

Original Paper

Comparative Analysis of the Nutrient and Anti-Nutrient Compositions of Five Different African Eggplants

B.C. Akin-Osanaiye¹, Aisha Hassan², C.A. Abodunde^{3*}

1) Department of Biochemistry, Faculty of Science, University of Abuja, Abuja, Nigeria.

2) Department of Biochemistry, Kaduna State University, Kaduna, Nigeria.

3) Department of Microbiology, Faculty of Science, University of Abuja, Abuja, Nigeria

*) Corresponding Author: abodunde.clement@yahoo.com

Received: 06 October 2023; Revised: 01 June 2024; Accepted: 28 June 2024

DOI: <https://doi.org/10.46676/ij-fanres.v5i2.230>

Abstract— Five distinct African eggplants were used in the study to determine their nutritional and anti-nutrient contents which include: *Solanum aethiopicum*, *Solanum gilo*, *Solanum inaequalatum*, *Solanum macrocarpon* and *Solanum melongena*. These analyses were carried out using standard methods. The result indicated that *S. inaequalatum* has the highest proximate composition with calorific value of 306.45kcal; *S. gilo* recorded the lowest carbohydrate value (9.28%). *S. aethiopicum* had the lowest proximate values but recorded the most value of crude fibre (22.00 ± 0.02%). *S. macrocarpon* has a low crude protein of 10.47% and a higher carbohydrate of 40.74% while *S. melongena* has the highest carbohydrate and moisture of 42.98 and 84.58% respectively. There is no significant difference ($p \geq 0.5$) between the values obtained for all the minerals, in all the eggplants. The anti-nutrient analysis showed that *S. gilo* has the highest oxalate (6.01 ± 0.02mg/g). *S. macrocarpon* has a lower saponin (14.05 ± 0.02), hydrocyanic acid (4.34 ± 0.02) and phenol (1.45 ± 0.01). *S. melongena* has the lowest tannin of 1.01 ± 0.01 but has the highest nitrate of 1.03 ± 0.01 µg/g. This shows that the eggplant, *S. inaequalatum*, has the highest nutrient composition and can be eaten regularly for health benefits.

Keywords— *Guibourtia coleosperma*, Nutritional composition, Wild edible seeds

I. INTRODUCTION

The garden egg, also known as the "mock tomato," "gilo," or "huckleberry" in the west, is a fruit of the African egg plant *Solanum aethiopicum*. It belongs to the family Solanaceae with its origin traced to tropical Africa. *S. anguivi* is a wild species that grows in tropical Africa, and *S. distichum*, a semi-domesticated species, were domesticated to create garden eggs [20]. The plant genus *Solanum* has approximately 1,000 species worldwide, and *Solanum* species (eggplants) are members of the Solanaceae family. About 25 species, including domesticated ones, are found in Nigeria; their leaves, fruits, or both are consumed as vegetables or utilized in traditional medicine [11][31]. In Nigeria, people refer to them as "garden eggs" and go by the names gauta in Hausa, afufa or anara in Igbo, or igba

in Yoruba. According to Rushton, all eggplants are members of the scientific order Polemoniales and family Solanaceae, also known as the nightshade [40]. According to botany, *S. melongena* is the name given to the majority of cultivated eggplants, which are non-tuberous plants [8][40]. Similar to other non-climacteric fruits, they are autogamous diploids with 12 chromosomes that are a significant crop for agriculture [15] [43]. According to historical data presented by certain writers, the cultivation of eggplant started in India but was first widely grown in China [8] [13] [41] [32].

According to studies, eggplant is one of the top ten food sources in the world for health [10] [12]. It is also regarded as the best species grown worldwide. They fall within the category of substances known as alkaloids, which has piqued the interest of scientists in a pharmaceutical sense [33]. Alkaloids are generally toxic compounds that are present in all eggplants and are responsible for the green colour and bitter flavour of the vegetable; nevertheless, boiling helps to reduce alkaloids [33]. Due to its widespread use, eggplant is referred to be the king of vegetables in India, South Africa, Malaysia, and Singapore [8]; [43]. Despite being classified as a poor man's vegetable and typically eaten by those with low incomes, it remains an important part of the Indian diet [8]. Although some people are afraid to eat eggplant because of a historical myth, production of the vegetable is rising owing to its culinary and health benefits [43]. The elite prefer eating exotic vegetables like lettuce, cabbage, carrots, cucumbers and cauliflower over native vegetables like eggplant, dandelion and spinach because they believe that these latter two cannot be utilised for official meal service unless they have been modified [23]. Additionally, due to a lack of understanding about the nutritional and health advantages of eggplants, most people simply consume them as and when they choose [8] [39] [46].

In many nations, eggplant is eaten as food in both its raw and cooked forms [6] [8]. According to these writers, eggplant is extremely adaptable and may be cooked in a variety of ways, including boiling, grilling, roasting, stewing, baking, drying,

braising, pickling, pureeing or breading, microwave cooking, sautéing, mashing and frying. The fruit called garden egg (*S. melongena*) is in season, and those who enjoy it enjoy stews cooked with it as well as steaming yams. However, the advantages of eating garden eggs go well beyond satisfying one's appetite for a satisfying breakfast [27]. This fruit, which is a highly prized delicacy and component of the African diet from Cotonou to Harare, Mozambique to Senegal, and which also symbolises fertility and blessing, is frequently offered during wedding rituals throughout the African continent. Experts advise those who wish to lose weight to consume more of it in its fresh form, just as they advise people who are urged to protect their hearts from the effects of cholesterol. In a previous study, garden egg plant significantly slowed weight growth in rats compared to animals fed oat and apple in both the mid-term and long-term tests [17]. They claimed that meals like garden eggs are effective in raising high plasma HDL-cholesterol, which is why eating them has health advantages. They said that it would be advantageous because research has conclusively shown an antagonistic association between HDL cholesterol and the prevalence of cardiovascular illnesses like stroke. Infusion of garden eggplant juice in people led to a similar observation, from studies showed the injection has a minor, transitory impact on people with cholesterol issues [22].

However, due to the benefits of garden eggs for vision, the Igbo population in Nigeria finds it difficult to live without them. Many people may adopt this culture since it has a scientific foundation. Experts discovered that glaucoma sufferers may benefit greatly from eating garden eggs in a research to evaluate the "Effects of garden egg on some visual functions of visually active Igbos of Nigeria" [17]. The study, which was originally designed to determine whether there would be side effects from the male participants' heavy intake, discovered that all of them had smaller pupils. Additionally, their intraocular pressure was reduced. Even though it was still within the usual range, it decreased by 25%. They came to the conclusion that eating garden eggs did not impair eyesight, and people shouldn't be afraid to consume large quantities of them since they may even assist reduce glaucoma patients' eye pressure [28]. Without exaggeration, this is the best recipe for fast weight reduction. Due to its extremely low calorie content, it is especially advantageous for diabetics [28]. It was noted that local residents still commonly eat garden egg soup, especially the elderly and those who are unwell. This is likely because the vegetable has sedative, carminative, or other medical effects. Garden eggs may have more potential worth in the domestic and international markets if further study into their medical characteristics is conducted [27].

There are several species of eggplant, and depending on the nation or continent, they go by the names eggplant, aubergine, or brinjalare. Due to cultivar variations, they also come in a variety of forms, ranging from enormous to little. Studies showed, some seem as enormous, cylindrical, oval, and long-necked fruit, such as giant zucchini, while others appear as round, little green fruits, such as peas, small pebbles, and small tomatoes [8] [26] [43] [48]. According to their morphology, the cultivars of eggplant were further divided into three botanical kinds [2][43]. According to Choudhury's proposed classification, "*S. melongena* var. *Esulentum* Dunal (Nees) –

"round, oval, or egg-shaped fruits"; *S. melongena* var. *serpentinum* L. – "long, slender fruits" and *S. melongena* var. *depressum* L.- "small, miniature fruits, dwarf, and early types" are the three classifications [14]. Additionally, it has been confirmed that the divisions were made based on fruit morphology [2]. The three botanical types have a recent history of close interaction, yet they do differ slightly due to geographic location and genetic variation. According to [2], these species are widespread over continents including Africa, Asia, Europe, and North America. Additionally, it was proposed that eggplant cultivars might be distinguished by their origin and colour in addition to their form [43].

The names given to them include dark purple, tiny, Chinese, Japanese, Thai, and Indian eggplants. Out of 98 aubergine accessions, it was found that 58 belonged to *S. melongena*, 27 to *S. aethiopicum*, and 16 to *S. macrocarpon* [38]; [43]. All these species of aubergine together exhibit both pronounced similarities and differences with considerable distinctions [2][8][43]. Due to its nutritional and therapeutic benefits, it is crucial to identify the nutritional content of African aubergine, so supplementation is carried out as needed. African eggplant can be used for animal and human food locally, as well as a commercial product locally and internationally, by spreading awareness of its nutritional and anti nutritional properties.



Fig.1 *S. incanum* (Small)

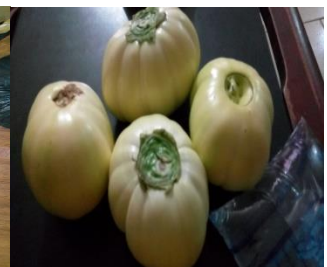


Fig.2 *S. melongena* (Big)



Fig.3: *S. macrocarpon*

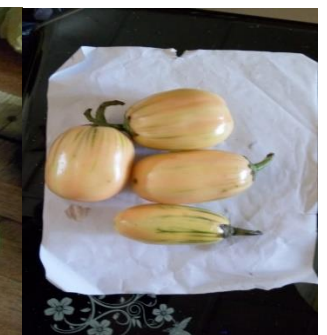


Fig.4: *S. aethiopicum* L

II. MATERIALS AND METHODS

A. Materials

Unripe fruits of *S. incanum*, *S. melongena* and *S. macrocarpon* were purchased from a street vendor in Ungwar Rimi, Kaduna state, Nigeria. The identification of the fruits was done in the Department of botany, Kaduna state University.

B. Methods

1) Preparation of samples

Samples were cut into shreds, baked in an oven at 105°C, and then ground into a fine dry powder. The ground-up sample was kept at room temperature in an airtight container.

2) *Phytochemical Screening*

By soaking 100g of the powdered samples in 200 mL of distilled water for 12 hours, an aqueous sample of the extract was created. Utilising Whatmann filter paper No. 42 (125mm), the extracts were filtered. The aqueous extract and the powdered samples were subjected to chemical analyses in order to determine the contents. Each phytochemical's presence was categorised according to colour intensity.

a) *Test for Tannin*

The ferric chloride test, as developed by [24] and reported by [37], was used to determine if tannin was present in the test sample. In 10mL of distilled water, two grammes (2g) of the powdered sample were added. For 30 minutes, the mixture was agitated, and the filtrate was then employed as an aqueous extract. Two drops of diluted ferric chloride (FeCl₃) were added to the mixture along with 2 mL of the aqueous extract, 3 mL of distilled water, and a lot of shaking to create a homogenate. Tanning is indicated by the production of an extremely black precipitate.

b) *Test for Saponins*

According to [37], the test for saponin was conducted using the [24] technique. The Froth test is another name for the saponin test. In a test tube for the froth test, 2mL of the aqueous extract and 6mL of distilled water were combined. After thoroughly shaking the mixture, froth formed, indicating the presence of saponins.

c) *Test for Alkaloids*

Each sample was tested for the presence of alkaloids using HCl on a steam bath and Whatmann filter paper no. 42 Wagner's reagent (2g of iodine and 3g of potassium iodine were dissolved in 20mL of distilled water and made up to 100mL with distilled water) was added to 1mL of the filtrate to make 0.5mL. The presence of alkaloids was confirmed by a reddish brown precipitate.

d) *Test for Flavonoids*

The test was done according to method described by [37] where he applied the acid-alkaline test to the sample to determine the presence of flavonoids. A test tube was filled with two mL (2mL) of the aqueous extract and a few drops of pure ammonia. Flavonoids are detected when a yellow coloration develops.

e) *Test for Phenols*

Methods from [35] were used to investigate this. 10mL of distilled water was added to the boiling 50mL flask in which the free fat sample was placed. Ammonium hydroxide (2mL) and concentrated Amyl alcohol (5mL) were added to the solution. For the purpose of colour development, the mixture was given 30 minutes to react.

f) *Test for Hydrocyanic Acid*

20g of the sample was placed in a 50cm conical flask to test for the presence of hydrocyanic acid. Without contacting the sample, a dry drop of alkaline picrate paper that has been soaked in an equivalent amount of a 10% Na₂CO and 1% picric acid solution is suspended from the flask's mouth. With cotton wool or tissue paper, the flask's mouth is tightly sealed. The setup is then heated in a water bath for up to an hour. When cyanogenic glycosides are present, the colour of the picrate paper changes from yellow to orange to brick red, according to [35] and [24].

g) *Test for Oxalates*

According to [42], the HPLC technique was used to determine the oxalate content. Total oxalate was extracted from 1g of finely ground, dried samples using 50 ml of HCl (2M) in a 200 mL beaker with a cover glass at 80°C for 15 minutes. Oxalic acid concentrations in each sample were measured using a standard calibration curve with concentrations ranging from 100 to 500 mg/ml, and results were represented as mg of oxalate per 100g of sample.

h) *Test for Phytates*

According to [21], phytate content was assessed using the HPLC technique. Five grammes (5g) of the samples were extracted under magnetic agitation for three hours at room temperature using 40mL of the extract solution (10g/100g Na₂SO₄ in 0.4mol/L HCl). The supernatant was filtered after the suspension was centrifuged at 500 rpm for 30 minutes. A known iron content acidic iron III solution was used to precipitate the phytic acid. The amount of phytic acid (phytate) is determined by the drop in the supernatant.

i) *Test for Nitrates*

0.1mL of HCl was added to 5mL of sample, and everything was properly mixed. The mixture was next transferred to a quartz micro-cuvette in an amount of around 1.0mL. Deionized water devoid of organics was used to zero the spectrophotometer at 220 nm in a quartz cuvette that was identical to the one used earlier. At 220 nm, sample absorbance (NO₃ + organic matter) was measured. The spectroscope was then set to zero at 275 nm. At 275 nm (organic stuff), sample absorbance was measured. To get the result for NO₃ adjusted for the quantity of organic solvent matter, absorbance 275nm was multiplied twice and then subtracted from absorbance 220nm. Additionally, a calibration curve was used to convert the 220nm to concentration.

j) *Proximate Analysis*

The approximate composition of the powdered eggplant samples was identified, including moisture, crude protein, crude fat, crude fibre, ash composition of the sample using the official Method of the Association of Official Analytical Chemists [4], and carbohydrate by difference as reported by [5].

k) *Determination of moisture*

Five grammes of each dried sample were placed in an aluminium dish and dried for 24 hours at 67°C until they reached their desired weight. The % moisture was calculated using the formula below.

$$\text{Moisture (\%)} = \frac{\text{Weight of original sample} - \text{Weight of dried sample (g)}}{\text{Weight of original sample (g)}} \times 100$$

l) Estimation of crude fat (ether extract)

Three grammes of dried samples were collected in thimbles with labels and placed in the extraction tube of the Soxhlet equipment in order to estimate crude fat. The heater's settings were set such that ether was continuously falling on the sample in the extraction tube. Petroleum ether, with a boiling point of 40–60°C, was used for the 16-hour extraction procedure. After removing the sample, the solvent was allowed to evaporate in a fume hood. In an air oven set at 105°C for 30 minutes, the extract was fully dried. Following chilling in a desiccator, the weight of the extract was noted.

$$\text{Crude fat (\%)} = \frac{\text{Weight of fat in sample (g)}}{\text{Weight of sample}} \times 100$$

m) Estimation of nitrogen and crude protein

Using the Kjeldhal's equipment, the nitrogen content of the samples was assessed, and crude protein was estimated by multiplying the nitrogen content by a factor of 6.25 [45].

n) Determination of crude fibre

Each 100 mL beaker had three (3) grammes of labelled, dried, and fat-free samples. 200 mL of 1.25% H₂SO₄ was added to the beakers, and the level of each beaker was noted. The beaker's contents were heated for 30 minutes while being constantly stirred; more water was added; then, the filtrate was given 2-3 washes with hot water (150mL) until it was acid-free. 200mL of 1.25% NaOH were added after the residue was once more transferred to a 1000mL beaker. For another 30 minutes, the mixture was boiled, adding volume as it went. Filtering the mixture and giving it two or three hot water washes before tarring the crucible and drying it for three to four hours at 100°C to get a consistent weight. The sample's contents were heated until no longer smoking on an oxidising (blue) flame. The samples were then heated in a muffle furnace to 550°C for four hours to produce a grey ash, cooled in a desiccator and weighed. Crude fibre was used to represent the weight difference and was computed using the following formula:

$$\text{Crude fibre (\%)} = \frac{\text{Loss of weight after ignition (g)}}{\text{Weight of sample (g)}} \times 100$$

o) Estimation of ash

Three grammes of each sample was collected and cooked in marked crucibles over an oxidising flame until the smoke stopped. The crucibles were moved to a muffled furnace and kept there for six hours at 550°C. The samples were weighed after cooling in a desiccator. The following formula was used to determine the amount of ash in the samples:

$$\text{Ash content} = \frac{\text{Weight of ash in sample (g)}}{\text{Weight of sample}} \times 100$$

p) Carbohydrate determination

According to [36], the difference approach was used to calculate the overall percentage of carbohydrates. The entire value of the sample's crude protein, fat, crude fibre, moisture, and ash components is added, and the result is subtracted from 100. The proportion of carbohydrates in the sample was the figure obtained. Thus,

$$\% \text{ Carbohydrate} = 100 - (\% \text{ moisture} + \% \text{ crude fibre} + \% \text{ protein} + \% \text{ lipid} + \% \text{ ash})$$

q) Mineral Analysis

The Association Official and Analytical Chemist's [3] official technique was used to determine the mineral composition of the sample. Two grammes of the sample were dried and ashed for 24 hours at 500°C in a muffle furnace using a porcelain crucible. After cooling in a desiccator, the resultant ash was weighed. 10% HCl was used to treat the ash. Using a 5 series atomic absorption spectrophotometer, the quantification was done.

3) Statistical Analysis

Analysis of variance (ANOVA) was used to examine the obtained data along with means, standard deviations, and standard errors of the means. To distinguish and contrast means, Duncan's New Multiple Range Test will be used.

III. RESULTS AND DISCUSSION

A. Results

TABLE 1: PHYTOCHEMICAL ANALYSIS OF THREE DIFFERENT AFRICAN EGGPLANTS

Parameters (%)	<i>S. incanum</i> Kaduna	<i>S. macrocarpon</i> Kaduna	<i>S. melongena</i>	<i>S. macrocarpon</i> Gwari	<i>S. aethiopicum</i> (Stripped)
Alkaloid	6.80 ± 0.03	5.60 ± 0.01	4.70 ± 0.02	6.22 ± 0.02	7.29 ± 0.03
Flavonoid	0.26 ± 0.01	0.22 ± 0.01	0.20 ± 0.01	0.26 ± 0.01	0.70 ± 0.02
Saponin	14.67 ± 0.01	14.05 ± 0.02	13.98 ± 0.01	5.61 ± 0.03	8.54 ± 0.02
Tannin	1.56 ± 0.01	1.24 ± 0.02	1.01 ± 0.01	1.47 ± 0.02	2.00 ± 0.01
Phenol	1.83 ± 0.03	1.45 ± 0.01	1.13 ± 0.01	1.81 ± 0.01	2.11 ± 0.01
Oxalate	2.29 ± 0.02	2.06 ± 0.05	2.03 ± 0.01	3.12 ± 0.02	6.01 ± 0.01
Hydrocyanic acids (µ/g)	4.71 ± 0.01	4.34 ± 0.02	4.03 ± 0.02	0.74 ± 0.01	0.81 ± 0.02

Parameters (%)	<i>S. incanum</i> Kaduna	<i>S. macrocarpon</i> Kaduna	<i>S. melongena</i>	<i>S. macrocarpon</i> Gwari	<i>S. aethiopicum</i> (Stripped)
Nitrate (μg)	1.46 ± 0.01	1.37 ± 0.01	1.03 ± 0.01	1.00 ± 0.01	2.33 ± 0.01
Phytate (μg)	13.20 ± 0.10	12.44 ± 0.20	10.33 ± 0.13	18.03 ± 0.11	24.54 ± 0.20

Values are mean \pm standard error of mean (SEM) of triplicate determinations.

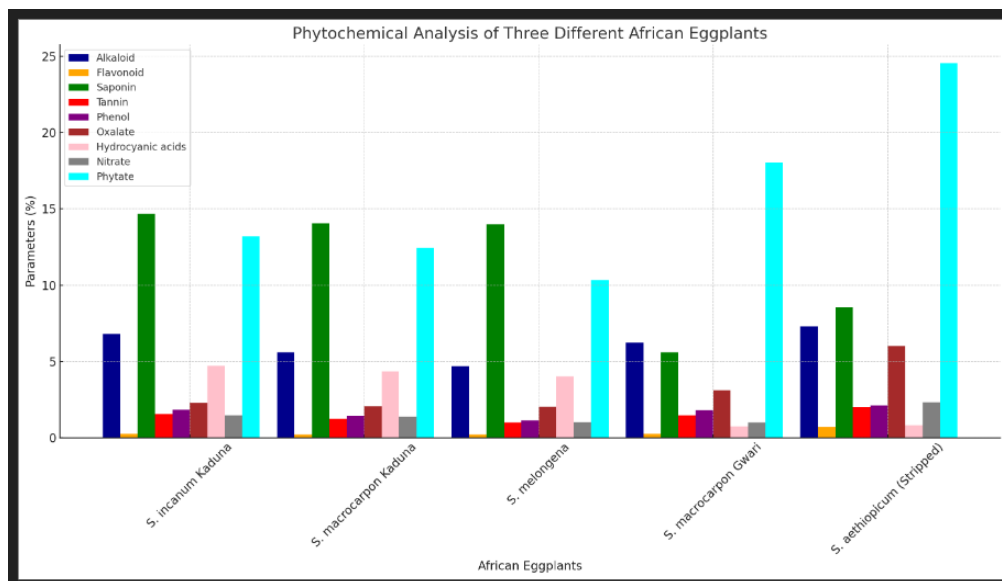


Fig. 1. Showing Phytochemical Analysis of Three Different Eggplants.

TABLE II: NUTRIENT COMPOSITION OF THREE AFRICAN EGGPLANTS

Parameters (%)	<i>S. incanum</i>	<i>S. macrocarpon</i>	<i>S. melongena</i>	BCO1	BCO2
Moisture	84.41 ± 0.01	83.86 ± 0.02	84.58 ± 0.02	9.72	7.24
Ash	15.66 ± 0.01	14.77 ± 0.01	14.22 ± 0.02	14.98	10.50
Crude fibre	18.65 ± 0.00	15.07 ± 0.01	14.71 ± 0.01	22.38	18.00
Crude fat	12.01 ± 0.01	10.44 ± 0.11	9.69 ± 0.02	5.44	7.64
Crude protein	11.48 ± 0.02	10.47 ± 0.02	10.01 ± 0.01	2.20	3.84
Carbohydrate	33.12	40.74	42.98	22.83	9.28
Calorific value (kcal)	306.45	302.55	296.72	152.04	165.28

Values are mean \pm standard error of mean (SEM) of duplicate determinations

TABLE III: MINERAL CONTENTS OF THREE DIFFERENT AFRICAN EGGPLANTS

Parameters (mg/100g)	<i>S. incanum</i>	<i>S. macrocarpon</i>	<i>S. melongena</i>	BCO1	BCO2
Phosphorus	1078.00 ± 0.00	1022.33 ± 0.01	1000.55 ± 0.00	18.2	22.07
Magnesium	34.86 ± 0.01	30.90 ± 0.04	27.55 ± 0.02	3.24	4.25
Potassium	212.87 ± 0.02	205.42 ± 0.02	198.70 ± 0.19	16.47	21.31
Copper	256.13 ± 0.03	244.01 ± 0.01	223.43 ± 0.02	0.57	0.83
Sodium	129.32 ± 0.02	127.76 ± 0.01	120.07 ± 0.02	20.26	26.68

Parameters (mg/100g)	<i>S. incanum</i>	<i>S. macrocarpon</i>	<i>S. melongena</i>	BCO1	BCO2
Iron	324.53 \pm 0.03	310.67 \pm 0.01	302.24 \pm 0.02	3.56	4.57
Manganese	147.78 \pm 0.03	142.33 \pm 0.00	138.89 \pm 0.02	2.05	4.24
Zinc	4.39 \pm 0.01	4.14 \pm 0.02	3.86 \pm 0.01	0.17	0.26
Calcium	15.31 \pm 0.02	14.97 \pm 0.01	14.10 \pm 0.02	13.51	18.14

Values are mean \pm standard error of mean (SEM) of duplicate determinations

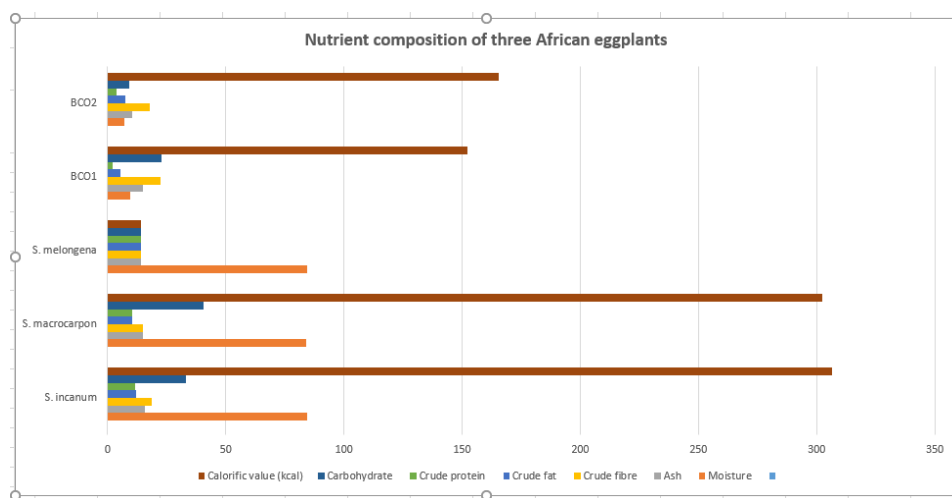


Fig.2. Showing Nutrient Composition of Three African Eggplants.

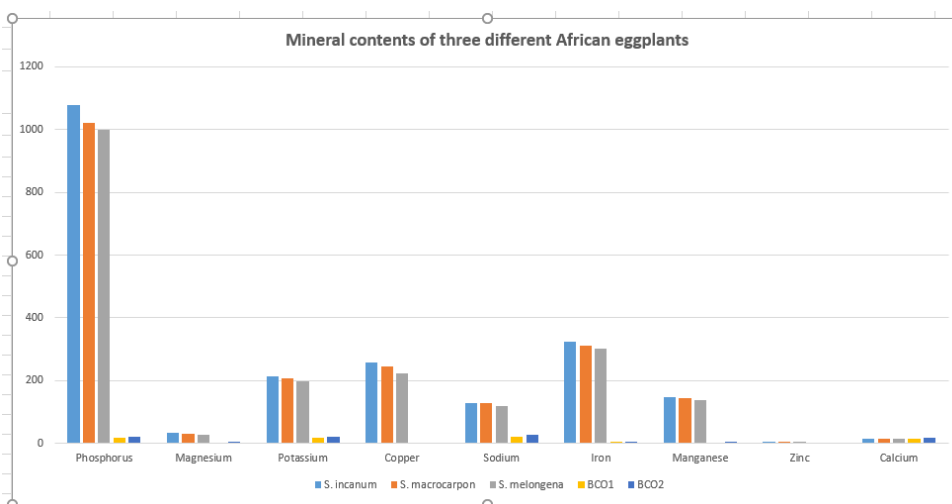


Fig. 3. Showing Mineral Contents of three Different African Eggplants.

B. Discussions

Results of quantitative analysis of phytochemicals present in *S. incanum*, *S. macrocarpon* and *S. Melongena* are shown in Table 1. The presence of alkaloids is crucial for medicine. They consistently cause plants to taste bitter. Codeine is one of these alkaloids and is utilised in cough medications and as an analgesic. The alkaloid contents of *S. incanum* were 0.68 0.03; *S. macrocarpon* were 0.56 0.01; and *S. melongena* were 0.47 0.02; these values are less than the 5.0% and 6.0% values reported for *S. aethopicum* and *S. gilo* [19] and are not far from the 0.99% value reported for *S. melongena* oval variety [1].

In general, flavonoids have antibacterial and antifungal properties. They are known to have antioxidant and anti-inflammatory properties and are possible sources of natural preservatives. Flavonoid of *S. incanum* (26.21 \pm 0.01) was lower than 39.6% reported for the same species [7], *S. macrocarpon* (22.06 \pm 0.01) was lower than 27% reported for *S. aethopicum* [19] and *S. melongena* (19.97 \pm 0.01) was similar to 19.50% value reported for *S. gilo*. The results showed that the species are rich in flavonoid.

As nutritional supplements and nutraceuticals, saponins are advocated. They serve as an adjuvant in the creation of vaccines. *S. incanum* contained appreciable high content of saponin (14.67 ± 0.01) from the result, which is lower than 19.9% value reported for the same species [7] *S. macrocarpon* (14.05 ± 0.02) which fall in line with the 14.0% value reported for *S. aethopicum* and *S. melongena* (13.98 ± 0.01) which is higher than 5.34% and 5% values reported for *S. Melongena* and *S. gilo* [1]. These species are moderate sources of saponin.

Tannins have demonstrated an ability to be antiviral, antibacterial, and antiparasitic. It was discovered that *S. incanum* contains (1.56 ± 0.01), *S. macrocarpon* (1.24 ± 0.02) and *S. melongena* (1.01 ± 0.01) had values that were lower than the 2.5% reported, but still compared favourably to the 1.0% value reported for *S. Gilo* [29]. This shows that these species are poor tannin suppliers Phenols are advantageous because they are a flexible precursor to a wide range of medications, such as Aspirin and many pharmaceuticals that, with extended contact, can be damaging to the eyes, skin, and respiratory system. *S. incanum*, *S. macrocarpon*, and *S. melongena* all had less phenol than the published values of 3.6% [18] and 4.7% for *S. aethopicum* [19] and *S. aethopicum* (1.83 ± 0.03 , 1.45 ± 0.01 , and 1.13 ± 0.01 , respectively). They are poor phenolic sources.

Oxalate is a substance that may be found in some foods and is also created by the body as waste. It is present in the body via urine [16]. The oxalate content of *S. incanum* was (2293.50 ± 1.50), *S. macrocarpon* was (2063.50 ± 0.50) and *S. melongena* was (2022.50 ± 1.50). Too much oxalate may cause kidney stones in some people [16].

S. incanum contained (4.71 ± 0.01) hydrocyanic acids, followed by *S. macrocarpon* (4.34 ± 0.02) and *S. melongena* (4.03 ± 0.02). The symptoms of exposure to hydrocyanic acids can range from nausea and stomach discomfort to coma and death [8].

Natural sources of nitrate include cereals, fruits, and vegetables. It is a salt of nitric acid. Although nitrate-rich foods provide a number of health advantages, some nitrate is converted to nitrite in our bodies, which can result in the formation of nitrosamines and have adverse consequences. *S. incanum* contained ($0.000146 \pm 1 \times 10^{-5}$), *S. macrocarpon* contained ($0.000137 \pm 1 \times 10^{-5}$) and *S. melongena* contained ($0.000103 \pm 1 \times 10^{-5}$) nitrates. These species are good sources of nitrate within safe limits [16].

All plant-based foods include the naturally occurring substance phytate, often known as phytic acid. One of the most important beneficial functions of Phytate is their anticancer activity [29]. Others include; improve immune function and also protect against osteoporosis [6]. The Phytate content of *S. incanum* was (1320.05 ± 0.01), *S. macrocarpon* was (1244.41 ± 0.02) and *S. melongena* was (1033.53 ± 0.03). The results indicate that these species are good sources of Phytate [6].

The nutrient composition of *S. incanum*, *S. macrocarpon* and *S. Melongena* is shown in Table 2. A chemical method of evaluating and expressing the nutritional value of a feed is

known as "nutrient composition," also known as "proximate analysis" or "Weende analysis," and it reports the moisture, ash (minerals), crude fibre, crude fat, and crude protein (total nitrogen) present in a food as a percentage of dry food weight. A difference determines the presence of carbohydrates (nitrogen-free extract). The entire nutritional makeup of the sample is revealed by the proximate analysis. These findings are consistent with the findings of other studies [20], according to which fruits typically contain between 80 and 85 percent moisture. Ash content is a crucial fruit characteristic since it establishes the fruit's mineral makeup [30]. The amount of ash found in *S. incanum* in this investigation was 15.66 ± 0.01 . This number falls in line with the 15.0% value reported for *S. aethopicum* [19], although it is lower than the 21.20% value previously recorded for the same fruit [25]. The ash content of *S. macrocarpon* was (14.77 ± 0.01) and *S. melongena* was (14.22 ± 0.02) were in line with the 14.80% value reported for *S. gilo*. This demonstrates that these species have a significant mineral content when compared to other species. Pectins, a kind of raw fruit fibre, play a crucial role in stomach emptying by slowing the rate at which sugar is absorbed. The crude fibre content of *S. incanum* (18.65 ± 0.00), *S. macrocarpon* (15.07 ± 0.01) and *S. melongena* (14.71 ± 0.01) were higher than 6.22%, 8.60%, 16.0% and 11.75% values reported for *A. Carambola* [16], *S. gilo* and *S. aubergine* fruits respectively [16] but less than the 21.33% amount reported for *S. aethopicum* [19].

The crude fat content of *S. incanum* (12.01 ± 0.01) compared well with the 12.50% value reported for the same fruit [25]. The crude fat of *S. macrocarpon* (10.44 ± 0.01) and *S. melongena* (9.09 ± 0.02) were lower than 11.7% value reported for *A. Carambola* [16] but higher than 7.0% for *S. gilo* and 40% for *S. aubergine* respectively [16]. This indicates that these species contain a high level of crude fat. They serve as an energy source that is stored in living things as well as important structural components of biological membranes such as phospholipid and sterols [34].

Although it is not usually known that proteins are more abundant in fruits, they are crucial because they include enzymes that catalyse and speed up certain chemical reactions. The crude protein content of *S. incanum* (11.48 ± 0.02), *S. macrocarpon* (10.47 ± 0.02), and *S. melongena* (10.01 ± 0.01) were measured. These numbers are greater than the 4.0% recorded for *A. carambola* fruits [16] and the 7.8% reported for *S. incanum* [25] but lower than the 14.87% and 15.75% reported for *S. gilo* and *S. aubergine*, respectively.

Because of their role in nutrition and metabolism, carbohydrates are essential; they serve as natural sweeteners and the basis for a variety of goods [47]. The three species are high sources of carbohydrate, *S. incanum* (33.12%), *S. macrocarpon* (40.74%) and *S. melongena* (42.98%) and this make them a good source of carbohydrate. These values are higher than 15.6% reported for *S. aethopicum* [19] but less than the 58.5% recorded for *S. aubergine* fruits and the 51.74% reported for *S. gilo*, respectively, according to [16].

S. incanum's total metabolisable energy was determined to be 306.55kcal, *S. macrocarpon*'s to be 302.55kcal, and *S. melongena*'s to be 296.72kcal. These values are lower than 308.9kcal reported for *S. incanum* [25], 403.54kcal reported for *S. nigrum* seeds [16] and 384.33kcal reported for *B. caricea* seeds. These findings demonstrate that the three species are reliable sources of energy that may be used as food for humans.

Main element and minor elements are vital elements required for the normal growth and maintenance of the body. The mineral analysis of *S. incanum*, *S. macrocarpon* and *S. melongena* show the presence of phosphorus, magnesium, potassium, manganese, copper, sodium, iron, calcium and zinc [25]. The significance of these elements cannot be over emphasized. For instance, phosphorus is an essential mineral element that form part of DNA and RNA as well as helps in strong bones and teeth formation; magnesium is involve in enzymatic reaction of carbohydrate metabolism example glycolysis, potassium plays an important role in electrolyte and acid-base balance in the body system; copper is used in the synthesis of cytochrome oxidase; sodium helps in the transmission of nerve impulse and brings about osmotic balance of the cells in living tissues; In order for red blood cells to produce haemoglobin, iron is absolutely necessary; zinc is a co-factor of about 200 enzymes or more that play important role in metabolic pathways and calcium will equally solve the problem of bone condition [25]. The mineral values of these species compare well with those obtained for *S. incanum* [25] apart from calcium and zinc which are lower than values reported for *Aegle marmelos* [18].

IV. CONCLUSIONS

Increased intake of the fruits (*S. incanum*, *S. macrocarpon*, and *S. melongena*) can have a beneficial impact on the population's diet and state of health. The presence of both major and minor elements indicates that the fruits are vital and could be used as supplement. It can, therefore, be concluded that *S. incanum*, *S. macrocarpon* and *S. melongena* fruits are a rich source of both nutrient and anti-nutrient components, including minerals which justify their uses as both vegetables and medicinal plants.

ACKNOWLEDGMENTS

Many thanks to staff of Microbiology department, university of Abuja, Nigeria and Botany department, Kaduna state university.

REFERENCES

- [1] B.O. Agoreyo, E. S. Obansa, and E. O. Obonor. Comparative Nutritional and Phytochemical Analyses of Two Varieties of *Solanum melongena*. *Science World Journal*, 7(1): 5 – 8, 2012.
- [2] Z. Ali, Z.L. Xu, D.Y. Zhang, X.L. He, S. Bahadur and J.X.Yi. Diversity Analysis of Eggplant Genetic Resources Molecular Research, online. *Journal Genetic Molecular Research*, 10 (2): 1141-1155.2011.
- [3] AOAC. In Official Methods of Analysis. Association of Official Analytical Chemists.17th edition. USA: Gaithersburg, MD. 2000.
- [4] AOAC. In Official Methods of Analysis. Association of Official Analytical Chemists.19th edition. Washington, D.C., 121 - 130. 2012.
- [5] E. Asibey-Berko. Proximate Analysis of some Underutilized Ghanaian Vegetables. *Ghana Journal of Science*. 39:91-92. 2009.
- [6] S. Asiedu – Addo. Turkey Berry: The Wonderful Medicinal Plant.Daily Graphic Online. Thursday, 2014; 16th January, Retrieved 29th July, 2015, graphic.com.gh/15850-turkey-berry-thewonderful-medicine-plant.html.2014.
- [7] R. Auta, S.A. James, T. Auta and E.M. Sofa. Nutritive Value and Phytochemical Composition of Processed *Solanum incanum* (Bitter Garden Egg). *Science World Journal*, 6(3):5-6.2011.
- [8] B. Bhaskar and K.P. Ramesh. Genetically Modified (GM) Crop Face an Uncertain Future in India: Brinjal Appraisal – A perspective, *Annals of Plant Sciences*, 4(2): 960 - 975.2015.
- [9] Biology of Brinjal. General Description of Brinjal or Eggplant. Government of India Department of biotechnology, Ministry of science and technology; Retrieved from dbtbiosafety.nic.in/guidelines/brinjal on 4th October, 2015.
- [10] R.M. Bliss and D. Elstein. Scientists Get Under Eggplants Skin. *ARS magazine*, January 2004; 52 (1). <http://www.ars.usda.gov/is/AR/archive/jan04/skin0104.htm>, 2004; Retrieved 28th July, 2015.
- [11] K.O. Bonsu, D.A. Fontem, G.O. Nkansah, R.N. Iruome, E.O. Owusu and R.R. Schippers. Diversity within the Gboma Eggplant (*Solanum macrocarpon*), An Indigenous Vegetable from West Africa. *Ghana Journal of Horticulture*, 1: 50 - 58. 2008.
- [12] X.G.I. Caguiat and D.M. Hautea. Genetic Diversity Analysis of Eggplant (*Solanum melongena* L.) and Related Wild Species in the Philippines using Morphological and SSR Markers, *SABRAO. Journal of Breeding and Genetics*, 46(2), 183-201.2014.
- [13] M. Chong. Perception of the Visit and Benefits of Eggplant by Indian farmers. *Journal of Risk Research*, 8(7): 617-634. 2005.
- [14] B. Choudhury. Vegetables. 4th Revised Edition. India, New Delhi: National Book Trust. pp. 50-58.1976.
- [15] A. Concellón, M.C. Anˆo'n and A.R. Chaves. Effect of Chilling on Ethylene Production in Eggplant Fruit, *Food Chemistry*,92(1): 63 – 69.2005.
- [16] C.A. Edem, M.I. Dounmu, F.I. Bassey, C. Wilson and P. Umoren. A Comparative Assessment of the Proximate Composition, Ascorbic Acid and Heavy Metal Content of Two Species of Garden Egg (*Solanum gilo* and *Solanum aubergine*). *Pakistan Journal of Nutrition*, 8(5): 582 - 84.2009.
- [17] J.K. Edijala, S.O. Asagha, U. Atomatofa and G.E. Eriyamremu. Department of Biochemistry, Delta State University, Abraka, Nigeria. Department of Biochemistry, University of Benin, Benin City, Nigeria, (2005) edition of the *Pakistan Journal of Nutrition*.2005.
- [18] J.E. Emurotu, P.K. Onojah and A.S. Musa. Proximate and Phytochemical Screening of the Fruit and Leaves Extract of Bael (*Aegle marmelos*). *IOSR Journal of Applied Chemistry*, 9(11): 22 – 28.2017.
- [19] S.O. Eze and C.Q. Kalu. Phytochemical and Nutritive Composition Analysis of *Solanum Aethopicum* L. *Journal of Pharmaceutical and Scientific Innovation*, 3(4): 358 – 362.2014.
- [20] G.J.H. Grubben and O.A. Denton. *Plant Resources of Tropical Africa II: Vegetables*, Leiden, Wageningen: Backhuys Publishers. pp. 475-480.2004.
- [21] E. Guerra-Hernandez, B. Garcia-Villanova and B. Garcia-Villanova. Maillard Reaction Evaluation by Furosine Determination during Infant Cereal Processing. *Journal of Cereal Science*, 29: 171 – 176. 1999.
- [22] P.R. Guimeraes, A.M.P. Galvao, C.M. Batistaand and N. Freire. Eggplant (*Solanum melongena*) Infusion has a Modest Effect on Hypercholesterolemic Subjects. *Brazilian Journal of Medical and Biological Research*, 33(9): 1027 - 1036.2000.
- [23] F.O. Habwe, K.M. Waling and M.O.A. Onyango. Food Processing and Preparation Technologies for Sustainable Utilization of African Indigenous Vegetables for Nutrition Security and Wealth Creation in Kenya, 2008; In *using Food Science and Technology to Improve Nutrition and Promote National Development* Robertson, G. L., Lupien, J. R., (Eds), International Union for Food Science and Technology.2008.
- [24] J.B. Harborne. *Phytochemical Methods*. London: Chapman and Hall Ltd. pp. 149-188.1973.

- [25] S.S. Haruna, O. Ahmed and S.K. Abdullahi. Phytochemical, Proximate and Mineral Analyses of *Solanum incanum* Fruit. *International Journal of Chemical, Material and Environmental Research*, 3(1): 8 – 13.2016.
- [26] K.K. Hirst. Eggplant History (*Solanum melongena*). *History of Eggplant Domestication Archaeology Expert* 2014; About.com. Retrieved on 11th July, 2015.
- [27] J.D. Horna and G. Gruère. Marketing Underutilized Crops for Biodiversity: The Case of the African Garden Egg (*Solanum aethiopicum*) in Ghana 8th International BIOECON Conference, 29-30 August 2006, Kings College Cambridge.2006.
- [28] S.A. Igwe, D.N. Akunyili and C. Ogbogu. Effects of *Solanum melongena* on Some Visual Functions of Visually Active Igbo of Nigeria, *Journal of Ethnopharmacology*, 86: 135 -138.2003.
- [29] J.D. Lambert and C.S. Yang. Mechanism of Cancer Prevention by Tea Constituents. *Journal of Nutrition*, (133)10: 32635 – 32675.2008.
- [30] W.T. Leung, F. Busson and C. Jardin. Food Composition for Use in Africa. *African Journal of Eggplant*, 10(3): 101 – 119.2009.
- [31] M.L.K. Manoko and G.M. van der Weerden. *Solanum americanum* In: G. J. H. Grubben and O. A. Denton (eds.), *Plant Resources of Tropical Africa 2. Vegetables*. PROTA Foundation Wageningen/ CTA. Leiden, Wageningen: Backhuys Publishers. pp. 477-480.2004.
- [32] K. Matsubara, T. Kaneyuki, T. Miyake and M. Mori. Antiangiogenic Activity of Nasunin, Antioxidant Anthocyanin, in Eggplant Peels. *Journal of Agricultural Food Chemistry*, 53(16): 6272 - 6275.2005.
- [33] D.S. McGehee, M.D. Krasowski, D.L. Fung, B. Wilson, G.A. Gronert and J. Moss. Cholinesterase Inhibition by Potato Glycoalkaloids Slows Mivacurium Metabolism. *Anesthesiology*, 93(2): 510 - 519.2000.
- [34] D.L. Nelson and M.M. Cox. *Lehninger Principle of Biochemistry*, 4th ed. W.H. Freeman.2005.
- [35] D.E. Okwu. Evaluation of Phytonutrients, Mineral and Vitamin Content of Some Varieties of Yam (*Discorea* spp). *International Journal of Molecular Medicine and Advances in Science*, 22:1999 - 2003. 2005.
- [36] E.U. Onyeike, E.O. Ayalogu and S.G. Uzogara. Influence of Heat Processing of African Yam Bean Seed (*Sphenostylis stenocarpa*) Flour on the Growth and Organ Weights of Rats. *Plant Foods and Human Nutrition*, 48: 85 – 93.1995.
- [37] A.U. Osagie. *Anti-nutritional Factors in Nutritional Quality of Plant Foods*. Nigeria, Benin City: Ambik Press. 2011.
- [38] G. Polignano, P. Uggenti, V. Bisignano, C. Della and G. Genet. Genetic Divergence Analysis in Eggplant (*Solanum melongena* L.) and Allied Species. *Resource Crop Evolution*, 57(0): 171 – 181. 2010.
- [39] G. Putra. Nutrition is a Key to Health. Retrieved from www.nutrient.net; 28th August, 2015. 2011.
- [40] P.J. Rushton, M.T. Bokowiec, S. Han, H. Zhang, J.F. Brrannock, X. Chen, T.W. Laudeman, M.P. Timko. Tobacco Transcription Factors: Novel Insights into Transcriptional Regulation in the solanaceae, *Plant physiology*, 147(0): 280-295.2008.
- [41] J. Samuels. *Solanum incanum* (Solanaceae): Taxonomic Relationships between *S. incanum*, *S. campylacanthum*, *S. panduriforme* and *S. lichtensteinii*. *Kew Bulletin*, 67:401–411.2012.
- [42] G.P. Savage, L. Vanhanen, S.M. Mason and A.B. Ross. Effect of Cooking on the Soluble and Insoluble Oxalate Content of Some New Zealand Foods. *Journal of Food Composition and Analysis*, 13: 201 – 206.2000.
- [43] A. Şekara, S. Cebula and E. Kunicki. Cultivated Eggplants – Origin, Breeding Objectives and Genetic Resources, A Review. *Folia Horticulture Annals*, 19(1): 97 - 114. 2007.
- [44] R.G.D. Steel and J.H. Torrie. *Principles and Procedures of Statistics*. New York: McGraw-Hill Book Company, Inc. 187 – 287. 1960.
- [45] S.R. Thimmaiah. *Standard Methods of Biochemical Analysis*. India, New Delhi: Kalyani Publishers. pp 5 – 20. 2004.
- [46] C.K. Tweneboah. *Vegetables and Spices in West Africa, with Special Reference to Ghana*. 3rd Edition. Ghana: Co-Wood Publishers. 1998.
- [47] C. Westman. *Industrial Organic Chemistry*. 3rd Edition. New York: Springer Verlag. pp. 148 – 155. 2007.
- [48] B.D. Whitaker and J.R. Stommel. Distribution of Hydroxycinnamic Acid Conjugates in Fruit of Commercial Eggplant (*Solanum melongena* L.) cultivars. *Journal of Agricultural Food Chemistry* 3448 - 3454. 2003.