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Nutritional Quality and Phytochemical Studies of *Solanum anguivi* (Lam.) Fruits

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Abstract
Solanum anguivi (Lam.) is a wild or semi-domesticated vegetable locally consumed in Nigeria. The fruits of this plant were collected and subjected to nutritional and phytochemical investigation. The phytochemical constituents were investigated qualitatively and quantitatively and the results revealed the presence of alkaloids, flavonoids, tannins, saponins, phenols, steroids and triterpenoids. The presence of these bioactive secondary metabolites supports its medicinal values. Results obtained for the proximate analysis showed that the percentage composition values of moisture content were 4.58±0.11, ash 8.89±0.02, crude fat 5.68±0.05, crude protein 36.35±1.63, crude fiber 15.50±0.71 and carbohydrate 28.98±0.78. The high crude fiber, crude protein and carbohydrate content in the eggplant fruits together with substantial amount of mineral like Calcium, Sodium, Potassium, Phosphorus and Magnesium support its nutritional importance to man. Absence of mineral elements such as Nickel, Cadmium and Lead makes the fruits save for human consumption.
Keywords: phytochemical constituent, proximate analysis, eggplant, *Solanum anguivi*, Ekiti State.

1.Introduction

Life on earth is threatened by various chronic diseases such as cancer, strokes, cardiovascular diseases and so on. There is need to exploit nature's best and endowed weapons such as fruits and vegetables in combating these threatening diseases. Craig & Beck (1999) as well as Wargovich (2000) described fruits and vegetables as a treasure house of variety of nutrients and bioactive phytochemical which are key components of human daily diet. Quantitative estimation of various phytochemical present in these fruits could be of great importance in addressing the challenges posed by chronic diseases. Fruits comprise a variety of phytochemical such as tannins, saponins, flavonoids, terpenes, phenolic compounds and so on. Various researchers have shown the disease protective capability of these phytochemical. There are wide array of research investigations highlighting the chemical and nutritional health beneficial properties of fruits and vegetables (Dike 2010; Adeleke & Abiodun 2010; Asaolu *et al*. 2012; Oyeyemi *et al* . 2014; Oyeyemi & Tedela 2014). It has become an acceptable notion that a diet rich in fruits, vegetables, grains and legumes reduces the risk of the diseases such as cancer, heart diseases, high blood pressure, diabetes and obesity (Uruquiaga & Leighton 2000). In addition, they help in prevention and elucidation of several micronutrient deficiencies, most especially in less developed countries.

Solanum species belong to the family Solanaceae, with over 1,500 species worldwide and at least 100 indigenous species spread across Africa continent. About 25 species of *Solanum* species had been reported in Nigeria (Gbile 1988), some of which are wild while some are cultivated with their leaves, fruits or both consumed as raw or cooked vegetables or used as folkore medicine (Edijala *et al*. 2005). Some of the *Solanum* species commonly found in Nigeria include *S. gilo*, *S. aethiopicum*, *S. melongena*, *S. incanum*, *S. macrocarpon* and *S. anguivi. Solanum anguivi* Lam. (Africa eggplant) is a rare ethno-botanical plant found throughout non-arid part of Africa. It grows mostly in the wild, but sometimes as a semi-cultivated vegetable. *S. anguivi* is a shrub, up to 3 m tall with spreading branches, often prickly, bearing small, sessile stellate hairs with 4-8 arms. Leaves are usually alternate, simple and sometimes opposite. The inflorescence is a raceme-like cyme, comprising about 5-15 flowers per inflorescence. The fruit is a subglobose berry 7-18 mm in diameter, smooth, green or white when young and red when ripe usually in clusters of up to 20 fruits. The plants are consumed as leafy and or/fruits vegetables and are very rich in essential minerals and vitamins (Dentol & Nwangburuka 2011). In Nigeria, especially South Western part of Nigeria where it is called "Igba yinrin" the fruits of *S. anguivi* is eaten as vegetable because it is believed that it can cure hypertension and diabetes. In Ghana they are used as an appetizer. In Cameroon, the bitter fruits are used as an ingredients of a dish, called "nkwi". Fresh or dried and ground fruits are also used as medicine against blood pressure. It has been reported that they formed dietary staple food and are recommended as supplements for nursing mothers, the young, the aged , and anemic patients (Elekofehinti *et al*. 2012). The roots are used as carminative and cough expectorant, nasal ulcers, asthma, difficult parturition, toothache, cardiac disorder, worm expeller, nervous disorder and fever. The leaves and fruits rubbed up with sugar are used as external application for itching (Johnson *et al*. 2010). Several researchers have studied the phytochemical as well as nutritional compositions of the leaves and fruits of *Solanum* species. Ravi *et al*. (2009); Santhi & Nadanakiyidam (2011) had reported the phytochemical properties

of *Solanum nigrum*. Dougnon *et al*. (2012) worked on phytochemical screening and nutritional analysis of leaves and fruits of *S. microcarpon* in Benin. Proximate and nutritional compositions of five different *Solanum* species commonly found in Nigeria were investigated by Adeyeye & Agesin (1999). Cholesterol lowering properties of saponin extracted from the fruits of *S. anguivi* was reported by Adanlawo & Akanji (2008). Despite the great nutritional value and medicinal importance of *S. anguivi* fruits, there is little or paucity information on the nutritional and phytochemical investigation of *S. anguivi* fruits in Nigeria. Hence, an attempt was made in the present study to evaluate proximate, mineral and phytochemical compositions in the fruits of *S. anguivi.*

2. Materials and Methods

2.1 Collection and preparation of samples.

Fresh green fruits of *Solanum anguivi* were harvested from an uncultivated farm land in Iyin Ekiti, Ekiti-State. The fruits were identified and authenticated by the Curator in charge of the herbarium of the Department of Plant Science, Faculty of Science, Ekiti State University. The fruits were thoroughly washed with distilled water and air dried for three weeks. The fruits were ground into fine powder using optimal mixer grinder (2053). The powder was stored in an air tight plastic container and analyzed. All analysis were done in triplicate and results are presented as mean ± standard deviation of triplicate determinations.

2.2 Phytochemical Analysis

2.3 Qualitative Analysis

Test for Alkaloids: Five grams of crude powder was defatted with 5% ethyl ether for 15 min and extracted for 20 min with 5ml aqueous HCL on a boiling water bath. The resultant mixture was centrifuged for 10 min at 3000 rpm. One milliliters (1ml) of the filtrate was treated with few drops of Mayer's reagent and another 1ml with Dragendoff's reagent. Creamish/ Brown/ Red/ Orange precipitate show the presence of alkaloids.

Test for Flavonoids: Two hundred grams of powdered sample was taken and a10 ml ethanol was added, and then filtered. 5 ml of diluted ammonia solution was added to 2 ml of the aqueous filtrate followed by addition of concentrated sulphuric acid. A yellow coloration was observed indicating the presence of flavonoids.

Test for Tannin: Two grams of the dried powdered sample was taken and boiled in 20ml of distilled water and then filtered. A few drops of 0.1% ferric chloride was added. The black precipitate indicates the presence of tannins and phenols.

Test for Saponins: The persistent frothing test for saponin described by Odebiyi & Sofowora (1978) was adopted. To 1g of the extract, 30 ml of distilled water was added. The mixture was shaken vigorously and heated to boil. Frothing persistent indicates presence of saponins.

Test for Cardiac glycoside: The Keller-Killani test was used. 5 ml of the extract was treated with 2 ml of glacial acetic acid, containing one drop of ferric chloride solution. This was underplayed with 1ml of concentrated sulphuric acid. Brown ring of the interface indicates deoxysugar characteristics of cardenolides. Below the 'brown' ring, a violet ring was observed while in the acetic acid layer, a greenish ring was observed.

2.4 Quantitative Analysis

The quantitative amount of phytochemical which are found in the eggplant fruits extract were determined using standard procedure as described by Singleton (1999), Obadoni & Ochuko (2001), Tease & Evans (2002), Atoui *et al*. (2005) and Amakura *et al*. (2009).

2.5 Proximate Analysis

Proximate composition (moisture, crude protein, crude fat, ash and crude fiber) were determined by the standard methods of the Association of Official Analytical Chemist (AOAC 1990). Moisture content was determined by heating 2.0 g of the powdered sample to a constant weight in a crucible placed inside ovum at temperature of 105 ^{0}C. The dry matter was used in the determination of the other parameters. The crude protein content was calculated by multiplying the total organic nitrogen by 6.25 (AOAC 2005). Crude fat was obtained by exhaustively extracting 5.0 g of the sample in a Soxhlet apparatus using petroleum boiling range 40-60 ^{0}C as the extract. Ash content was determined by incineration of 10.0 g sample placed in a muffle furnace maintained at 550 ^{0}C for 5 h. Crude fiber was obtained by digesting 2.0 g of sample with H_2SO_4 and NaOH and incinerating the residue in a muffle furnace maintained at 550 ^{0}C for 5 h. Carbohydrate content was determined according to Onwuka (2005) calculation equation i.e Available carbohydrates = (% moisture+ % Ash + % protein + % fiber). Each analysis was carried out in triplicate.

2.6 Determination of the mineral compositions

The minerals Potassium, Calcium, Phosphorus, Sodium, Iron and Magnesium were determined by atomic absorption spectrophotometry after dry ashing of the sample. Quantitatively, the sample was transferred into a

conical flask and dissolved in 10 ml of 3% ferric chloride and the mixture was heated on a hot plate. The solution was then filtered into a 100 ml flask and made to the mark with distilled water.

3. Results

Table 1: Qualitative phytochemical screening of *S. anguivi* fruits.

Phytochemical	Result
Saponins	++
Alkaloids	+
Flavonoids	++
Tannins	+
Phenols	++
Steroids	++
Glycosides	_
Triterpenoids	+

Key = ++ (moderate), + (slightly present/trace), - (absent)

Table 2: Quantitative phytochemical screening of *S. anguivi* fruits.

Phytochemical	Percentage composition (%)
Saponins	1.29± 0.11
Alkaloids	0.05± 0.01
Flavonoids	0.46±0.02
Tannins	0.17±0.07
Phenols	1.520±.04
Steroids	1.68±0.06
Triterpenoids	0.35±0.07

Table 3: Proximate Composition (%) of *S. anguivi* fruits

Constituents	Percentage composition (%)
Moisture content	4.58±0.11
Ash content	8.89±0.02
Crude fat	5.68±0.05
Crude protein	36.35±1.63
Crude fiber	15.50±0.71
Carbohydrate	28.98±0.78

Table 4: Mineral composition of *S. anguivi* fruits

Mineral Composition	Quantity in fruits
% Calcium	0.49±0.01
%Sodium	0.03±0.00
% Potassium	2.03±0.03
Iron (mg/kg)	222.25±2.80
Magnesium (mg/kg)	255±0.02
Manganese (mg/kg)	27.65±0.19
Zinc (mg/kg)	28.15±0.57
Copper (mg/kg)	13.80±0.28
Phosphorus (mg/kg)	650.86±1.61
Nickel (mg/kg)	N.D
Cadmium (mg/kg)	N.D
Chromium (mg/kg)	N.D
Lead (mg/kg)	N.D

Key = N.D Not detected

The results of the qualitative and quantitative phytochemical screening of *S. anguivi* fruits are presented in Table

1 and 2 respectively. The fruits of *S. anguivi* contained alkaloids, flavonoids, saponins, tannins, phenol, steroids and triterpenoids while glycoside was absent in the sample analyzed (Table 1). The phytochemical constituents of *S. anguivi* fruits on dry weight basis revealed that the fruits contained 0.05±0.0% alkaloids, 0.46±0.02% flavonoids, 1.29±0.11% saponins, 0.17±0.07% tannins, 1.52±0.04% phenols, 1.67±0.06% steroids and 0.35 ±0.07% triterpenoids (Table 2). The result of the proximate composition (Table 3) indicated that the vegetable constitute a rich source of protein, crude fiber and carbohydrate. The nutrient composition quantified in *S. anguivi* fruits in the study were 8.89±0.02% ash, 4.58±0.11% moisture, 5.68±0.05% crude fat, 15.50±0.71% crude fiber, 36.35±1.63% crude protein and 28.98±0.78% carbohydrate. Similarly, the result of the mineral composition (Table 4) revealed that *S. anguivi* fruit has appreciable quantity of Phosphorus (650±1.16mg/kg), Iron (222.25±0.02mg/kg), Magnesium (225±0.02mg/kg), Manganese (27.65±0.19mg/kg) and Copper (13.8± 0.28mg/kg) with low quantity of Sodium (0.03±0.00mg/kg), Calcium (0.49±0.01mg/kg) and Potassium (2.03± 0.03mg/kg). The results further revealed that Nickel, Cadmium, Chromium and Lead were not detected in the eggplant.

4. Discussion

The results obtained from the quantitative screening of bioactive constituents of *S. anguivi* fruits revealed that the fruits of this vegetable are good sources of bioactive phytochemicals which include alkaloids, flavonoids, tannins, saponins, triterpenoids and phenols. The results in the study are in consonance with earlier report of Pronob & Islam (2012) who noted the presence of alkaloids, saponins, tannins and flavonoids in the leaves of *S. myricanthus* and *S. nigrum*. Chinedu *et al*. (2011) reported the presence of cardiac glycosides in *S. aethiopicum* and *S. microcapon* but noted absence of steroids in *S. macrocarpon* fruits which is contrary to the results obtained in this finding. Similarly, phytochemical screening of *S. macrocapon* fruits by Dougnon *et al*. (2012) showed the presence of flavonoids, triterpenoids and steroids. From our findings, it is evident that *S. anguivi* generally contained more phytochemicals when compared to other reported *Solanum sp.* Hence, most of the observed effect of *S. anguivi* may be due to its richness in bioactive phytochemical constituents. The concentration of alkaloids (0.054%) present in the *S. anguivi* fruits investigated is low and could be considered safe for human consumption. The tannins found in this eggplant are confirmed by the previous work of Chinedu *et al*. (2011) which revealed moderate amount of tannins in the fruits of *S. myricanthus* and *S. macrocarpon* in Nigeria. The sharp bitter taste of *S. anguivi* fruits might be as a result of the presence of tannins in the fruits. The combination of glycoalkanoids and saponins present in the plant had been reported to protect plants from the attack of many fungi, yeasts, bacteria and viruses (Sczkowski *et al.* 1988). Sodipo *et al.* (2008) emphasized that strong presence of tannins in a vegetable can cause harm. Similarly, it has been cautioned that consumption of food rich in tannins in large dose may cause cancer, such as esophageal cancer (Shils *et al*. 2006). Hence, the fruits of *S. anguivi* as revealed by this study supports its moderately consumption. Tannins are known to posses antioxidant and antibacterial, as well as anti-inflammatory properties (Mensah *et al*. 2013). The presence of tannins in *S. anguivi* fruits accounts for their astringents properties and their physiological role in treating wounds (Sodipo *et al*. 2008) as well as curbing hemorrhages and restrict bare swellings. The fruits of *S. anguivi* also contained phenols and they have been shown to possess antibacterial, antiviral, anti-mutagenic and anti-carcinogenic properties (Moure *et al*. 2001; Monach *et al*. 2004). Phenols have the ability to retard lipid oxidation in oils and fatty foods (Rumbaoa *et al*. 2009) thereby reducing cardiovascular diseases. Phenols can as well reduce cancer risk by interfering with all stages of the cancer process (Hollman 2001). Apart from phenols, other phytochemicals detected include steroids and triterpenoids. The results in this work confirmed the presence of steroids which is contrary to what was reported by Dougnon *et al*. (2012) and Chinedu *et al*. (2011) who reported the absence of steroids in the fruits of *S. macrocarpon* in other areas. The positive results of steroids in this study might be attributed to the fact that the fruits do not come from the same geological areas and growing conditions are different (Dougnon *et al*. 2012). Steroids regulate carbohydrate and protein metabolism, and possess anti-inflammatory properties. Furthermore, terpenoids and steroids are known to possess antibacterial and antineoplastic properties (Oduro *et al*. 2009). Terpenoids have anti-hepatoxic properties thus helping to prevent liver damage. This study verified the presence of phytochemical constituents in *S. anguivi* fruits which could partly explain the use of the plant for the treatment of various diseases as claimed by various researchers (Pronob & Islam 2012; Ravi *et al*. 2009; Agoreyo *et al*. 2012).

The proximate composition of *S.anguivi* fruits showed low moisture content (4.58±0.11%). Chinedu *et al*. (2011) submitted that African eggplant fruits generally have high moisture content . However, the results of this finding proved otherwise. The moisture content was lower than those reported for *S. gilo*, *S. aethiopicum* and *S. anguivi* (Adeyeye & Fagbohun 2006). Low moisture content hamper the growth of microorganism and promote longer shelf-life. (Adeyeye & Ayejuyo 1994). The value for ash in the eggplant fruits was 8.89±0.02%

and was higher than 0.87±0.03% and 0.47±0.02% respectively for *S. aethiopicum* and *S. macrocarpon* (Chinedu *et al*. 2011). The result obtained compared favourably with *S. gilo* (9.75%) and *S. anguivi* (7.60%) reported by Adeyeye & Fagbohun (2006). Ash content is a reflection that the fruits are rich in mineral elements. The value of crude fat in this study (5.68±0.05%) was lower than 0.52% and 0.17% respectively for *S. aethiopicum* and *S. macrocarpon*. The value was comparatively lower than fat content reported by Adeyeye & Fagbohun (2006) for *S. gilo* (9.50%), *S. aethiopicum* (13.60%) and *S. anguivi* (15.20%). Crude lipids are the major sources of energy but should be consumed with caution so as to avoid obesity and other related diseases. The low crude fat content in this vegetable would favour prevention of constipation and colon-cancer (Showemimo & Olarewaju 2004). The estimated value (36.35±1.63%) for crude protein in *S. anguivi* fruits was quite higher than the reported values for some *Solanum sp* (Adeyeye & Fagbohun 2006; Chinedu *et al*. 2011). This result showed that the investigated eggplant fruits is a good source of protein and can meet the recommended daily requirements for human (FND 2002). The *S. anguivi* fruits contained 15.50±0.71% crude fiber which can be compared well with 15.50% reported for *S. anguivi* fruits collected in Nigeria (Adeyeye & Fagbohun 2006). The result established that the vegetable can be ranked as fiber rich vegetable. Vegetables that are rich in dietary fiber are usually employed in the treatment of diseases such as obesity, diabetes, cancer and abdominal disorder (Saldanha 1995).

The results of the mineral composition revealed that *S. anguivi* fruits constitute a good source of Iron (222.25±2.80mg/kg), Magnesium (255.00±0.02mg/kg) and Phosphorus (650.86±1.61mg/kg). These values were higher than the recorded values for Iron content (55.0mg/100g) and Magnesium (71.0g/100g) in *S. anguivi* investigated by other researchers (Adeyeye & Fagbohun 2006). Other essential minerals detected in the eggplants that play very indispensable role in normal human metabolism are Sodium, Potassium, Calcium, Zinc, Manganese and Copper. This result differs from the work of Adeyeye & Fagbohun (2006), who reported absence of Copper and Manganese in *S. gilo*, *S. aethiopicum* and *S. anguivi* fruits. In addition, Nickel, Cadmium, Chromium, and Lead were not detected in this study. The absent of these elements suggest that the eggplant cannot pose any health hazard for consumers. The presence of bioactive phytochemicals and essential minerals has justified its medicinal usage of the plant. It has also unveiled its potentials for dietary supplements in our daily food intake. Consequently, there is need to encourage the consumption and cultivation of this uncommon eggplants most especially among the people of Ekiti State.

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