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Comparative Proximate, Mineral and Vitamin Composition of *Solanum aethiopicum* and *Solanum melongena*

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Abstract

This study evaluated the nutritional composition of Solanum melongena (aubergine) and Solanum aethiopicum (Family: Solanaceae) using standardized procedures. Crude protein and carbohydrate contents of S. melongena were significantly (p<0.05) higher than those of S. aethiopicum. There was no significant (p>0.05) difference in the ash and fibre contents between the two species. Moisture and lipid contents of S. aethiopicum were significantly higher (p < 0.05) than those of S. melongena. Mineral analysis showed that S. melongena has significantly higher (p<0.05) levels of calcium, magnesium and iron while, zinc content of S. melongena was significantly (p<0.05) lower than that of S. aethiopicum. Vitamin analysis revealed vitamins C and E contents of S. melongena were significantly higher (p<0.05) than those of S aethiopicum. The levels of vitamins A and D in the two species were not significantly (p >0.05) different. Overall, the results suggest that these species of eggplant are good sources of naturally occurring antioxidants and nutritionally important nutrients such as fibre that could play a role in preventing obesity, constipation and even cancer. Their low energy content makes them useful adjuncts in weight reducing diets.

Keywords: Eggplant, Analysis, Proximate, Minerals, Vitamins

Introduction

Solanum species (eggplants) belong to the family of *Solanaceae* with over 1,000 species worldwide (1). Common names include garden egg (English) guata (Hausa) afufa or anara (Igbo) and igba (Yoruba). As a member of the genus *Solanum*, it is related to both the tomato and potato. The fruit is botanically classified as a berry and contains numerous small, soft seeds which are edible but may have a bitter taste in the raw state due to the presence of some alkaloids. The plant grows to about 40-150cm, with large, coarsely lobed leaves that are about 10-20 cm long and 5-10 cm wide. The fruit of the plant comes in a wide array of shapes, sizes and colours depending on the species (2). The most common species in the tropical region are: the *Solanum melongena* (big eggplant) *Solanum macrocarpon* (mid eggplant) and *Solanum aethiopicum* (small eggplant).

Solanum melongena is popularly called aubergine in American and Canadian English. The skin is smooth and purple coloured though some varieties are light green. Eggplants are used in the cuisine of many countries and may be fried, roasted, mashed and mixed with pepper, onions and spices for a gravy sauce. Eggplant sauce usually served with boiled yam is a delicacy.

Nutritionally the eggplant contains various nutrients and phytonutrients (3) such as nasunin and chlorogenic acid which are good antioxidants. It is also a good source of fibre and is low in calories, fat and sugar which may be helpful to the diabetic. It helps in relieving constipation as a result of its high fibre content thereby protecting the digestive tract. Eggplant is also high in bioflavonoids which are known to control high blood pressure and relieve stress (4). It is regarded as a brain food because it contains the phytonutrient, anthocyanin, found in its skin, nasunin, a potent antioxidant and free radical scavenger that has been known to protect the fats in the brain cell membranes from free radical damage. It also inhibits neuroinflammation and facilitates blood flow to the brain. This helps prevent age-related mental disorders and also improves memory (5). It is also said to increase HDL-cholesterol, and has antiviral and antimicrobial properties.

This study evaluates the proximate composition, vitamin and mineral contents of *Solanum aethiopicum* and *Solanum melongena* for comparative purposes.

Materials and Methods

Plant materials

Fresh fruits of *Solanum melongena* (aubergine) were purchased from Ode-lrele main market, Ondo State and *Solanum aethiopicum* (small garden egg) at New Benin market, Edo State, both in Nigeria. They were identified and authenticated at the Department of Plant Biology and Biotechnology, University of Benin, Benin City, Nigeria.

Preparation of Samples

Both fruits (*S. aethiopicum* and *S. melongena*) were washed, sliced and then oven-dried (Gallenkamp, UK) at 70 ^{0}C till a constant weight was achieved (three days). The dried samples were pulverized (Thomas Wiley machine, England) and the powdered samples kept in glass stopperred bottles until needed for analysis.

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Proximate Analysis

Proximate composition for crude protein, fibre, fat, moisture, ash and total carbohydrates of *S. aethiopicum* and *S. melongena* were carried out in triplicates according to the procedure of the Association of Official Analytical Chemists (6) using the powdered sample. For the moisture determination, 2g each of the fresh fruits were utilized.

Determination of Moisture

The method is based on drying the sample under controlled temperature (Gallenkamp, UK) until a constant weight was obtained. The moisture content was calculated as a fraction of the original weight.

$$\% \, Ash = \frac{W2 - W3}{W2 - W1} \text{ x } 100$$

where w_1 = weight of empty crucible (g), w_2 = weight of crucible plus fresh sample (g) and w_3 = weight of crucible plus sample after drying (g).

Determination of Ash

The method involved the oxidation of all organic matter by incineration in a muffle furnace. 2.0 g of the milled sample was incinerated at 600 ^{0}C (dry ashing) in a muffle furnace (Gallenkamp, UK).

$$\% \, Ash = \frac{W3 - W1}{W2 - W1} \text{ x } 100$$

where w_1 = weight of empty crucible and lid (g), w_2 = weight of crucible, lid and sample (g) and w_3 = weight of crucible and ash (g)

Determination of Crude Protein

Crude protein was determined using the semi-micro Kjeldahl method (7) as reported by Pearson (8), which involves protein digestion, distillation and titration. The percentage total organic nitrogen was initially determined as a first step and then multiplied by a conversion factor of 6.25 to obtain the percentage crude protein:

$$\% \text{ Nitrogen} = \frac{titre \; value \; x \; 1.4 \; x \; total \; volume \; of \; sample}{1000mg \; x \; sample \; weight \; (g) x \; aliquot \; volume \; distilled} \; x \; 100$$

% Crude Protein = % total nitrogen x 6.25.

Determination of crude fat

The method is based on the continuous extraction of crude lipids with petroleum ether or other fat solvents such as chloroform or hexane for a defined period of time.

$$\% \, Crude \; fat = \frac{W3 - W2}{W1} \text{ x } 100$$

where w_1 = weight of sample (g), w_2 = weight of dried extraction flask before fat extraction (g) and w_3 = weight of dried extraction flask after fat extraction (g).

Determination of Crude fibre

The crude fibre is the plant polysaccharide and lignin, which are resistant to hydrolysis by digestion with acid and alkali. The washed and dried residue after acid and alkali digestion was ignited in the furnace (Gallenkamp, UK) at 600 ^{0}C for 20 min. The loss in weight during incineration is equivalent to the weight of crude fibre in the sample.

$$\% \, Crude \; fibre = \frac{W2 - W3}{W1} \text{ x } 100$$

where w_1 = weight of the sample, w_2 = dry weight of residue before ashing and w_3 = dry weight of residue after ashing

Determination of total carbohydrate

Total carbohydrate was obtained by “difference” (9)

% Total carbohydrate =

100 – (% moisture + % ash + % crude fat + % crude protein) in 100g of food

The carbohydrate estimated in this fashion includes fibre (10).

Gross energy

The energy content of the samples were calculated using the Atwater factors of 4, 9, 4 for protein, fat and carbohydrate respectively (11).

Calorific value = (% carbohydrate x 4) + (% crude fat x 9) + (% crude protein x 4)

Mineral Assay

The concentrations of zinc, calcium, magnesium, and iron in *Solanum aethiopicum* and *Solanum melongena* were determined using atomic absorption spectrophotometer (Solar 969 Unicam series) after acid digestion (12).

Vitamin Assay

The concentrations of vitamins A, C, and D in *S. aethiopicum* and *S. melongena* were determined using the spectrophotometric (Solar 969 Unicam series) procedures (13), (14) and (15) as modified by Maciej and Krzystof (16).

Statistical Analysis

Data was expressed as mean ± SEM of triplicate determinations. Unpaired t–Test was performed using INSTAT software and the level of significance was set at $p \leq 0.05$.

Results and Discussion

The present study generally showed that *S. melongena* (aubergine) contained higher levels of protein, fibre, carbohydrate, minerals, vitamins and energy.

The results of the proximate composition of *Solanum aethiopicum* and *Solanum melongena* are presented in Table 1. Moisture content was high in both species of eggplant suggesting short storage periods. The values obtained in this study (Table 1) for both eggplants were similar to those reported by other researchers (17), (18). The high moisture content could aid the functions of the gastrointestinal tract. The moisture content of any food item could be used as an index of stability and susceptibility of fungal infection (19).

The crude protein value of 3.03 ± 0.15 g% of *S. melongena* was significantly ($p<0.05$) higher than that of *S. aethiopicum* (Table 1). The values obtained for *S. aethiopicum* (1.10 ± 0.15 g%) and for *S. melongena* (3.03 ± 0.15 g%) in this study are lower than the values reported earlier (17), (18), but in the same range of 4.0 g% reported for the unripe pulp of *dennettia tripetala* (pepper fruit) (20). The main function of protein is for growth and maintenance of body tissues and a deficiency causes poor growth and muscle wasting in children (21). Thus the addition of eggplant to the family diet would increase protein consumption somewhat.

Crude fibre content though higher in *S. melongena*, the difference was not statistically ($p>0.05$) significant (Table 1). A similar trend was earlier reported (22). The values recorded here for both species fall within the 0.3g% and 5.5 g% dry weight in selected fruits reported by other workers (10). Though dietary fibres cannot be digested by man, they play useful roles in providing roughage that aid digestion (23). Fibre also helps to prevent heart disease, diabetes and weight gain. Thus, eggplants may play a role in human nutrition.

The ash content of 1.23± 0.15g% for *S. aethiopicum* though higher, was not statistically different ($p>0.05$) from that of *S. melongena* (Table 1). Values recorded for both eggplants fall within the range for *Musa paradisiaca* (plantain) of 1.9% (unripe, green) to 0.96% (just ripe) (24). The value obtained for *S. melongena* in the present study (0.87g%) is same as that reported for *S. aethiopicum* by others (17). The ash content is a reflection of the mineral content of the plant sample.

Lipid content was the lowest recorded proximate composition of the two eggplants (Table 1). *S. aethiopicum* had a low lipid content of 0.37± 0.03g% which was statistically ($p < 0.05$) higher than the 0.17± 0.03g% recorded for *S. melongena*. Similar findings have been reported (22).The values reported in the present study are lower than those reported by other workers (17). Values as low as 0.3mg% for banana *(Musa sapientum*) and only traces for such fruits as the citrus species have been reported (25). Fruits are not very good sources of fats and are usually recommended as part of weight reducing diets (26). Variations in composition of the eggplant can be attributed to the species, climatic differences between regions (soil nutrient composition) and seasons of the year.

Carbohydrate content of *S. melongena* (4.99 ± 0.27g%) was significantly ($p<0.05$) higher than the value of 3.07 ± 0.19g% recorded for *S. aethiopicum*. (Table 1). *S. melongena* (aubergine) also recorded higher energy content (41.77 kcal/100g) than *S. aethiopicum* (27.33 kcal/100g) in this study. Energy content of 42.0 kcal for *S. marcrocarpon* and 38.0 kcal for *S. nigrum* has been reported (27).While the energy content of *S. melongena* falls within this range, that of *S. aethiopicum* is much lower. The carbohydrate and energy contents being low suggest eggplants can be part of the diet of weight watchers.

The mineral composition of *S. aethiopicum* and *S. melongena* is presented in Table 2. Of the four minerals examined *S. melongena* (aubergine) had significantly ($p<0.05$) higher values for magnesium, calcium and iron while *S. aethiopicum* had significantly ($p<0.05$) higher zinc levels. Minerals obtained from fruits are low in quantity but serve important functions in the body such as cofactors to enzymes and electrolytes in body fluids and cells (28). The levels of calcium reported here for both species are lower than the 15.8 mg% reported earlier (29). Calcium prevents rickets in children and osteomalacia in adults (30). *S. melongena* recorded significantly ($p<0.05$) higher levels of magnesium (26.08 ± 0.25 mg/kg) than *S. aethiopicum* (12.77 ± 0.13 mg/kg).

The magnesium content of *S. aethiopicu*m obtained in this study was much higher than that reported by other workers (17) but lower than the 12.9 mg/100g reported for the fruit shell of *tetrapleura tetraptera* (31). Magnesium prevents mental depression and muscular tremor and is required by many enzymes (30).

The iron content in *S. melongena* (18.89 ± 0.14 mg/kg) was more than twice the amount in *S. aethiopicum* ($p<0.05$). Iron content of *S. melongena* in the present study is much higher than that reported by Shalom *et al.* (17). These values are higher than the 0.4 mg% for pawpaw and 0.9 mg% for banana reported by other researchers (29). Eating iron rich fruits would prevent deficiency symptoms of iron such as anaemia, fatigue, impaired immunity amongst others (21).

S aethiopicum recorded significantly ($p<0.05$) higher zinc levels than *S. melongena*. Zinc had the lowest concentration amongst the four elements analyzed, as also reported by others (17). Zinc is a part of insulin and is required by several enzymes. Presence of zinc in foods/diets prevents stunted growth, delayed sexual maturation, impaired immune function, hair loss and loss of appetite among other deficiency symptoms (21).

Concentrations of vitamins A, C, D, and E of the two species of eggplants studied are displayed in Table 3. The levels of the vitamins were in the following order C> E> A> D in both species with *S. melongena* (aubergine) having significantly higher levels of vitamins A, C and E. The main contribution of fruits and their products to nutrition is undoubtedly their supply of vitamins most especially the antiscorbutic vitamins (32).

Vitamin C content of *S. melongena* was more than twice that of *S. aethiopicum* ($p<0.05$). Vitamin C is a major vitamin found in these species having recorded the highest level of the vitamins analyzed. Ascorbic acid concentration of 48 mg/kg was reported for *Capsicum frutescence L* (hot pepper) (28) which is equal to the value obtained for *S. melongena* in the present study. Ascorbic acid in the body aids iron absorption from the intestines and is also necessary as an anti-stress and protector against cold, chills and dampness. It prevents muscle fatigue and scurvy (28).

Vitamin E content in *S. melongena* was statistically higher than that of *S. aethiopicum* suggesting *S. melongena* is a better source of the vitamin. Vitamin E occurs in the diet as a mixture of several closely related compounds, called tocopherols and tocotrienols. All of the tocopherols and tocotrienols are important naturally occurring antioxidants. Recent studies have shown that vitamin E is required for maintaining normal immune function particularly in the elderly, and may be important in preventing macular degeneration and cognitive decline. While the recent emphasis on high polyunsaturated fat diets to reduce serum cholesterol may be of benefit in controlling heart disease, the propensity of polyunsaturated fats to form free radicals on exposure to oxygen may lead to increased cancer risk. It is prudent to increase vitamin E intake for diets rich in polyunsaturated fats (33). Addition of eggplant to the diet could be a regular source of the natural antioxidant, vitamin E.

Vitamin A content of *S. melongena* ($15.30 \pm 0.90 \times 10^{-2}$ μM) was not significantly greater than that of *S. aethiopicum* ($14.30 \pm 0.90 \times 10^{-2}$ uM). The active forms of vitamin A are retinol, retinal (retinaldehyde), and retinoic acid. Their precursors are synthesized by plants as the carotenoids, beta–carotene and some other carotenoids have an important role as antioxidants. At low oxygen tensions prevalent in the body, beta-carotene is a very effective antioxidant and may reduce the risk of those cancers initiated by free radicals and other strong oxidants. Vitamin A-deficient animals are more susceptible to infections and cancer (33) and night blindness is an early symptom of deficiency. Thus including eggplants as part of the diet is recommended.

The vitamin D content of *S. aethiopicum* though higher than that of *S. melongena* was not statistically ($p>0.05$) different. Technically, vitamin D should be considered a pro-hormone rather than a vitamin. Cholecalciferol (D_3) is produced in the skin by UV irradiation of 7- dehydrocholesterol. Thus as long as the body is exposed to adequate sunlight, there is little or no dietary requirement for vitamin D. The most common symptoms of vitamin D deficiency are rickets in young children and osteomalacia in adults (33)

Conclusion

The results of the present study have shown that eggplants are good sources of essential nutrients and natural antioxidants that are beneficial to the body. *Solanum melongena* and *Solanum aethiopicum* both contain valuable mineral elements and antioxidant vitamins in addition to major nutrients such as protein and fibre. This study clearly shows *S. melongena* (aubergine) contains higher amounts of these nutrients. Since these vegetable fruits are commonly cultivated in many Nigerian communities, they are recommended as part of a healthy balanced diet. Their low energy and fibre contents make them good choices for those wanting to lose weight and an antidote for digestive tract diseases.

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