

Proximate and Phytochemical Analyses of *Solanum aethiopicum* L. and *Solanum macrocarpon* L. Fruits

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Available online at: www.isca.in

(Received 26th April 2011, revised 4th May 2011, accepted 25th May 2011)

Abstract

Chemical analyses were carried out to determine the nutritional and phytochemical constituents of fruits of two indigenous Africa eggplants, *S. aethiopicum* L. and *S. macrocarpon* L. Proximate analysis of fresh fruits of *S. aethiopicum* L. (per 100 g) showed: 89.27 ± 0.12 g moisture, 2.24 ± 0.03 g protein, 0.52 ± 0.04 g fat, 0.87 ± 0.03 g ash, 2.96 ± 0.08 g crude fiber, 4.14 ± 0.11 g carbohydrate and 498.47 ± 2.14 mg calcium, 1.98 ± 0.10 mg magnesium and 1.02 ± 0.02 mg iron. Fresh fruits of *S. macrocarpon* L. contained (per 100 g): 92.50 ± 0.14 g moisture, 1.33 ± 0.05 g protein, 0.17 ± 0.01 g fat, 0.47 ± 0.02 g ash, 1.11 ± 0.03 g crude fiber, 4.42 ± 0.12 g carbohydrate, 101.56 ± 1.21 mg calcium, 1.01 ± 0.08 mg magnesium and 0.70 ± 0.01 mg iron. There was a significant presence of alkaloids, saponins, flavonoids, tannins and ascorbic acid in both fruits; terpenoids was found in trace amount. Steroids were present in *S. aethiopicum* L. and absent in *S. macrocarpon* L. These phytochemicals are of therapeutic importance; their presence in *S. aethiopicum* and *S. macrocarpon* fruits indicate the beneficial effects of the plants. *Solanum aethiopicum* L. contained higher levels of the beneficial agents than *S. macrocarpon* L. The two indigenous eggplants are not only nutritionally and therapeutically valuable, but also have the potential of providing precursors for the synthesis of useful drugs.

Keywords: African eggplants, *solanum aethiopicum* L., *solanum macrocarpon* L., proximate composition, phytochemicals.

Introduction

Solanum, 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.¹ 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.^{2,3} Among them are two African eggplants, *S. aethiopicum* L. (Ethiopian eggplant) and *S. macrocarpon* L. (Gboma eggplant), which are widely cultivated in Nigeria and across the African continent.⁴⁻⁶

African eggplants, also called garden eggs (Hausa: Dauta; Igbo: afufa or añara; Yoruba: igbagba), are highly valued constituents of the Nigerian foods and

indigenous medicines; they are commonly consumed almost on daily basis by both rural and urban families.⁷ The eggplants form part of the traditional sub-Saharan African culture. The fruits, said to represent blessings and fruitfulness, are offered as a token of goodwill during visits, marriages and other social events. They are eaten raw and also when boiled or fried as ingredient of stews, soups and vegetable sauces. Wide variations exist within the vegetative and fruit characters both within and between the African eggplant species including variations in characters like diameter of corolla, petiole length, leaf blade width, plant branching, fruit shape, and fruit colour.⁸

Their uses in indigenous medicine range from weight reduction to treatment of several ailments

including asthma, allergic rhinitis, nasal catarrh, skin infections, rheumatic disease and swollen joint pains, gastro-esophageal reflux disease, constipation, dyspepsia.^{9,10} Several studies support the folkloric use of the plants in local foods and medicinal preparations; for instance, different researchers have reported significant analgesic, anti-inflammatory, anti-asthmatic, anti-glaucoma, hypoglycemic, hypolipidemic, and weight reduction effects of eggplants, particularly *S. melongena*, on test animals and humans.^{9,11-13} These pharmacological properties have been attributed to the presence of certain chemical substances in the plants, such as fiber, ascorbic acid, phenols, anthocyanin, glycoalkaloids and α -chaconine.^{14,15} In this study, proximate and phytochemical analyses were carried out on two indigenous eggplants, *S. aethiopicum L.* and *S. macrocarpon L.*, and used to assess their potential nutritive and medicinal benefits.

Material and Methods

Collection and Identification of specimens: Fruits of *S. aethiopicum L.* and *S. macrocarpon L.* were purchased from Mile 12 market in Lagos, Southwest Nigeria. The fruits were identified and authenticated in the Department of Biological Sciences of Covenant University by a botanist, Mr. C. A. Omohinmin. Voucher specimens were also deposited at the Department. The fruits were selected and thoroughly washed in water to remove dirt and unwanted particles. The stalks were removed and the edible portion of the fruits was analyzed.

Proximate Analysis: Proximate composition of the fruits was determined by the official method of the Association of Official Analytical Chemists as follows: Moisture (section 926.08 and 925.09), Protein (section 955.04C and 979.09), Fat (section 922.06 and 954.02), ash (section 923.03) and crude fiber (section 962.09)¹⁶. Carbohydrate was calculated by difference.

Analysis of mineral contents: Five grams (5 g) of the sample was dry-ashed in an electric furnace at 550°C for 24 hours. The resulting ash was cooled in

a desiccator and weighed. The ash was dissolved with 2 ml of concentrated HCl and few drops of concentrated HNO₃ were added. The solution was placed in boiling water bath and evaporated almost to dryness. The content was then transferred to 100 ml volumetric flask and diluted to volume with deionized water. Appropriate dilutions were made for each element before analysis. Calcium, magnesium and iron contents were quantified using S series atomic absorption spectrophotometer as described in the official method of the Association of Official Analytical Chemists.¹⁶

Phytochemical screening: Samples were sun-dried, pulverized and passed through a sieve (about 0.5 mm pore size) to obtain a fine dry powder. Aqueous extract of the sample was prepared by soaking 100 g of the powdered samples in 200 ml of distilled water for 12 hours. The extracts were filtered using Whatman filter paper No 42 (125 mm). Chemical tests were carried out on the aqueous extract and on the powdered samples to identify the constituents using standard procedures.¹⁷⁻¹⁹ Colour intensity was used to categorize the presence of each phytochemical into copious, moderate or slight (trace).

Test for Alkaloids: About 0.5 g of crude powder was defatted with 5% ethyl ether for 15 minutes. The defatted sample was extracted for 20 min with 5 ml of aqueous HCl on a boiling water bath. The resulting mixture was centrifuged for 10 minutes at 3000 rpm. One milliliter (1 ml) of the filtrate was treated with few drops of Mayer's reagent and another 1 ml with Dragendroff's reagent and turbidity was observed^{17,19}.

Test for tannins: About 0.5 g of the dried powdered samples was boiled in 20 ml of water in a test tube and then filtered. A few drops of 0.1% ferric chloride was added and observed for brownish green or a blue-black coloration.

Test for terpenoids: (Salkowski test): Five milliliters (5 ml) of the extract was mixed in 2 ml of chloroform, and 3 ml concentrated H₂SO₄ was

carefully added to form a layer. A reddish brown coloration of the inter face was formed to show positive results for the presence of terpenoids.

Test for cardiac glycosides (Keller-Killani test): Five milliliters (5 ml) of the extracts was treated with 2 ml of glacial acetic acid containing one drop of ferric chloride solution. This was underlayered with 1 ml of concentrated sulphuric acid. A brown ring of the interface indicates a deoxysugar characteristic of cardenolides. A violet ring may appear below the brown ring, while in the acetic acid layer, a greenish ring may form just gradually throughout thin layer.

Test for steroids: Two ml of acetic anhydride was added to 0.5 g ethanolic extract of the sample with 2 ml H₂SO₄. The colour changed from violet to blue or green in some samples indicating the presence of steroids.

Test for saponins: About 2 g of the powdered sample was boiled in 20 ml of distilled water in a water bath and filtered. 10ml of the filtrate was mixed with 5 ml of distilled water and shaken vigorously for a stable persistent froth. The frothing was mixed with 3 drops of olive oil and shaken vigorously, then observed for the formation of emulsion.

Test for flavonoids: The presence of flavonoids in the plant sample was determined by the methods described by Sofowara and Harborne^{17,18}. Five milliliter (5 ml) of dilute ammonia solution was added to a portion of the aqueous filtrate of the plant extract followed by addition of concentrated H₂SO₄. A yellow coloration observed in each extract indicated the presence of flavonoids. The yellow coloration disappeared on standing. Few drops of 1% aluminum solution were added to a portion of each filtrate. A yellow coloration was observed indicating the presence of flavonoids. A portion of the powdered plant sample was in each case heated with 10 ml of ethyl acetate over a steam bath for 3 min. The mixture was filtered and 4 ml of the filtrate was shaken with 1 ml of dilute ammonia solution. A yellow coloration is positive for flavonoids.

Test for phytosterol: The aqueous extract was refluxed with solution of alcoholic potassium hydroxide till complete saponification takes place. The mixture was diluted and extracted with ether. The ether layer was evaporated and the residues were tested for the presence of phytosterol. The residue was dissolved in few drops of diluted acetic acid; 3ml of acetic anhydride was followed by few drops of conc. H₂SO₄. A bluish green color indicates the presence of phytosterol.

Test for Ascorbic acid: Iodine solution consisting of 0.5g of iodine dissolved in 100ml of 1% potassium iodide solution was freshly prepared. One drop of the iodine solution was added into 1ml of 0.1% starch solution placed in a suitable receptacle. Aqueous extract of the sample was added drop by drop until the blue-black colour of the starch iodine complex disappears leaving a colourless solution. The colourless solution indicates the presence of ascorbic acid.

Results

Fruits of *S. aethiopicum L.* and *S. macrocarpon L.* are shown in plates 1 and 2. *Solanum aethiopicum L.* fruits were mostly round shaped, medium or large sized and dark green in colour. Fruits of *S. macrocarpon L.* were oval shaped with a mixture of cream white to light yellow and green with dark green stripes. Table 1 shows the approximate composition of *S. aethiopicum L.* and *S. macrocarpon L.* fruits. The nutrient and mineral composition of *S. aethiopicum L.* fruits per 100 g fresh sample is as follows: 89.27 ± 0.12 g moisture, 2.24 ± 0.03 g protein, 0.52 ± 0.04 g fat, 0.87 ± 0.03 g ash, 2.96 ± 0.08 g crude fiber, 4.14 ± 0.11 g carbohydrate, 498.47 ± 2.14 mg calcium, 1.98 ± 0.10 mg magnesium and 1.02 ± 0.02 mg iron. *Solanum macrocarpon L.* contained per 100g fresh fruit: 92.50 ± 0.14 g moisture, 1.33 ± 0.05 g protein, 0.17 ± 0.01 g fat, 0.47 ± 0.02 g ash, 1.11 ± 0.03 g crude fiber, 4.42 ± 0.12 g carbohydrate, 101.56 ± 1.21 mg calcium, 1.01 ± 0.08 mg magnesium and 0.07 ± 0.01 iron. Result of the phytochemical screening of the fruits is contained in Table 2. There was copious presence of alkaloids, flavonoids,

phytosterols, saponins and vitamin C, moderate presence of cardiac glycosides, steroids and tannins, and trace amount of terpenoids in *S. aethiopicum* L. fruits. The result for *S. macrocarpon* L. fruits showed copious presence of alkaloids and saponins, moderate presence of flavonoids, cardiac glycosides, tannins and vitamin C, trace amount of phytosterols and terpenoids and absence of steroids.



Plate-1: *Solanum aethiopicum* L. fruit



Plate 2: *Solanum macrocarpon* L. fruit

Discussion

The fruits of *S. aethiopicum* L. and *S. macrocarpon* L. differed markedly in their shape and colour. *Solanum aethiopicum* L. fruits were mostly round shaped and dark green in colour, at the point of purchase, whereas the fruits of *S. macrocarpon* L. were largely oval shaped with a mixture of cream white to light yellow and green with dark green stripes (Plates 1 and 2). The wide variations in vegetative and fruit characters both within and between *Solanum* species create ambiguity in taxonomic delineation of African eggplants.⁸ This has often resulted in a mix-up of the identity of species of garden egg with some researchers referring to different species as varieties of one species. For instance, five eggplants apparently belonging to different *Solanum* species were described as varieties of *Solanum gilo*; among them were the round green and sweet white varieties which most appropriately describe *S. aethiopicum* and *S. macrocarpon* respectively²⁰. *Solanum aethiopicum* L. contained higher levels of nutrients: protein, fat, crude fiber, ash and mineral elements (calcium, magnesium and iron) than *S. macrocarpon* L. On the hand, *S. macrocarpon* L. contained more moisture and carbohydrate than *S. aethiopicum* L. African eggplant fruits generally have high moisture content and low dry matter. The moisture content of 89.27 ± 0.12 and $92.50 \pm 0.14\%$ respectively obtained for *S. aethiopicum* L. and *S. macrocarpon* L. falls in line with the report of several researchers. Moisture content of 88.73 and 92.61% respectively was reported for round green (*S. aethiopicum*) and sweet white (*S. macrocarpon*) varieties²⁰. Gboma fruits (*S. macrocarpon*) was also reported to contain 89.0% moisture²¹ while another researcher reported 90.6% moisture for *S. aethiopicum*.⁵ The protein content of 2.24 ± 0.03 and $1.33 \pm 0.05\%$ respectively obtained for *S. aethiopicum* and *S. macrocarpon* compared very well with the value of 1.6 and 1.4% respectively for *S. aethiopicum* and *S. macrocarpon*, 1.5% for *S. aethiopicum* reported by Grubben and Denton (2004) and 1.0% for gboma reported by different researchers^{3,5,21}. The fat content of 0.52 ± 0.04 and $0.17 \pm 0.01\%$ respectively for *S. aethiopicum* and *S. macrocarpon*, was lower than

the 1.0% reported for gboma²¹ but higher than 0.1% reported for *S. aethiopicum*.⁵ The ash content was 0.87 ± 0.03 and $0.47 \pm 0.02\%$ respectively for *S. aethiopicum L.* and *S. macrocarpon L.* compared with ash content of 4.06 and 5.58% of total solids respectively for round green (*S. aethiopicum*) and sweet white (*S. macrocarpon*) varieties.²⁰ The crude fiber content of $2.96 \pm 0.08\%$ obtained for *S. aethiopicum L.* is slightly higher than 2.0% reported for *S. aethiopicum* whereas the fiber content of $1.11 \pm 0.03\%$ for *S. macrocarpon L.* is slightly lower than 1.5% reported for *S. macrocarpon*.^{5,21} Carbohydrate content of 4.14 ± 0.1 and $4.42 \pm 0.12\%$ respectively obtained for *S. aethiopicum L.* and *S. macrocarpon L.* compared with 4.0% carbohydrate content reported for *S. aethiopicum*.²² The high moisture content, moderate ash and protein content of the garden eggs is typical of fleshy vegetable and desirable to remain fresh for longer period to meet market demand. High crude fiber, low fat and low dry matter of the eggplants may be helpful in preventing such diseases as constipation, carcinoma of the colon and rectum, diverticulitis and atherosclerosis²⁰. This may also partly account for the weight reduction effect of African eggplants^{12,23}. Both eggplants apparently are good sources of calcium with *S. aethiopicum* yielding higher level of the mineral.

Phytochemical screening of the plants revealed that both fruits contained alkaloids, flavonoids, phytosterols, saponins, ascorbic acid (vitamin C), cardiac glycosides, tannins and terpenoids at different levels. *Solanum aethiopicum L.* generally contained higher levels of the phytochemicals than *S. macrocarpon L.* Steroids were present in *S. aethiopicum L.* but absent in *S. macrocarpon L.*

Most of the observed effects of eggplants may be due to their phytochemical contents. Alkaloidal extracts of *S. melongena* leaves showed analgesic effects and some CNS depression.¹¹ Bitterness of eggplants is due to the presence of alkaloids, mainly glycoalkaloids; the relative bitterness determines to great extent their edibility or otherwise. Poisoning by *Solanum* species have been attributed to the

presence of toxic glycoalkaloids which cause diarrhea or calcinogenic glycosides which cause excessive deposition of calcium in tissues. In a quantitative study of glycoalkaloids of *S. macrocarpon* and *S. aethiopicum* fruits, the levels in *S. macrocarpon* fruits were found to be 5–10 times higher than the value considered safe in foods whereas the levels in *S. aethiopicum* were about 14% of values considered as toxic, similar to those of *S. melongena*.¹⁵ It is important to apply caution in their uses, though some researchers insist that the fruits are widely consumed in ‘small dose’⁹. Saponins found in the fruits are important dietary supplements and nutraceuticals. Glycoalkaloids and saponins are known to exhibit antimicrobial activities and protect plants from microbial pathogens²⁴. Studies have also shown that saponins present in traditional medicine preparations cause hydrolysis of glycoside from terpenoid to avert the toxicity associated with the intact molecule^{25,26}. *Solanum aethiopicum* and *S. macrocarpon L.* fruits contain ascorbic acid and flavonoids both of which are effective antioxidants^{27,28}. Nasunin, an anthocyanin (flavonoid) isolated from eggplant peel, is a potent antioxidant and free radical scavenger and has been shown to protect cell membranes from damage²⁹. Flavonoids also have hypolipidemic effects; flavonoids extracted from the fruits of *S. melongena* showed significant hypolipidemic action in normal and cholesterol fed rats³⁰. *In-vitro* studies have also shown that flavonoids have anti-allergic, anti-inflammatory, anti-microbial and anti-cancer activities³¹⁻³³. The eggplants, like several *Solanum* species, have antiviral, anticancer, anticonvulsant and anti-infective effects due to the phytochemicals they contain³. These chemo-preventive agents can enhance host protective systems, such as detoxification enzymes against carcinogens, more effectively by their synergistic actions.

Many researchers have investigated *Solanum* species for their steroidal saponin and alkaloid content. Very good quantity of crude solasodine was found in *S. mammosum*³⁴. Solasodine is a suitable for commercial synthesis of 3β -acetoxy-5, 16-pregnadiene-20-one. *Solanum macrocarpon* fruits

have also been reported to furnish solasodine, tomatidine, diosgenin and sitosterol on chemical hydrolysis^{35,36}. *Solanum* species are therefore rich sources of precursors of steroid drugs. These steroidal raw materials have been found useful in cardiovascular therapy as human abortifacients, anti-inflammatory agents and menopause regulants and are also known to influence the CNS³. The two indigenous African eggplants investigated in this study clearly fits into the WHO description of plant as “a plant with one or more organs which contain substances that can be used for therapeutic purposes and/or which are precursors for the synthesis of useful drugs”³⁷.

Conclusion

Solanum aethiopicum L. and *S. macrocarpon* L. fruits showed significant differences in morphological features as well as chemical constituents. *Solanum aethiopicum* L. fruits contained higher levels of beneficial nutrients and phytochemicals than *S. macrocarpon* L. fruits. The fruits of the two indigenous African eggplants are nutritionally and therapeutically valuable and also have the potential of providing precursors for the synthesis of useful drugs.

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Table-1: Proximate composition of *Solanum aethiopicum L.* and *Solanum macrocarpon L.* fruits

Nutrient	Composition (per 100g of fresh fruit)	
	<i>Solanum aethiopicum L.</i>	<i>Solanum macrocarpon L.</i>
Moisture	89.27 ± 0.12 g	92.50 ± 0.14 g
Dry matter	10.73 ± 0.12 g	7.50 ± 0.14 g
Protein	2.24 ± 0.03 g	1.33 ± 0.05 g
Fat	0.52 ± 0.04 g	0.17 ± 0.01 g
Ash	0.87 ± 0.03 g	0.47 ± 0.02 g
Crude Fiber	2.96 ± 0.08 g	1.11 ± 0.03 g
Carbohydrate	4.14 ± 0.11 g	4.42 ± 0.12 g
Mineral Element		
Calcium	498.47 ± 2.14 mg	101.56 ± 1.21 mg
Magnesium	1.98 ± 0.10 mg	1.01 ± 0.08 mg
Iron	1.02 ± 0.02 mg	0.70 ± 0.01 mg

Table-2: Phytochemical Screening of *Solanum aethiopicum L.* and *Solanum macrocarpon L.* fruits

Phytochemicals	<i>Solanum aethiopicum L.</i>	<i>Solanum macrocarpon L.</i>
Alkaloids	+++	+++
Cardiac Glycosides	++	++
Flavonoids	+++	++
Phytosterols	+++	+
Saponins	+++	+++
Steroids	++	-
Tannins	++	++
Terpinoids	+	+
Vitamin C	+++	++

+++ (copiously present), ++ (moderately Present), + (slightly present/trace), - (absent)