosphorous, sodium, potassium and iron, while calcium was most abundant in *V. subterranea* These disparities in mineral content provide valuable insight into the diverse nutritional benefits offered by these legumes as well as the extent to which they play crucial roles in various physiological functions within the human body. The amino acid profile of both legumes indicated they are rich in protein, with *V. subterranea* being the richest in amino acid content. Moreover, both legumes contained significant amounts of macro and micro-nutrients essential to human nutrition. The findings of the gas chromatography-mass spectrometry (GC-MS) analysis shed light on the chemical diversity of the samples analysed, underscoring their potential as valuable sources of bioactive compounds with implications for food, pharmaceutical and nutraceutical industries. The result showed that 24 compounds were identified in *T. africana* seeds with Myristic acid being the most abundant compound, while 18 compounds were identified in *V. subterranea* seeds, with ethyl palmitate being the most abundant compound. The findings of this research could provide valuable insights into the potential uses of these legumes in functional foods and nutraceuticals.

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COMPETING INTEREST DISCLAIMER

The authors declare that they have no conflict of interest in this study.

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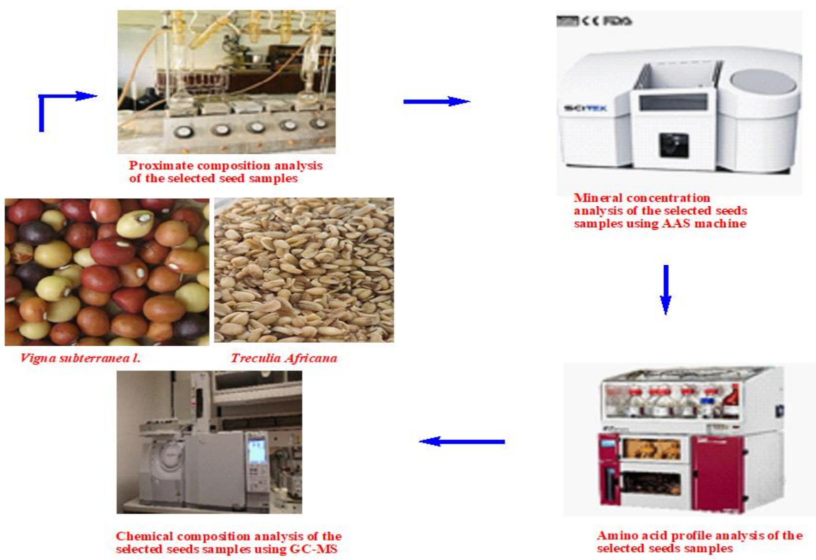
Graphical abstract:



REFERENCES

1. Dakora F. D. and Belane A. K. Evaluation of protein and micronutrient levels in edible cowpea (*Vigna Unguiculata L. Walp*.) leaves and seeds. *Frontiers in Sustainable Food Systems*. 2019; 3: 1-10. https://doi.org/10.3389/fsufs.2019.00070
2. James S., Ugochukwu T., Onwuka G. I., Ndife J. and Ata M. Chemical and nutritional composition of some selected lesser-known legumes indigenous to Nigeria. *Heliyon*. 2020; 6(11):e05497. https://doi.org/10.1016/j.heliyon.2020.e05497
3. Oyeyinka S. A., Ajisafe A. O., Akintayo O. A., Iyiola O. A. Oyeyinka A. T., Olatunde S. J., Badmos A. H. A., Fasogbon B. M. and Patel N. Effect of microwave treatment on cooking time, colour, sensory and nutritional properties of Bambara groundnut (Vigna subterranea). *Croatian Journal of Food Technology, Biotechnology and Nutrition*. 2020; 15 (1–2):11–16.
4. Mashau M. E., Mukwevho T. A., Eugenia S. and Siwela M. The influence of Bambara groundnut (Vigna subterranean) flour on the nutritional, physical and antioxidant properties of steamed bread nutritional, physical and antioxidant properties of steamed bread. *CyTA - Journal of Food*. 2022; 20(1):259–270. https://doi.org/10.1080/19476337.2022.2130435
5. Oyeyinka A. T., Pillay K. And Siwela M. In vitro digestibility, amino acid profile and antioxidant activity of cooked Bambara groundnut grain. *Food Bioscience*. 2019; 31:100428. https://doi.org/10.1016/j.fbio.2019. 100428
6. Osukoya O. Nwoye-Ossy M. Olayide I. Ojo O. Adewale O. and Kuku A. Antioxidant activities of peptide hydrolysates obtained from the seeds of Treculia africana Decne (African breadfruit). *Preparative Biochemistry & Biotechnology*. 2020; 50(5):504-510.
7. AOAC. Association of Official Analytical Chemists. *Official method of analysis (19th edition).* 2006; Gaithersburg: AOAC Press, USA.
8. Cooper C. (Ed.). *Amino acid analysis protocols*. 2008; (159). Springer Science & Business Media.
9. Karki D., Pandey B., Jha P., Acharya A., Khanal D., Raut B. and Panthi S. Senna alata: Phytochemistry, Antioxidant, Thrombolytic, Anti-inflammatory, Cytotoxicity, Antibacterial activity, and GC-MS analysis. *Jordan Journal of Pharmaceutical Sciences*. 2023; 17(3):549–566. https://doi.org/10.35516/jjps.v17i3.2406
10. Musah M., Azeh Y., Mathew J. T., Nwakife N. C., Mohammed A. I. and Saidu F. Nutritional evaluation of Bambara groundnut (Vigna subterranea (L.) Verdc) from Lapai, Nigeria. *African Journal of Agriculture and Food Science*. 2021; 4(4):32-39.
11. Godfrey E. O. Faith O. and Esther I. I. Comparative Assessment of the Proximate Composition, Functional Properties and Amino Acid Profile of Dioscorea bulbifera, Dioscorea alata and Dioscorea rotundata Found in Minna, Niger State. *Biology, Medicine, & Natural Product Chemistry*. 2023; 12(1):177–185.
12. Abejide D. R. Samson O. Ehoniyotan O. I. Olubiyo G. T. Onemayin D. Y. Proximate composition of some Nigerian Bambara groundnut (Vigna subterranea (L.) Verdc.) accessions. *GSC Biological and Pharmaceutical Sciences*. 2023; 24(1):339-345.
13. Godfrey E. O. Esther I. I. and Faith O. Proximate Composition, Levels of Some Essential Mineral Elements and Anti-Nutritional Components of Some Yam Species Found in Minna, Niger State. *Biology, Medicine, & Natural Product Chemistry*. 2022; 12(1):9–16. https://doi.org/10.14421/biomedich.2023.121.9-16
14. Nkwocha Chinelo C., Nworah Florence N., Okagu Innocent U. and Nwagwe Onyinyechi R. Proximate and Phytochemical Analysis of Monodora myristica (African Nutmeg) from Nsukka, Enugu State, Nigeria. *Journal of Food and Nutrition Research*. 2018; 6(9):597- 601.

15. Mohammed A. and Mhya H. D. Evaluation of phytochemical constituents, proximate contents and glycemic index of bambara groundnut (Vigna subterranea L. Verdc) varieties grown in Northeastern Nigeria. *African Journal of Biochemistry Research*. 2021; 15(2): 22-27.
16. Yahya I. H., Abd Hamid H. and Iwansyah A. C. (2024). Evaluation of Proximate Composition, Multielement, and Bioactive Phenolics Contents of Different Coix Seed Varieties using Multivariate Analysis Techniques. *Jordan Journal of Pharmaceutical Sciences*. *17*(3):492-505.
17. Frances E. C. and Johnson O. O. Assessment of Proximate, Vitamins and Minerals of African Breadfruit Seed (Treculia africana). *Journal of Global Ecology and Environment*. 2022; 16(2):28-36.
18. Amarteifio J. O. Tibe V. and Njogu R. M. The mineral composition of bambara groundnut (Vigna subterranea (L) Verdc) grown in Southern Africa. *African Journal of Biotechnology*. 2006; 5(23).
19. Trailokya A., Srivastava A., Bhole M. and Zalte N. Calcium and Calcium Salts. *Journal of the Association of Physicians of India.* 2017; 65(1):1-2.
20. World Health Organization. *Vitamin and mineral requirements in human nutrition*. 2004; World Health Organization.
21. Ojimelukwe P. C. and Ugwuona F. U. The traditional and medicinal use of African breadfruit (Treculia africana Decne): an underutilized ethnic food of the Ibo tribe of Southeast, Nigeria. *Journal of ethnic foods*. 2021; 8(1):1-13.
22. Eneogwe O. G., Okpala O. E., Anthony W. O., Obuye F., Ibrahim I. E. and Bilkisu I. A. Nutraceutical evaluation of some selected indigenous spices found in Kogi State, Nigeria. *Fudma Journal of Sciences*. 2023; 7(5):71-79.
23. Malhotra H., Vandana A., Sharma S. and Pandey R. Phosphorus nutrition: plant growth in response to deficiency and excess. *Plant nutrients and abiotic stress tolerance*. 2018; 171- 190.
24. Minegishi S., Luft F. C., Titze J. and Kitada K. Sodium handling and interaction in numerous organs. *American journal of hypertension*. 2020; 33(8):687-694.
25. Muhammad S. S., Muhammad H. Y., Sheshe S. M., Aliyu R. M., Zubair A. A. Comparative Analysis of Proximate and Mineral Compositions of Bambara nut (Vigna subterranea) and Groundnut (Arachis-hypogea). *J Nutr Sci Res*. 2021; 6(6):1000150.
26. Georgieff M. K. Iron deficiency in pregnancy. *American journal of obstetrics and gynecology*. 2020; 223(4): 516-524.
27. Kyoung H., Lee J. J., Cho J. H., Choe J., Kang J., Lee H. and Song M. Dietary glutamic acid modulates immune responses and gut health of weaned pigs. *Animals*. 2021; 11(2):504.
28. Slominski A., Semak I., Pisarchik A., Sweatman T., Szczesniewski A. and Wortsman J. Conversion of L-tryptophan to serotonin and melatonin in human melanoma cells. *FEBS Letters.* 2002; 511(1):102–106.
29. Jyotsana N., Ta K. T. and DelGiorno K. E. The role of cystine/glutamate antiporter SLC7A11/xCT in the pathophysiology of cancer. *Frontiers in oncology*. 2022; 12:858462.
30. Clemente Plaza N., Reig García-Galbis M. and Martínez-Espinosa R. M. (2018). Effects of the Usage of l-Cysteine (l-Cys) on Human Health. *Molecules*. 23(3):575.
31. van Goudoever J. B., Vlaardingerbroek H., van den Akker C. H. de Groof F. van der Schoor S. R. Amino acids and proteins. *Nutritional Care of Preterm Infants*. 2014; 110: 49-63.
32. Verruck S., Balthazar C. F., Rocha R. S., Silva R., Esmerino E.A., Pimentel T. C., Freitas, M. Q., Silvac M. C., Gomes da Cruz A. and Prudencio E.S. Dairy foods and positive impact on the consumer's health. *Advances in food and nutrition research*. 2019; 89:95-164.
33. Chowdhury R., Steur M., Patel P. S. and Franco O. H. Individual fatty acids in cardiometabolic disease. In *Handbook of lipids in human function*. 2016; 207-318. AOCS Press.

34. Orch H., Chaachouay N., Douiri E. M., Faiz N., Zidane L., and Douira, A. Use of medicinal plants in dermato-cosmetology: An ethnobotanical study among the population of Izarène. *Jordan Journal of Pharmaceutical Sciences*. 2021; 14(3):323-340.
35. Heredia D., Green I., Klaasen J. and Rahiman F. Importance and relevance of phytochemicals present in *Galenia Africana. Scientifica*. 2022. https://doi.org/10.1155/2022/5793436
36. Saeed N. M., El-Demerdash E., Abdel-Rahman H. M., Algandaby M.M., Al-Abbasi F.A. and Abdel-Naim A.B. Anti-inflammatory activity of methyl palmitate and ethyl palmitate in different experimental rat models. *Toxicology and applied pharmacology*. 2012; 264(1):84-93.
37. Kumar R., Madras G. and Modak J. Enzymatic synthesis of ethyl palmitate in supercritical carbon dioxide. *Industrial & engineering chemistry research*. 2004; 43(7):1568-1573.

تقييم التركيب الغذائي والكيميائي لبذور ***Treculia Africana*** و ***Vigna subterranea l.*** المجمعة من ولاية كوجي، نيجيريا

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ملخص

تهدف هذه الدراسة إلى التحقيق في التركيب الغذائي لمحصولين من البقوليات غير المستغلة بشكل كافٍ، وهما بذور *Treculia africana*و*Vigna subterranea*، التي تم جمعها من ولاية كوجي، نيجيريا .حللت الدراسة تركيبها التقريبي ومحتواها المعدني وملف الأحماض الأمينية باستخدام طرق تحليلية قياسية .بالإضافة إلى ذلك، تم تحديد التركيب الكيميائي للعينة باستخدام كروماتوغرافيا الغاز-مطيافية الكتلة .أظهرت النتائج وجود فروق ذات دلالة إحصائية ($P \leq 0.05$)في عينات البقوليات .ومع ذلك، كان لبذور *V. subterranea* أقل محتوى للرطوبة (0.81 ± 12.90)٪ (بالإضافة إلى أعلى محتوى للدهون الخام ومحتوى الألياف الخام والبروتين الخام ومحتوى الرماد بنسبة 0.41 ± 15.70٪ و 0.16 ± 5.06٪ و 0.25 ± 27.86٪ و 0.50 ± 3.23٪ على التوالي .أشار التحليل العنصري بالملغ 100/جرام إلى أن العينات تحتوي على مستويات ملحوظة من المعادن الأساسية .كان لدى *T. africana* أعلى تركيزات من المغنيسيوم والفوسفور والصوديوم والبوتاسيوم والحديد بواقع 1.70 ± 190.03مجم 100/جرام و 1.60 ± 315.95مجم 100/جرام و 1.82 ± 32.61 مجم 100/جرام و 2.61 ± 1941.53مجم 100/جرام و 1.73 ± 39.50مجم 100/جرام على التوالي، بينما كان الكالسيوم (1.63 ± 58.46)أكثر وفرة في *V. subterranea* وكانت العينات غنية أيضًا بالأحماض الأمينية، وهي اللبنات الأساسية للبروتين .ومع ذلك، كان *V. subterranea* هو الأغنى بمحتوى الأحماض الأمينية، حيث كان يحتوي على ± 33.07 2.22جم 100/جم و 4.24 ± 46.01جم 100/جم، للأحماض الأمينية الأساسية وغير الأساسية، على التوالي .أظهر توصيف كروماتوغرافيا الغاز ومطياف الكتلة للتركيب الكيميائي للعينات أن حمض الميريستيك (48.1)كان الأكثر وفرة في *T. africana*، بينما كان إيثيل بالميتات (31.17)الأكثر وفرة في *V. subterranea.* بشكل عام، تشير النتائج إلى أن عينات البقوليات هذه هي مصادر غنية بالخصائص الغذائية والصيدلانية المفيدة للاستهلاك البشري.

الكلمات الدالة: ملف تعريف الأحماض الأمينية، التركيب الكيميائي، تركيز المعادن، التركيب التقريبي، *Treculia africana*، *Vigna subterranea*.

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