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Chemical Composition of *Sesamum indicum* L. (Sesame) Grown in Southeastern Nigeria and the Physicochemical Properties of the Seed Oil

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ABSTRACT

The proximate, phytochemical and mineral compositions of the seeds, leaves, root and whole plant of *Sesame indicum* were evaluated. The present study also assessed physicochemical characteristics of the oil extracted from the seeds. The root contains appreciable levels of moisture (6.60 ± 4.39%), crude fibre (12.80 ± 8.53%) and total carbohydrate (67.90 ± 45.26%), whereas the whole plant, seeds and the leaves had the lowest moisture (4.22 ± 2.81%), crude fibre (6.60 ± 4.39%), and total carbohydrate (56.37 ± 37.59%). The protein content was highest (21.44 ± 14.29%) in the whole plant, followed by leaves (19.25 ±12.83%) but was lowest in the root (7.88 ± 5.25%). The various parts of the plant showed noticeable amount of ash content (9.62-4.82%), as well as lipids (38.54-4.54%). The seed exhibited highest value of food energy (662.30 ± 441.53%) and lipid (38.54 ± 25.69%). *S. indicum* was found to be a good source of calcium and potassium in various parts investigated. The percentage flavonoids, alkaloids and tannins of the samples were between the range of 16.20-4.80, 10.04-1.96 and 3.32-1.18%, respectively. The extracted seed-oil showed good physicochemical properties of acidic (2.48 mgKOH/g), iodine (1.27 gT2/100 g) and saponification values (1.8 7 mgKOH/g) with dark brown colour and aromatic odour. The overall results of this study imply that the various parts of *S. indicum* possess nutritional values to meet the needs of the less privileged people.

Keywords: medicinal plant, mineral, nutritive, phytochemical, proximate

INTRODUCTION

The increase of food prices has led to severe hunger worldwide owing to increasing population, shortage of fertile land and restrictions on the importation of food (Weaver 1994). The number of undernourished people all over the world has been estimated to increase to 963 million compared to 923 million in 2007 (FAO 2008). This estimation confirms the need for immediate attention considering the ongoing financial and economic crisis. The nutritional value of local indigenous plants, wild herbs and edible seeds rich in protein are of great significance. These plants require special considerations in the pursuit to solve the problem of food sufficiency (Singh *et al*. 1993). The consumption of these plants is supported by Obiajunwa *et al*. (2005) who reported that essential minerals and trace elements of local vegetables fall within recommended dietary intakes values. Recent reports have also revealed that quite a large number of indigenous plant species are high in nutrients value (Lalas and Tsaknis 2002). However many of such plants have been identified but lack data on their chemical compositions. One of such plant is sesame which has been recommended as a potential source to solve the problem of micronutrients deficiencies in modern day nutrition.

Sesamum indicum L. (Pedaliaceae), also known as sesame, is widely distributed in India and Africa with high reputation in their folk medicine (Jefferson 2003). It is commonly found in cultivated farms, bush fallows and waste places before harvest in South-Eastern Nigeria. Sesame is a broad leaf crop with opposite leaves. The leaves of the plant are hardly sheds especially during its vegetative phenology but self defoliates after capsule formation. It has a bell-shaped flower that is yellow in colour but may be varied to either blue or purple. *S. indicum* has a nutty sweet aroma with a rich, milk-like buttery taste. The seeds have been utilized for a long time as edible oilseeds and food materials. The decoction or infusion of different part (roots, leaves, seeds) of this plant have been recommended by traditional health practitioners in South-Western Nigeria for the treatment of various ailments including bruised, catarrh, eye pains, inflamed membranes of the mouth, chicken pox, measles and as a hair shampoo against *Taenia capitis* (Gill 1992). Phytochemical studies conducted on this plant revealed the presence of lignans, phenolics acids, flavonoids, saponins and alkaloids (Hassan and Umar 2004). Several studies have been conducted on different species of sesasum grown in the Western part of Nigeria. The Proximate composition and mineral analysis of sesame seeds both whole and dehulled at different part of the world has been determined (Hui 1996; Obiajunwa *et al*. 2005; Uaboi *et al*. 2008). However there is scanty or no scientific information on *S. indicum* grown in the South-Eastern part of Nigeria considering their seasonal variation and geographical location.

At the beginning of this study there was no comprehensive report on the phytochemical, proximate and mineral composition of various parts of *S. indicum* grown in the study area. Therefore, the present study aimed to provide information on the chemical composition, available nutrients and the physicochemical properties of the oil extracted from the seed of *S. indicum* grown in South-Eastern Nigeria.

MATERIALS AND METHODS

Collection of plant materials

The leaves, roots, seeds and whole plant of *S. indicum* were collected from the Garden of Michael Okpara University of Agricul-

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ture, Umudike, Abia State. The plant was identified and authenticated using necessary literature (Akobundu and Agyakwa 1987). Vouchers of the reported parts of the plants were deposited at the herbarium of the Biological Sciences Laboratory of the University.

Preparation of the extract

The samples were oven-dried at about 50°C in the laboratory. The dried materials were then pulverized using an electric blender (Waring Products Division, Torrington, USA) into a fine powder. About 100 g powder of each sample was stored and used for different analyses.

Phytochemical determination

The quantitative phytochemical determination of flavonoids, alkaloids, tannin, phenols and phytate on the leaves, seeds, roots and the whole plant of *S. indicum* was determined according to the method of Trease and Evans (1989) and Harbone (1973).

Oil extraction

The seed oil was extracted with hexane at 20°C for 72 hrs in a Soxhlet apparatus and then filtered. This process was repeated three times using fresh solvent each time in order to extract most of oil from sesame seeds. The oil was collected, mixed and evaporated at 50°C under vacuum after which the extracted oil was dried using anhydrous sodium sulphate.

Proximate and mineral analysis

The proximate composition of the leaves, roots, seeds and the whole plant of *S. indicum* were investigated. The moisture, crude protein, fats and oil, crude fibre and ash contents of the samples were determined following the method described by AOAC (1990). The crude protein was expressed as percentage nitrogen (%N_2 × 6.25). Carbohydrates content was calculated by subtracting the sum of the moisture, fat, ash content, crude protein and fibre from 100. Dry matter weight and food energy value was determined by using the method of AOAC (1990). The different part of *S. indicum* investigated in this study were put into solution individually by wet digestion to determine the mineral composition of magnesium, calcium, sodium, potassium and phosphorus using UV-VIS atomic absorption spectrophotometer (AJ-IC03).

Physicochemical properties of seed oil

The physicochemical properties for fatty acid, saponification and iodine value were determined according to the method of AOAC (1997).

RESULTS AND DISCUSSION

The results of the phytochemical analysis revealed the presence of alkaloids, flavonoids, tannins, phenol and phytate (**Table 1**). Our results indicate that all parts of *S. indicum* contained significant amounts of flavonoids while the seeds possessed the highest flavonoids levels. Flavonoids belong to a group of polyphenolics compounds. Polyphenols are plant compounds with a high level of antioxidant activity (Rice-Evans 1995). This activity is due to their ability to adsorb, neutralize and quench free radicals (Duh *et al*. 1999). The high content of flavonoids in this plant (4.98-16.12%) might be responsible for its usefulness as a food and herbal drug.

Phenols are known as important plant constituents that protect plants from oxidant damage due to their hydroxyl group. The levels of phenol contents in all the parts of *S. indicum* (0.13-0.016%) as shown in this study were very low. This observation substantiates narrow range of its medicinal purposes. Alkaloids are valuable chemicals to plants which help in repelling predators and parasites. It also possesses several pharmacological properties for the treatment of various ailments. Conversely, when ingested by the animals may affect mammalian hormone and enzymic activities (Okaka *et al*. 1992). The present study revealed high contents of alkaloids in every part of *S. indicum* except the roots (1.96-10.04%). The leaves had the highest contents of alkaloids (10.04%) followed by the whole plant (7.72%). Similarly, the presence of tannins in this plant between the ranges of 1.81-3.32% may account for the plant's reported antidiarrhoea and antihemorrhagic properties (Asguith and Butler 1996). Phytate is a known anti-nutritional factor that reduced carbohydrate digestibility as well as uptake of cholesterol at the gut through intralumenal physicochemical interaction (Price *et al*. 1987). The decreased level of phytate (0.18-0.79%) and phenol contents are virtually encouraging and may substantiate the increased levels of dietary nutrients such as carbohydrate and protein. Thus, the presence of flavonoids, tannins and alkaloids may be attributed to the antibacterial, antifungal, astringent and antiviral properties of *S. indicum* (Gill 1992; Bankole *et al*. 2007).

The proximate analysis data of the leaves, seeds, roots and the whole plant are presented in **Table 2**. The moisture content of root (6.60%) was significantly different to other parts of the plant while that of the whole plant (4.22%) showed the least content. Both the leaves (5.04%) and the seeds (5.60%) compared well with each other. These values contradict the report of Dashak and Fali (1993) who reported the moisture content values of 4.12-4.73%. The low moisture contents observed in the whole plant may enable this plant to possess a long storage capability. The major nutritional compositions of *S. indicum* were found to include carbohydrates, proteins, crude fibre and food energy

Table 1 Phytochemical constituents (%) of various parts of *Sesamum indicum*.

Plant parts	Flavonoid	Alkaloid	Tannin	Phenol	Phytate
Leaves	13.90 ± 9.27 b	10.04 ± 6.70 a	1.81 ± 1.21 c	0.013 ± 0.01 a	0.52 ± 0.35 b
Seeds	16.12 ± 10.7 a	6.28 ± 4.19 c	2.04 ± 1.37 b	0.013 ± 0.66 a	0.18 ± 0.12 c
Roots	4.98 ± 3.32 d	1.96 ± 1.31 d	2.03 ± 1.36 b	0.016 ± 1.04 a	0.43 ± 0.29 b
Whole plant	9.36 ± 6.24 c	7.72 ± 5.14 b	3.318 ± 2.21 a	0.016 ± 0.01 a	0.79 ± 0.53 a

Test values carrying different letters within a column are significantly different ($P > 0.05$) using the F- test. Data are expressed as mean ± SD (n = 3).

Table 2 Proximate composition (%) of various parts of *Sesamum indicum*.

Nutrients	Leaves	Seed	Root	Whole parts
Moisture	5.04 ± 3.37 b	5.60 ± 3.74 b	6.60 ± 4.39 a	4.22 ± 2.81 c
Crude fibre	9.72 ± 6.48 b	6.60 ± 4.39 ac	12.80 ± 8.53 a	8.80 ± 5.87 b
Carbohydrates	56.37 ± 37.59 c	62.23 ± 41.49 ab	67.90 ± 45.26 a	58.86 ± 38.94 b
Crude protein	19.25 ± 12.83 b	16.63 ± 11.09 c	7.88 ± 5.25 d	21.44 ± 14.29 a
Ash	9.62 ± 6.41 a	8.94 ± 0.96 a	4.82 ± 3.22 c	6.68 ± 4.45 b
Fats and oil	3.88 ± 2.59 b	38.54 ± 25.69 a	2.66 ± 1.77 c	4.54 ± 3.03 b
Dry matter weight	94.96 ± 63.31 a	94.40 ± 62.93 a	93.40 ± 64.94 a	95.78 ± 68.85 a
Food energy value	337.40 ± 224.93 bc	662.30 ± 441.53 a	327.06 ± 218.1 c	362.06 ± 241.37 a

Test values carrying different letters within a column are significantly different ($P > 0.05$) using the F- test. Data are expressed as mean ± SD (n = 3).

Table 3 Mineral compositions (%) of various parts of *Sesamum indicum*.

Minerals	Leaves	Seed	Root	Whole parts
Sodium	0.48 ± 0.32 a	0.23 ± 0.23 a	0.33 ± 0.22 a	0.63 ± 0.42 a
Phosphorus	0.49 ± 0.38 b	0.55 ± 0.37 a	0.20 ± 0.14 c	0.46 ± 0.31 b
Calcium	1.41 ± 0.94 b	0.90 ± 0.60 c	1.71 ± 1.14 ab	2.41 ± 1.61 a
Potassium	0.90 ± 0.64 b	1.20 ± 0.80 a	1.03 ± 0.69 a	0.70 ± 0.47 b
Magnesium	0.49 ± 0.38 b	0.24 ± 0.16 c	0.61 ± 0.40 a	0.61 ± 0.40 a

Test values carrying different letters within a column are significantly different ($P > 0.05$) using the F- test. Data are expressed as mean ± SD (n = 3).

Table 4 Physicochemical properties of seed oil of *Sesamum indicum*.

Acid value mg KOH/g	Iodine value g T2/100 g	Saponification number mgKOH/g	Colour	Odour
2.48	1.27	1.87	Dark brown	Strongly aromatic

value. The good distribution of nutrients in the leaves may explain the usage of this plant as a forage feed given to the domestic animals. The roots had the highest content of crude fibre (12.80 ± 8.53%) and carbohydrate (67.90 ± 45.26%). Crude protein was highest (21.44 ± 14.29%) in whole plant followed by the leaves (19.25 ± 12.83%) but lowest in the roots (7.88 ± 5.25%). The high concentrations of proteins suggest that the whole plant of *S. indicum* can contribute to the daily protein need of 21.44 g for adults near 23.6 g recommended by the National Research Council (1975). These values corroborate with the protein content (21.44) found in non-Nigerian benniseed within the range of 18.00 to 23.18% as reported by Dashak and Fali (1993).

The seeds have the maximum oil contents (38.54%), lowest in roots (2.66%). The observed results support the usefulness of sesame seeds as a good source of edible oils which can be used in cooking as well as soap manufacturing industry. The data revealed high food energy value in the seed (662.3%) which may be due to high lipids content. There was no significant different in dry matter weight (93.40-95.78%) of various plant parts investigated in this study. The proximate analysis of the ash contents was significantly high in the leaves (9.62 ± 6.41%), followed by the seed (8.94 ± 5.96%), whole plants (6.68 ± 4.45%) while that of the roots (4.82 ± 3.22%) was very low. The values of ash and crude fibre content are important in terms of the suitability of food vegetable and digestibility (Bowmen and Russell 2001). The values of crude fibre contents of this plant as recommended by National Research Council (1975) may contribute to the daily needs of fibre. Recently, the interest in dietary fibre has been stimulated due to its ability to prevent chronic diseases such as cardiovascular disease, cancer and diabetes mellitus (Bowmen and Russell 2001). However, lower or higher intake of fibre may results to bowel irritation and possibly colon cancer.

The vital function of minerals for normal metabolism of human system cannot be overemphasized. Among the various elements investigated magnesium (0.61-0.24%), sodium (0.63-0.23%) and phosphorous (0.55-0.20%) are found to be present at the minor levels in all the various parts of the plant while calcium (2.41-0.90%) and potassium (0.70-0.20%) are the predominant minerals as compared with others. The amount of calcium was high in the order < 0.09% in seed < 1.14% in leaves < 1.17% in roots < 2.41% in the whole plant (**Table 3**). The difference in the concentration of the various elements within the different parts may be attributed to preferential absorbability of the plant for the corresponding elements. In addition, the observed results may be linked to the minerals composition of the soil in which the plant grows and climatology conditions. The functional roles of these elements are well documented but must be taken appropriately to meet the daily requirement. Data obtained on elemental concentrations of various parts of *S. indicum* may be useful in deciding the dosage or quantity for consumption as well as herbal remedies of this plant.

The physico-chemical properties of the oil are shown in **Table 4**. The colour of the oil is characteristic brown and aromatic in odour. The acid value (2.48 mg KOH/g) was high compared to 0.40 mg KOH/g in groundnut oil (Ebuehi *et al.* 2006) and 2.24 mg KOH/g in pumpkin seed (Ihediohanma *et al.* 2006). This result was in agreement with the value reported by Akintayo (2002) who suggested that oils of this value are good for consumption. The quality assurance of the seed oil was monitored by examining the iodine and saponification values. The low content of saponification (1.87 mg KOH/g) values indicates low proportion of fatty acids of high molecular weight which make it useful in soap making industry while the iodine value (1.27 g T2/100 g) indicates the drying nature of the oil. Acidic number is known as a measure of the amount of carboxylic acid groups such as fatty acid in the compound. The low content of acidic number agrees with iodine and saponification values observed in the seed oil.

Generally, the results obtained in this present study suggest that *S. indicum* and the various parts investigated can be good source of protein, carbohydrate, minerals and crude fibre. Therefore could be exploited as commercial source to supplement both animal and human consumption consider the anti-nutrient factors. The high percentage of oil contents of the seeds as well as its good physicochemical properties make it viable for commercial extraction. The oil could be a good material for soap making. More so, high flavonoids and alkaloids contents suggest the antioxidant and medicinal properties of different parts of *S. indicum* grown in the study area.

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