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Research Article

NUTRITIONAL AND OIL PROFILE OF THE SEEDS OF *SESAMUM INDICUM* L. AND *VITELLARIA PARADOXA* C. F. GAERTN.

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Abstract: Nutritional and oil profile of the seeds of *Sesamum indicum* and *Vitellaria paradoxa* from Sokoto, Nigeria was carried out using standard biochemical procedures. Proximate, ascorbic acid, mineral analysis as well as extraction, quantification and the physicochemical analysis of the seed oil were assessed. On proximate and ascorbic acid analysis. The seeds were found to contain appreciable amounts of crude proteins with 18.23% and 8.70% obtained in *S. indicum* and *V. paradoxa* respectively. Lipid contents revealed 42.51% in *S. indicum* and 51.34% in *V. paradoxa* respectively. Total carbohydrates revealed that 39.03% and 52.12% were obtained in *S. indicum* and *V. paradoxa* respectively. Crude fiber contents revealed 5.31 g/100 g in *S. indicum* while in *V. paradoxa*, 7.11 g/100 g was recorded. Percentage ash contents revealed 6.62% and 4.61% in *S. indicum* and *V. paradoxa* respectively. Available energy (kj) revealed that *S. indicum* had 603.04 kj/100 g while *V. paradoxa* had 614.12 kj/100 g respectively signaling them as formidable energy sources. Ascorbic acid analysis revealed 97.36 mg/100 g and 179.16 mg/100 g in *S. indicum* and *V. paradoxa* respectively. With significant difference ($P \leq 0.05$) in the contents of crude proteins, crude lipid, crude carbohydrate, calorific value and ascorbic acid between the two sampled seeds. Minerals analysis revealed that the two seeds were rich in most of the essential minerals required for healthy growth and development. For instance, sodium was found to be 2.67 mg/100 g in *S. indicum* while 2.23 mg/100 g was identified in *V. paradoxa*. Potassium, magnesium and phosphorus results indicate that *S. indicum* had 56.96 mg/100 g, 62.12 mg/100 g and 76.72 mg/100 g and *V. paradoxa* had 46.72 mg/100 g, 31.64 mg/100 g and 116.74 mg/100 g respectively. With significant difference ($P \leq 0.05$) in the contents of potassium, magnesium and phosphorus oil extraction and its physicochemical properties revealed that the two seed contained substantial amounts of oil with 38.23% in *S. indicum* and 43.14% in *V. paradoxa* respectively. Acid value analysis showed that *S. indicum* had 32.14 mg KOH/kg while *V. paradoxa* had 33.24 mg KOH/kg. Saponification value analysis revealed that 131.86 mg KOH in *S. indicum* while 154.74 mg KOH was found in *V. paradoxa*. Iodine value analyzed showed that 116.86 g I_2 /100 g in *S. indicum* while 124.77 g I_2 /100 g was obtained in *V. paradoxa* while % Free Fatty Acid analysis revealed that *S. indicum* had 7.63% while *V. paradoxa* had 8.74% respectively. With significant difference ($P \leq 0.05$) between the two species in percentage yield, saponification and iodine values between the two seeds. The two studied seed types are endowed with natural food reserves and other much needed raw materials that could have industrial application making the seeds as formidable ingredients required for use by man.

Keywords: nutritional, physicochemical, seed-oil, *Sesamum indicum*, *Vitellaria paradoxa*.

Introduction

Nigeria, a country with a population exceeding 200 million, grapples with a multifaceted challenge: the intersection of energy and dietary problems within its food supply system. From food insecurity and malnutrition to agricultural practices and cultural dynamics, the factors influencing energy and dietary problems are explored in-depth. At the heart of

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Nigeria's energy and dietary issues lies food insecurity, affecting a substantial portion of the population [BENNETT & VOKOUN, 2023]. Many Nigerians lack consistent access to sufficient and nutrient-dense foods, resulting in chronic under nutrition and malnutrition. A significant consequence is the prevalence of deficiencies in essential vitamins, minerals, and macronutrients that are crucial for maintaining optimal health and well-being [ADEYEMI & al. 2023]. A defining feature of the Nigerian diet is its heavy reliance on staple crops such as cassava, yam, and maize. While these crops provide energy, they often fall short in providing a diverse range of nutrients necessary for a balanced diet [JACOB & al. 2023]. This dietary imbalance contributes to both under nutrition and over nutrition, as individuals may consume high quantities of carbohydrates while lacking essential vitamins and proteins. Nigeria's agricultural practices are marred by low productivity, traditional farming methods, and inadequate storage facilities. These challenges result in reduced yields, post-harvest losses, and limited availability of fresh produce. Inefficient agricultural practices hinder the country's ability to provide an ample and varied food supply, further exacerbating energy and dietary issues. The energy and dietary problems associated with Nigeria's food supply system are complex and interlinked, driven by a combination of factors spanning from agriculture and economy to culture and infrastructure. Addressing these challenges necessitates a multi-pronged approach that involves government policies, community engagement, education, agricultural innovations, and healthcare interventions. By acknowledging the depth of these issues and implementing comprehensive strategies, Nigeria can pave the way towards a more nourished and healthier future for its population. Rapid urbanization has introduced shifts in dietary habits, as individual transition from traditional diets to processed and convenience foods. Urban dwellers often face challenges in accessing fresh and affordable produce, leading to a higher consumption of energy-dense but nutrient-poor foods. This trend contributes to rising rates of diet-related non-communicable diseases such as diabetes and obesity. The term oil is used in general sense to describe all substances that are greasy or oily fluid at room temperature. There are abundant vegetable oils, namely; coconut oil, ground nut oil, rubber seed oil, cotton seed oil, olive oil, soy bean oil and cotton seed oil, etc. [DAWODU, 2009]. Vegetable oils are normally extracted from fruits, seeds kernel and nuts either by mechanical press or by use of solvents [AKPABIO & al. 2011].

Sesame (*Sesamum indicum* L.) is an herbaceous annual plant that belongs to the family Pedaliaceae genus *Sesamum*. Sesame seed is also known as benniseed (Africa), benne (Southern United States), gingerly (India), gengelin (Brazil), sim-sim, semsem (Hebrew) and tila (Sanskrit) [HASSAN, 2012]. Sesame has many species; most are wild and are native to sub-Saharan Africa. Sesame is highly tolerant to drought like conditions, and grows where other crops may fail. It is well suited to smallholder farming with a relatively short harvest cycle of 90-140 days allowing other crops to be grown in the field [USDA, 2005]. The world harvested about 4.76 million metric tons of sesame seeds in 2013, with Burma as the largest producer. The world's largest exporter of sesame seeds was India, while Japan was the largest importer [FAO, 2012]. Nearly 70% of the world production is from Asia. Africa grows 26% of the world's sesame, with Sierra Leone, Sudan, Nigeria and Uganda being key producers [MAKINDE & AKINOSO, 2013]. Sesame production in Nigeria probably began in the middle belt region of the country and later spread out between latitudes 6º and 10ºN. The major producing areas in order of priority are Nasarawa, Jigawa and Benue States. Other important areas of production are found in Yobe, Kano, Katsina, Kogi, Gombe and Plateau States [OJIAKO & al. 2010]. The black and white cultivars are grown basically in Nigeria. The white cultivar is grown around Benue (Oturkpo), Nassarawa (Doma), Jigawa (Malam-Madori) and Taraba states while the black cultivar grows in the Northern Nigerian region; Kano (Dawanau), and Jigawa (near Hadejia) states and in some parts of Katsina state [MAKINDE & AKINOSO, 2013].

S. indicum, known as sesame is an herbaceous annual plant that belongs to the family Pedaliaceae [AMOO & al. 2017]. Sesame has one of the highest oil contents of any seed. It is probably the most ancient oilseed used by humans as a food source [ABOU-GHARBIA & al. 2000]. Having nutty flavor, it is a common ingredient in cuisines across the world. In Nigeria, sesame seeds are used as soup ingredient, and constitute a useful source of vegetable oil for cooking [BEDIGAN, 2006]. At the local level it is processed into *Kantun ridi* and *Kunun ridi.* Oil is also extracted from the seed and the cake is made into *kulikuli* which together with the leaves are used to prepare local soup known as *Miyar taushe* and also used for cooking [MAKINDE & AKINOSO, 2013].

Sesame seeds have the highest oil content than rapeseed, groundnut, soybean and other oilseed crops [ANILAKUMAR & al. 2010]. Its oil and protein contents are estimated to be 50-60% and 18-25% respectively. To this can be added carbohydrates, fibers and ash [ALPASLAN & al. 2001]. This composition is supplemented by methionine (3.2%) which is often the limiting amino acid in legume-based tropical diets; tryptophan and the wide range of minerals such as phosphorus, calcium, iron, magnesium etc. as well as vitamins B1 and Vitamin E [OJIAKO & al. 2010].

Vitellaria paradoxa C. F. Gaertn. was cited three decades ago as the second most important oil crop in Africa after oil palm and is probably the most economically and culturally important tree species in the Sudan Sahelian region of Africa where oil palm does not grow. Across the distribution area, the estimated actual number of productive trees ranges from several hundred million [LOVETH, 2014] to a couple of billion respectively making it one of the largest population size of an economic tree species in the region. The dried kernel of fruit is used to produce oil or fat (Shea butter) for local consumption and is commercially sold as an ingredient in cosmetics, pharmaceutical and edible product. Shea was reported as a traded commodity by the Arab traveler, Ibn Battuta as early as the 14^{th} century. The magnitude of its distribution and local importance caught the attention of early explorers such as Mungo Park in 1798 and has been a subject of research since colonial times. It is interesting to note that, the Shea is estimated to serve as the primary source of edible oil for more than 80 million rural people [NOUGHTON & al. 2014].

V. paradoxa is among the major tree species in African agro forestry systems. It is an indigenous oil producing wild plant that belongs to the family Sapotaceae and spontaneously grows in Africa. The plant is adjudged to play an important role in the provision of edible oil or fat that is traditionally used for frying, adding to sauces, as a skin pomade, for medicinal applications, for soap making, oil for lanterns and for cultural purposes during ceremonies, such as births, weddings as well as for funerals. In fact, the seed kernels produce oil content which is highly nutritious with unsaturated fatty acids such as oleic and linoleic fatty acids and fat-soluble vitamins [KARIN, 2004; KAPSEU & al. 2007]. The tree is the main indigenous oil producing wild plant spontaneously growing in Africa [HONFO & al. 2012]. HEE (2011) reported that Shea tree begins to bear fruit of commercial quantity after approximately 20-50 years. Butter extracted its nuts offers an opportunity for sustainable development in Sudanian countries and an attractive potential for the food and cosmetics industries [DAVRIEUX & al. 2010].

Materials and methods

Sample collection and preparation

Freshly harvested ripe seeds of *S .indicum* were procured from vegetable market at Kasuwar Dankure while *V. paradoxa* seed kernels were obtained from Kasuwan Ramin Kura all within Sokoto metropolis. The seeds were carried to Departmental Herbarium Department of Plant Biology, where voucher specimens were deposited. The seeds were dehulled, cleaned and dried under the sun for a day and later dried in the oven for three hours at 50 ºC to ensure that moisture content was highly removed. The seed samples were made into powder using cleaned pestle and mortar and kept in labeled bottles until used.

Proximate and ascorbic acid composition analysis

The micro-kjeldal method [PEARSON, 1976] was followed by the determination of crude proteins. Crude fats, crude fibre, moisture % and ash % were determined using the methods of [AOAC, 2005], while carbohydrate was determined by difference. The calorific values in kilo joule (kj) were calculated by multiplying the crude fat, protein and carbohydrate by Atwater factors of (k) 37, 17, and 17 respectively. Ascorbic acid was determined according to the method described by MUSA & al. (2010).

Mineral composition analysis

The minerals were analyzed by first dry ashing the samples at 550 ºC in the muffle furnace. The filtered solutions were used to determine Na, K, Mg, Ca, Fe, Cu, Zn, Co, Cd, and Ni by means of Atomic Absorption Spectrophotometer [AAS] (Buck Scientific Model-200A/210, Norwalk, Connecticut [06855]) and phosphorus was determined calorimetrically by Spectronic 20 (Gallenkamp, UK) using the phosphovanado molybdate method [AOAC, 2005].

Oil extraction and its physiochemical properties

Percentage oil yield and physicochemical properties of the Seed oil were determined in accordance with the protocols of ASTM D 189, ASTM-D 974, kinematic viscosity of the seed oil was carried out in accordance with the ASTM D 445 while iodine value and oil specific gravity were determined using the procedure as reported by AJIBOLA& al. (2018). Determination of the cetane number of the biodiesel was determined by the use of empirical formula in the literature using the result of saponification number (SN) and the iodine value (IV) of biodiesel. Oil colour and its physical state at room temperature were determined by organoleptic method [AOAC, 1975]. While physical state of the oil was determined by sensory evaluation [IBETO & al. 2012].

Data analysis

Treatments were replicated three times and the results obtained has been presented as means± S.E. of the means. The data collected was subjected to Analysis of Variance (ANOVA) using GenStat$^{(R)}$ 18th edition. Where the treatments were found to be significantly different, mean separation was carried out using Duncan’s Multiple Range Test (DMRT) at 5% level.

Results

Proximate and ascorbic acid composition

Proximate composition of *S. indicum* and *V. paradoxa* in Sokoto, Nigeria has been presented in Table 1 below. From the results, there was significant difference ($P \leq 0.05$) in the composition of crude proteins, total carbohydrates and ascorbic acid in the two samples. Crude protein content obtained in *S. indicum* was 16.96% while 7.72% was obtained in *V. paradoxa*. For total carbohydrates, 39.03% was recorded for *S. indicum* while 52.12% was obtained in *V.*

paradoxa. Ascorbic acid analysis revealed that *S. indicum* had 97.36 mg/100 g while *V. paradoxa* had 179.16 mg/100 g respectively.

Table 1. Proximate and ascorbic acid composition of *Sesamum indicum* and *Vitellaria paradoxa*

Parameters	Units	*Sesamum indicum*	*Vitellaria paradoxa*
Moisture Content	%	2.67±0.63^a	2.23±0.53^a
Crude Protein	g/100 g	16.96±2.89^a	7.72±1.26^b
Crude lipid	g/100 g	42.12±2.86^a	41.64±1.62^a
Total carbohydrates	g/100 g	39.03±2.19^a	52.12±.2.10^b
Crude Fibre	g/100 g	5.31±0.86^a	7.11±0.99^a
Ash	%	6.62±0.07^a	4.61±0.05^a
Calorific Value	kj/100 g	603.04±5.88^a	614.12±4.67^a
Vitamin C	mg/100 g	97.36±2.43^a	179.16±3.19^b

Values are means ± standard deviation of three replications. Values within a row with different superscripts were significantly different (p≤0.05).

Table 2. Mineral composition of the seeds of *Sesamum indicum* and *Vitellaria paradoxa*

Mineral (mg/100g)	Symbol	*Sesamum indicum*	*Vitellaria paradoxa*
Sodium	Na	2.67±0.63^a	2.23±0.53^a
Potassium	K	56.96±2.89^a	46.72±1.26^b
Magnesium	Mg	62.12±2.86^a	31.64±1.62^b
Phosphorus	P	76.72±1.69^a	116.74±2.83^b
Manganese	Mn	32.76±1.05^a	48.66±2.36^a
Calcium	Ca	116.64±1.14^a	132.54±1.98^b
Iron	Fe	33.06±1.62^a	15.07±1.02^b
Cupper	Cu	6.24±0.06a	0.31±0.04^a
Chromium	Cr	0.06±0.03^a	0.02±0.01^a
Zinc	Zn	13.36±0.09^a	11.74±0.08^a
Nickel	Ni	0.17±0.04^a	0.19 ±0.02^a

Values are means ± standard deviation of three replications. Values within a row with different superscripts were significantly different (P≤0.05).

Results of mineral analysis have been presented in Table 2. The table revealed that there was significant difference (P≤0.05) in the composition of potassium, magnesium, phosphorus and iron. Calcium was the most abundant mineral with 116.64 mg/100 g and 132.54 mg/100 g in the seeds of *S. indicum* and *V. paradoxa* respectively. Phosphorus was the other mineral element with appraisable abundance in both the seeds with 76.72 mg/100 g obtained in *S. indicum* while 116.74 mg/100 g was obtained in *V. paradoxa.* Potassium was the third mineral with appreciable abundance with 56.96 mg/100 g while *V. paradoxa* had 46.72 mg/100 g.

Oil yield (%) and the physico-chemical properties of the seed oil of *S. indicum* and *V. paradoxa*

Results of the physico-chemical properties of the seed oils from *S. indicum* and *V. paradoxa* have been presented in Table 3. From the results, it can be seen that the two seed samples were endowed with quantifiable biofuel reserves with 48.23% in *S. indicum* and 53.14% in *V. paradoxa*. Acid value was analyzed with 32.14 mg KOH/kg obtained in *S. indicum* while 33.24 mg KOH/kg was obtained in *V. paradoxa*. Saponification value revealed that *S. indicum* had 131.86 mg KOH while *V. paradoxa* had 154.74 mg KOH and iodine value with

116.86 g I_2/100 g recorded for *S. indicum* while 124.77 g I_2/100 g was recorded for *V. paradoxa*. Cetane number analysis revealed 32 and 34 for *S. indicum* and *V. paradoxa* respectively. Oil colour was determined and it was yellow to pale brownish for the *S. indicum* and *V. paradoxa* respectively. State of the oil at room temperature revealed that the oils were liquid and semi-solid at room temperature. With significant difference ($P \leq 0.05$) in the percentage yield, saponification value and iodine value between the sampled seeds.

Table 3. Percentage oil yield and its physico-chemical properties

Parameters	Unit	*Sesamum indicum*	*Vitellaria paradoxa*
Oil Content	%	38.23±1.26[a]	43.14±2.54[b]
Acid Value	mg KOH/kg	32.14±1.12[a]	33.24±1.17[a]
Saponification Value	mg OH/g	131.86 ±2.84[a]	154.74±3.08[b]
Kinematic Viscosity	mm^2 /S	0.89±0.09[a]	0.96±0.07[a]
Specific Gravity	g/cm^2	0.82±0.05[a]	0.89±0.08[a]
Free Fatty Acid	%	7.63±0.89[a]	8.74±0.66[a]
Iodine Value	g/100 g	116.86±2.36[a]	124.77±4.38[b]
Cetane Number	-	32.00±1.06[a]	34.00±1.12[a]
Oil Color	-	Yellow	Pale brown
State of Oil at Room Temp.	-	Liquid	Semi solid

Values are means ± standard deviation of three replications. Values within a row with different superscripts were significantly different ($p \leq 0.05$).

Discussions

A moisture content of value 2.67-3.16% (Table 1) indicate that the seeds have a long shelf life. That is to say that they can be stored for a long time. The values obtained in the current study were in close agreement to the moisture content of 2.84% as reported by RAIMI & al. (2014) on the seeds of *V. paradoxa*, and 3.70% as reported by NZIKOU (2009), on *S. indicum* seeds. The moisture content compares favorably with the report of UGESE & al. (2010) who reported 2.2 to 3.8%. Protein content obtained in the current study is lower than 9.3% as reported by RAIMI & al. (2014) on *V. paradoxa*. Also, a bit lower protein with 7.6 to 8.9% was reported on *V. paradoxa* seeds by UGESE & al. (2010). Protein content as reported by NZIKOU & al. (2009) is a bit lower than obtained in the current study. Proteins are for growth and repair of tissues, and also serve as alternative energy sources in the absence of carbohydrate and fats. Crude fats contents of the seed types could be considered as being highly good. Results obtained compares favorably with the reported oil contents of 49.16% in *V. paradoxa* by RAIMI & al. (2014). Results obtained in the current study also compares favorably with the 46.95% fat contents of *Jatropha curcas*. More so, higher moisture content of 9.97% and 9.40%, high protein of 35.95% and 17.13% were reported on raw and defatted *Moringa oleifera* seeds. More so, high values of protein and crude fats were reported as 30.63% and 49.05% on the seeds of watermelon by JACOB & al. (2015). These values were higher than obtained in the current study. Crude fibre content obtained in the current study could be considered good but lower than the reported 12.57% reported on *Moringa oleifera* by OKIKI & al. (2015). Vitamin C with the ranges from 97.36 to 179.66 mg/100 g was reported by AFOLAYAN & al. (2014), also reported was high vitamin C content in locust bean pulp at a value of 542 mg/100 g quite higher than values obtained from the current study but this variation could be attributed to environmental condition and post-harvest handling.

The two seeds could be considered as being highly good in terms of nutrients composition especially when compared with other reports. For instance, very low minerals were reported by NWEZE & al. (2014) on *Moringa oleifera* leaf extracts with Ca, Mg, P, Zn, Cu and K with 2.29, 0.48, 0.44, 0.05, 0.01 and 1.62 mg/100 g respectively. The above values were highly low when compared with values obtained in the current study. In another study HASSAN & UMAR (2004), higher values of Ca, P, Mg and K were reported to be 342.50 mg/100 g, 400.00 mg/100 g, 215.38 mg/100 g and 600.00 g/100 g on whole seeds of African locust bean (*Parkia biglobosa*) by OLUWAGBENLE & al. (2019) on comparative assessment of the proximate, minerals composition of cucumber (*Cucumis sativus*), higher values than obtained in the current study were reported for Ca with 177.00 mg/100 g; Na with 156.00 mg/100 g and K with 541.00 mg/100 g while lower values of 2.21 mg/100 g, 0.56 mg/100 g and 9.08 mg/100 g reported for Cu, Mn and Fe respectively. Variation in the mineral composition could be attributed to the environmental factors such as soil and climatic conditions; this is in addition to species variability as well as the method of extraction.

Results of oil analysis revealed that the two seeds could be considered as highly good in terms of the percentage yield and physicochemical parameters analysis of the seed oil. According to EGBEKUN & EHIEZE (1997), variation in oil yield may be attributed to the differences in plant variety, cultivation pattern, climate, ripening stage as well as the extraction technique. Results obtained in the current study were however, higher than the percentage yield of 32.21% as reported on *Momordica balsamina* seed oil by AJIBOLA & al. (2018). In addition, values obtained in the current study were a bit lower than the range of values 44.72 to 53.88% as reported by KARAYE & al. (2021) on seeds of selected cucurbits seeds. The obtained values were higher than the 36.70% as reported on seeds of calabash (*Lagenaria vulgaris*) by SOKOTO & al. (2013). More so, iodine value of 153.40 g/ 100 g as reported by AKINONSO & RAJI (2010) was higher than values obtained in the current study. In another report by NZIKOU & al. (2009) on Sesame (*Sesamum indicum*) grown in Congo-Brazzaville, yield was 52.00%, higher than the value obtained in the current study, iodine value reported to be 112.40 g/100 g a bit less than the values obtained in the current study.

Conclusion

In conclusion, results in the current study on proximate, ascorbic acid and mineral composition of *S. indicum* and *V. paradoxa* seeds show that the seeds have high nutritional and energy values, and would be in addition to consumption by humans, serve as useful raw materials for industries. The seed oil could be described as having a sterling quality grade with high commercial value. It is edible and would find applications in food, soap and cosmetics production. The utilization of these types of seeds could be considered as valuable raw materials for inclusion in animal feed formulation so that the conventional oil seeds presently used as raw materials for animal feed production would be better utilized for human food.

Conflict of interest

Authors hereby declare that there is no competing interest of any sort among them.

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