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INVESTIGATION ON THE COMPARATIVE PROXIMATE AND ELEMENTAL COMPOSITIONS OF THE FRUIT AND LEAF OF *SOLANUM AETHIOPICUM* CULTIVATED IN JOS

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ABSTRACT

Solanum aethiopicum, commonly referred to as the African eggplant, is one of the commonly consumed vegetables in Nigeria and other African countries because of its nutritional value and health benefits. Despite its pervasiveness, limited studies have focused on the proximate and elemental compositions of this species, especially in Jos, Nigeria. The study conducted a comprehensive proximate and elemental analysis of the fruit and leaf extracts of *S. aethiopicum* using n-hexane, acetone, and ethanol for maceration. Proximate and elemental analyses were conducted on fruit and leaf extracts of *Solanum aethiopicum*, using n-hexane, acetone, and ethanol for maceration. The results showed that fruit extracts had higher moisture, crude fat, fiber, and total protein compared to leaf extracts. However, leaf extracts had slightly higher total carbohydrates and total ash. Specifically, the moisture content for n-hexane fruit extract was 61.04 ± 0.47, while for leaf extract was 59.75 ± 0.64. Total protein in n-hexane fruit extract was 1.74 ± 0.04 compared to 1.55 ± 0.25 in leaf extract. Fiber content was 5.57 ± 0.11 in fruit and 3.54 ± 0.04 in leaf extracts. Crude fat was 5.70 ± 0.45 in fruit and 6.23 ± 0.13 in leaf extracts. Total carbohydrates was 10.24 ± 0.37 in fruit and 11.40 ± 0.09 in leaf extracts, while total ash was 15.71 ± 1.24 in fruit and 17.52 ± 1.17 in leaf extracts. Elemental analyses revealed that magnesium (Mg) was 183.06 ± 2.56 in fruit and 165.60 ± 0.29 in leaf extracts; iron (Fe) was 68.17 ± 0.28 in fruit and 46.33 ± 0.06 in leaf; zinc (Zn) was 5.42 ± 0.07 in fruit and 3.28 ± 0.01 in leaf; copper (Cu) was 2.38 ± 0.02 in fruit and 1.51 ± 0.03 in leaf. Calcium (Ca) was 82.99 ± 0.17 in fruit and 112.95 ± 0.05 in leaf; nickel (Ni) was 85.17 ± 3.27 in fruit and 92.40 ± 1.61 in leaf. The study indicates that both fruit and leaf extracts of *S. aethiopicum* have high nutritional and mineral values, and are recommended for consumers and pharmaceutical industries.

Keywords: *S. aethiopicum*, Proximate content, Mineral compositions, Nutritive value

INTRODUCTION

Solanum aethiopicum a widespread plant genus of the family *Solanaceae*, has over 1000 species worldwide with at least 100 indigenous species in Africa and adjacent islands; these include a number of valuable crop plants and some poisonous ones(Gbile.,1987). It is represented in Nigeria by some 25 species including those domesticated with their leaves, fruits or both eaten as vegetables or used in traditional medicine (Gbile et al., 1988). Eggplants are common and popular vegetable crops grown in the subtropics and tropics (Sarker et al., 2006). They are perennial but grown commercially as an annual crop. Prominent among these are the *S. aethiopicum L*. (Ethiopian eggplant) which are widely cultivated in Nigeria and across the African continent (Bonsu et al., 2004). Among these species known and cultivated in Africa including Nigeria is *S. aethiopicum L*. known as the African eggplant or Ethiopian eggplant (Janic, 2011). It is often cultivated as an annual plant. The African eggplant or commonly called garden egg is also called in native Nigerian languages as "Afufa"or "Anara" in Igbo, "Dauta" in Hausa and "Igbaga" in Yoruba. The African egg plant species are commonly consumed almost on daily basis by both rural and urban families. The fruit said to represent blessings are offered as a token of goodwill during visits, marriages and other social events (Eze, 2014). African eggplant contains many protein, minerals, vitamins, carbohydrates, fat, crude fiber, ash and water substances that are relevant and massively helpful in nutrient supplement and health promotion (Han et al., 2021). The leaves and fruits are relatively bitter and more medicinal hence; old people prefer it to "Anara Adazi". "Anara Adazi" is preferably used for kola to this cultivar in some cultures. This cultivar is moreresistant to pests than the other cultivar(Mabberley, 2017).As a traditional food plant in Africa, this little known vegetable has a potential to improve nutrition, boost food security, foster rural development and support sustainable land care (Lester et al., 1988). *S. aethiopicum* is a wonderful source of potassium, manganese, copper, dietary fiber, folate, magnesium, niacin, vitamin B1, B2, C and K (in very small quantities) (Rezuanul et al., 2004).The highly soluble minerals such as Calcium (Ca), Magnesium (Mg), Phosphorus (P), Iron (Fe) and Potassium (K), help in the maintenance of acid-base balance of the hydrogen ion concentration of the body tissues, and also help complete the absorption of vitamins, proteins, fats and carbohydrates of food (Gropper et al., 2005).The vegetable plant *S. aethiopicum* is very low in carbohydrates, fats and proteins and therefore contribute very little to the energy values of a meal(Szeto et al., 2002).The fruits of *S. aethiopicum*. are known for possessing a diverse range of alkaloids, for example, tropane alkaloids (Museum,2008) and these alkaloids can be desirable, toxic, or both, though they presumably evolved because they reduce the tendency of animals to eat the plants (Vohroa et al., 1984). The pharmacological properties of S. aethiopicum L. have been attributed to the presence of certain chemical compounds in the plants, such as fiber, ascorbic acid, phenols, anthocyanin, glycoalkaloids and a chaconne (Sanchez et al., 2010; AOAC,1990).Proximate analysis of a food sample determined the moisture content, total protein, crude fat,

carbohydrate, total ash and fiber reported as percentage composition of the product(Henry et al., 2022).

To our knowledge, only limited reports are available in literature on the nutritive value of S. aethiopicum cultivated in Jos, in spite of several reports on the plant from other geographical regions. In this work, we therefore demonstrate the proximate and elemental analyses of both the fruit and leaf of *S. aethiopicum*. The biologically very important phytochemicals reported in S. *aethiopicum* could be responsible for its exhibition of various medicinal activities such as antimicrobial, antioxidant, antifungal, blood pressure reduction etc (Eze et al., 2014). The findings from this project could be of great value to the consumers and pharmaceutical industries on the nutritional and medicinal benefits of the fruit and leaf of the said fruit.

MATERIALS AND METHODS

Plant Material and Extraction

Sample Collection

The leaves and fruits of *S .aethiopicum* were obtained from Farin Gada market in Jos North Local government area of Plateau State, Nigeria. The samples were taken to the Department of Plant Science and Technology, University of Jos, where the samples were authenticated and identified. The voucher number is JHUN23000.

Preparation of Sample

The fresh leaves and fruits of the plant sample were properly wash with distilled water and thinly sliced with stainless steel knife and air-dried at room temperature for 21 days. After drying, the samples were separately pulverized to powder using pestle and mortar and thin hole mesh powdered samples were separated in three different sample bottles.

Method of extraction

The three separate samples were macerated using three different solvents (n-Hexane, acetone and ethanol) for 72 hours in a tight container to enhance extraction, after which the filtrates were collected using filter paper. The filtrates collected from the different solvent extracts of the fruit and leaf were concentrated on a water-bath to obtain the crude extracts of the fruit and leaf. The crude extracts were appropriately kept for further analyses.

Proximate analysis

Moisture content, crude fat, carbohydrate, total protein, total ash and fibre were determined respectively using standard procedures of the Association of Official Analytical Chemists (AOAC.,1990).

Determination moisture content

Procedure: The petri dish was washed and dried in air oven. The hot, clean and dry petri dish was then transferred to the desiccator and was allowed to cool. The weight of the petri dish was determined 5.0 g of powdered sample was weighed into the petri dish. The petri dish and its content where then transfer into the oven maintained at about 100 ^{0}C. The content was allowed to dry at 100 ^{0}C temperature for 3 hours thereafter remove from the oven and cooled in a desiccator, after cooling, the weight was determined. These were later return to the oven and the process continued. Subsequent weight was recorded after drying for hours until constant weight was obtained. The percentage moisture content was then calculated as follows:

$$\% \text{ Moisture content} = \frac{Weight\ Loss\ (g) x\ 100}{Weight\ of\ Sample(s)}$$

Determination of fat content

It is determined using Soxhlet apparatus. 3.0 g of the ground sample was accurately weighted into a thimble made of filter paper and fixed into the Soxhlet extractor. n-hexane was used as the solvent. The n-hexane was poured into a round bottom flask fitted and placed on the heating mantle. Extraction was being performed as the solvent refluxed several times. The extraction continued for 7 hours after which the flask was cooled and disconnected. The thimble with sample was removed and dried to a constant weight in an air oven at 80 ^{0}C. The difference between the weight of the thimble before and after drying was recorded in order to obtain the weight of fat extracted. The percentage of fat content was then calculated on dry basis as follow:

$$\% \text{ Fat content} = \frac{\text{Weight of oil or fat extracted (g)}}{\text{Initial weight of sample (g)}}$$

Determination of protein content

Protein Analysis

The keldal method of nitrogen analysis is the worldwide standard for determining the protein in a variety of materials ranging from human and animals' food, fertilizer, waste water to fossils fuels. Digestion is the first step and it is accomplished by 0.5 g of all sample placing the same in the digestion tube along 5mLof Conc. H_2SO_4 and a keldal tablet which is the catalyst. The tubes were heated until they gave light green clear solution. The tubes were carefully removed and allowed to cool. The resulting solution was then made up to 50mL and kept in a plastic container. Steam distillation to separate ammonia from the digestion mixture. It is affected by raising the H of the mixture by adding 10 mL of 4 % NaOH solution and 5 mL of the sample into the steam distillation unit. The NaOH has the effect of changing the ammonium ions to ammonia which is a gas. The Nitrogen was separated away from the digestion mixture by distilling the ammonia by raising the temperature and then trapping the distillate in a separate trapping solution of 5mL of 2 % boric acid with drop of mixed indicator. The distilled solution made up to 50mL and titrated against 0.1 mL HCl until the blue solution turns pink.

% N = 0.014 x T x 10 x 0.1 x 100 ÷ W

Where T = titre value, W = weight of the sample

% P = % N x 6.25

Determination of Ash content

The crucibles for the ashing were washed, dried in the oven and allowed to cool in a desiccator. The cooled crucibles were weighed and 3.0 g of the powdered sample was put in the crucibles and the weight was determined. The crucibles and its content were then transferred into a muffle furnace and its temperature was maintained between 500 ^{0}C and 600 ^{0}C to burn off all the organic matters for hours. The ashing was complete when there was no black spec in the ash. That is, when the samples turned to ash. The crucibles were taken out and immediately covered and were placed in a desiccator to cool and later weighed.

The % is calculated as $\% \text{ Ash} = \frac{\text{Weight of ash(g)} \times 100}{\text{Weight of sample}}$

Determination of Crude fibre

The samples were defatted with Soxhlet extraction using n-hexane as solvent. Samples were continuously defatted for 8 hours. Defatted flours were dried at 50 ^{0}C to drive off the n-hexane completely from the samples. The samples were later boiled 200 mL of 1.25 % H_2SO_4 for 30 minutes, after boiling it was filtered with white cloth and rinsed twice with distilled water. The resulting sample was again boiled in 1.25 % of NaOH for 30 minutes and rinsed with distilled water and 10

% HCl rinsed with ethanol diethyl ether the residue was weighed and ashed lightly.

$$\% \text{ Crude fibre} = \frac{\text{wt of residue} - \text{wt of ash} \times 100}{W1}$$

Where W1 = wt of defatted sample
Wt of residue = wt of sample before ashing
Wt of ash = wt of sample after ashing

Carbohydrate content

The carbohydrate content was calculated by difference, using the formula:
100-(MC + CF + TP + TA + FC).

Determination of Mineral Composition

The minerals were analyzed from solution obtained by ashing as follows: about 1.5 g of the samples was placed in the crucible which has been weighed and was heated gently on a Bunsen burner in a fume cupboard. When the sample ceased to emit smoke and was transferred to a muffle furnace at 550 ^{0}C. Heating was continued until all the carbon was burnt away while the crucible and the sample were then transferred to a desiccator to cool after which 0.1 M HCl solution was added to the crucible so as to break up the ash. It was then filtered over acid with Whatman filter paper into 100 mL volumetric flask. The residue was ashed, three times with 0.1 M HCl and then diluted to 100mL with the same acid solution. Minerals analyses were then determined using two different methods. Ca, Fe, Mg were analyzed using Atomic Absorption Spectrophotometer (AAS). While others were analyzed using Vanadomolybdate (Yellow method).

Atomic Absorption Spectrophotometer (AAS)

AAS was used for the analysis of the following metals Fe, Zn, Ni and Mg. This instrument is use for metal analysis. The techniques require atoms into their ground state to be atomized by absorption. Radiation of their characterized wavelengths is used in the analysis. The flames required depend on the metals being analyzed. For example, an air-acetylene flame is typically employed, while a hotter nitrous oxide flame is used for refractive elements such as calcium (Ca).

RESULTS AND DISCUSSION

Result of the Proximate Analysis

The moisture content of the fruit extract is relatively higher than that of the leaf extracts except foracetone extract of the fruit (Table1, Entry 1), the difference may be as a result of water absorption and water retention capacity of thenatural component of the fruit compared to the leaf of the plant. These values are comparatively below the moisture content of fruits (80-85%) reported in another location. The crude fat % of the fruit extracts are a bit higher compare tothe leaf extracts(Entry 2).While the total carbohydrate % of the fruit extracts are relatively lower in analogy to the leaf extract (Entry 3).The total protein of fruit extracts are also a bit higher than the leaf extracts (Entry 4) while the total ash % content of the fruit extracts are a bit lower compare to the leaf extracts (Entry 5) and the Fibre % content of the fruit extracts are also higher than those of the leaf extracts (Entry 6). Generally, the result shows that the fruit extracts have higher percentage values of the moisture content, crude fat, total protein and fiber, but however contain lower of total carbohydrate and total ash compare to the leaf extracts. This suggests that, the nutritive value of the fruit may not be superior to that of the leaf which also possesses good nutritive composition that is within the WHO limit.

Result of the Elemenal Analysis

Table 2, demonstrates the essential minerals of the fruit and leaf extracts. The micro minerals are elements required in little amount by body though very little but can be useful, these elements found in food are required to be from 5.0 mg/g to 10.0 mg/g maximum according to NAFDAC approved standard.

Fe was detected in the n-hexane fruit extract as 68.17±0.28,while n-hexane leaf extract was 46.33±0.06, Zn in n-hexane of fruit extract was 5.42±0.07, while n-hexane leaf extract gave 3.28±0.03, Cu in n-hexane fruit extract was 2.38±0.02, while then-hexane leaf extract was 1.5±0.03. Micro minerals are also important in the functions of immune system, energy metabolism and antioxidant functions as reported by some researchers.

Macro minerals are element require by the body in large amount macro minerals from the fruit extracts are higher than the leaf extracts. Interestingly, they are not above the NAFDAC standard limit (20.0mg/g-30.0mg/g). In n-hexane fruit extract, 183.06±2.56 Mg was obtained while165.60±0.29 Mg was obtained in the n-hexane leaf extract, Ca in n-hexane fruit extract was found to be 82.99±0.17 and n-hexane leaf extract obtained 112.95±0.05 Ca. Then Ni in n-hexane fruit extract was 85.17±3.27 while n-hexane leaf extract was 92.40±0.33. These elements are very important in body daily metabolic functions for the formation of bone, teeth and also production of energy, nerve and muscle function (Eze et al., 2014).

Table 1: Proximate Composition of Fruit and Leaf Extracts

S/No.	Proximate Composition	Fruit %			Leaf %		
		n-Hexane	Acetone	Ethanol	n-Hexane	Acetone	Ethanol
1	Moisture Content	61.04±0.47	60.72±0.36	61.41±1.50	59.75±0.64	62.35±0.29	61.47±0.96
2	Crude Fat	5.70±0.45	7.34±0.19	6.65±0.37	6.23±0.13	4.93±0.31	5.28±0.24
3	Total Carbohydrate	10.24±0.37	8.62±0.21	9.93±0.36	11.40±0.09	10.29±0.19	10.53±0.17
4	Total Protein	1.74±0.04	2.04±0.02	3.20±0.01	1.55±0.25	2.23±0.06	2.70±0.04
5	Total Ash	15.71±1.24	16.84±0.93	16.10±0.16	17.52±1.17	19.06±0.27	18.95±0.18
6	Fibre	5.57±0.11	4.44±0.03	2.70±0.02	3.54±0.04	1.14±0.02	1.06±0.04

Table 2: Elemental Concentration of Fruit and Leaf Extracts

S/No.		Fruit			Leaf		
		n-Hexane	**Acetone**	**Ethanol**	**n-Hexane**	**Acetone**	**Ethanol**
1	Mg	183.06±2.56	184.26±0.28	206.48±7.06	165.60±0.29	172.20±1.56	183.35±0.41
2	Ca	82.99±0.17	85.25±0.21	83.85±0.18	112.95±0.05	108.48±0.68	123.50±0.17
3	Fe	68.17±0.28	63.22±0.51	66.22±0.09	46.33±0.06	46.80±0.00	45.91±0.20
4	Zn	5.42±0.07	5.56±0.06	5.44±0.02	3.28±0.03	3.28±0.01	3.37±0.01
5	Ni	85.17±3.27	85.07±0.73	90.49±1.61	92.40±0.33	94.60±0.03	103.18±0.07
6	Cu	2.38±0.02	2.41±0.01	2.38±0.01	1.51±0.03	1.47±0.02	1.68±0.02

Discussion

The moisture content of the fruit extracts (61.04–61.41%) was generally higher than that of the leaf extracts (59.75–62.35%), except for the acetone extract of the fruit. Similarly, Han et al. (2021) reported a higher water retention capacity in fruits than in leaves, attributing it to differences in cellular structure and natural composition. However, the moisture values were slightly lower than the general range of 80–85% reported for other fruits by Gropper et al. (2005).

Crude fat content was a bit higher in fruit extracts (5.70–7.34%) compared to leaf extracts (4.93–6.23%). This follows the trend from the results of Henry et al. (2022), where fruits showed higher lipid concentrations; this is attributed to their metabolic role in energy storage. Conversely, the total carbohydrate content was relatively higher in leaves (10.29–11.40%) than in fruits (8.62–10.24%), in line with Rezuanul et al. (2004) in indicating that leaves store more carbohydrates for photosynthesis and energy transfer.

Protein content ranged from 1.55–2.70% in leaf extracts to 1.74–3.20% in fruit extracts, which is in agreement with the observation of Eze et al. (2014) that fruits generally accumulate more proteins during development. On the other hand, ash content was higher in leaves, 17.52–19.06%, than in fruits, 15.71–16.84%, which agrees with earlier reports that leaves are richer in inorganic minerals (Sánchez-Mata et al., 2010). Fiber content was remarkably higher in fruits (2.70–5.57%) than in leaves (1.06–3.54%), which corroborates previous findings of Szeto et al. (2002), where fiber plays a structural role in the formation of fruit tissue.

Generally, whereas the fruit shows higher moisture, fat, protein, and fibre content, the leaf has a higher carbohydrate and ash content. Both organs are nutritionally good, and their proximate compositions are within WHO limits, as confirmed by Lester and Thitai, 1989.

Elemental composition underlines important nutritive contributions of both fruit and leaf extracts. Considering micro minerals, iron (Fe) was remarkably high in fruits with a concentration of 68.17 mg/g as opposed to leaves which contained 46.33 mg/g. It supports Mabberley (2017) in highlighting fruits as a source rich in the provision of vital trace minerals. Zinc (Zn) and copper (Cu) were similarly of higher concentrations in fruits, following Bonsu et al., (2004) findings. These micro-minerals are major actors for body functions like immune functionality and enzyme activities due to the report of Vohora et al. (1984).

Macro minerals like magnesium (Mg) and calcium (Ca) were found in abundance in both parts, with leaves indicating a slightly higher level of calcium (112.95 mg/g vs. 82.99 mg/g in fruits). These findings are in agreement with Henry et al. (2022), which reported similar trends in the distribution of macro minerals in leafy vegetables. Nickel (Ni) was higher in leaves (92.40 mg/g) compared to fruits (85.17 mg/g), in support of Pearson (1981).

The mineral values observed are within the NAFDAC-approved standards (5.0–10.0 mg/g for micro minerals and 20.0–30.0 mg/g for macro minerals), ensuring the safety and efficacy of these parts for consumption and pharmaceutical applications.

CONCLUSION

Conclusively, *S.aethiopicum*is a vegetable with lots of nutritional and medicinal benefits. The fruit and leaf of this plant are excellent sources of in proximate compositions such as moisture content, crude fat, total carbohydrates, total proteins, fibre, total ash and they both contain good concentrations of essential minerals such as Mg, Ca, Fe, Zn, Cu and Ni. We recommend that toxicity test and further research should be carried out on the fruit and leaf of this plant in order to ascertain the safe consumption of this plant especially the leaf.

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