



## Nutritional, Antinutritional and Therapeutic Potentials of *Solanum incanum* Linnaeus Fruit Cultivated in Sokoto, Northern Nigeria

### ABSTRACT

*Solanum incanum* Linnaeus (bitter garden egg) is widely cultivated and consumed as a vegetable by many people in Northern Nigeria, but its nutritional and therapeutic significances are under-exploited due inadequate scientific knowledge. The present study therefore, investigated the nutritional, antinutritional and therapeutic potentials of *Solanum incanum* fruit using the standard analytical methods. The values obtained for moisture, carbohydrates, crude protein, crude lipids, fibre and ash contents of the fruit are  $13.5 \pm 0.50$ ,  $43.08 \pm 7.08$ ,  $15.03 \pm 0.45$ ,  $23 \pm 7.73$ ,  $4.16 \pm 0.58$  and  $1.06 \pm 1.42$  % ww respectively. The phytochemical constituents screening indicated the presence of alkaloids, flavonoids, glycosides, cardiac glycosides, saponins, steroids, and volatile oils in the tested fruits, while anthraquinones and balsams were not detected in the samples tested. Quantitatively, the levels of alkaloids, flavonoids, glycosides and saponins obtained are  $5.87 \pm 0.23$ ,  $13.46 \pm 0.17$ ,  $0.22 \pm 0.03$  and  $6.73 \pm 0.12$  mg/100g respectively. The antinutritional agents analyzed are cyanides, nitrates, oxalates and phytates which were found as  $0.95 \pm 0.03$ ,  $96.14 \pm 15.16$ ,  $54.08 \pm 1.00$  and  $55.05 \pm 4.48$  mg/100g respectively. Antioxidant vitamins (A, C and E) contents were found as  $12.65 \pm 0.54$ ,  $17.75 \pm 9.13$  and  $12.61 \pm 0.815$  mg/100g respectively. The results obtained in the current study suggest that *S. incanum* fruit contains substantial amounts of macronutrients, phytochemicals and vitamins of nutritional and therapeutic relevance essential for survival and well-being of humans and animals.

**Keywords:** Nutrients, antinutrients, phytochemicals, antioxidant vitamins, *Solanum incanum*.

### Introduction

Plants are vital natural resource and component of global biodiversity. Beside their role as food and nutrients sources, plants play therapeutic roles for prevention, treatment or alleviation of many ailments (Bishnu *et al.*, 2009). Plants with therapeutic potentials are known as medicinal plants and have been found to be valuable in the traditional system of medicine from times immemorial (WHO, 2001). Medicinal plants provide ingredients for formulations of new

medicines in pharmaceutical industries as well. Substantial number of medicinal plants have been evaluated for their biological activity to rationalize their use in traditional medicine (Djipa *et al.*, 2000). According to the World Health Organization, traditional medicine is used by more than 80 per cent of the world's population in meeting their primary health care needs (WHO, 2001). Throughout the world, there is increasing interest in the importance of fruits and vegetables

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as dietary source of numerous nutrients, minerals and vitamins (Hassan, *et al.*, 2007). There is therefore, the need to harness them more and encourage the use of their products in formulation of new drugs as they are effective, cheaper and accessible to most populations (Danian and Muhammad, 2010).

Many chemical constituents occur naturally in plants that are non-nutritive but required by the plants for specific functions like resistance against pests, pathogens and herbivores, attraction of pollinators, or survival in adverse growing conditions (Panda *et al.*, 2009). These compounds are called phytochemicals, and include alkaloids, flavonoids, glycosides, steroids, tannins, and phenol compounds. They are mostly secondary metabolites synthesized by the plants and deposited in specific or all their parts (Bishnu *et al.*, 2009). Most of these phytochemicals however, have biological and pharmacological properties that provide therapeutic benefits to humans. Some phytochemicals either reduce the bioavailability of a nutrient or cause acceptability problems, these are known as antinutrients antinutritional factors (Panda *et al.*, 2009). Antinutrients antagonize good nutrition, either by causing toxicity leading to secondary nutritional deficiencies. They are present in almost all foods at some levels, but their levels can be reduced in modern crops, probably due to domestication processes (Welch and Graham, 2004).

Vitamins with antioxidant activities namely; vitamins A, C and E are available in some plants abundantly. These vitamins play important roles in scavenging free radicals or reactive oxidants, thereby protecting humans and animals against oxidative stress or DNA damage (Ponnan *et al.*, 2006). In addition to their importance in protecting the cell membranes from oxidative stress/damage caused by the free radicals, antioxidant vitamins promote many aspects of cellular and noncellular immunity (Damon, 2009). Their antioxidant function could, at least in part,

promote immunity by maintaining the functional and structural integrity of the immune cells. Generally, the chemical constituents in plants are responsible for many aspects of their properties associated with nutrition, health, toxicity or safety, as well as stability to physical, chemical or microbial changes (Akubugwo *et al.*, 2007).

*Solanum incanum* Linnaeus is commonly known as bitter garden egg, thorn apple or bitter tomato. In Nigeria, its names include 'Data' (Hausa), 'Igbagba' (Yoruba) and 'Afufa' (Igbo) (Auta and Ali, 2011). It is a native African shrub which belongs to the family *Solanaceae*. *S. incanum* is a delicate, herbaceous perennial plant with simple ovate, elliptical leaves; 2.5–12 cm long and 2.5–8 cm wide. It is often cultivated as an annual crop and attains the height of 1–3 m when matured. The fruit of *S. incanum* is fleshy, succulent and contains many small, whitish, soft and edible seeds. It botanically classified as 'berry' and has a diameter of <3 cm for the wild type but could be much larger in the cultivated types. It is mostly eaten fresh and tastes bitter due to the composition of lesser amounts of nicotinic alkaloids (Beaman and Muhammad, 1976).

Many locally cultivated and widely consumed vegetables in the study area (Sokoto, northern Nigeria) including *S. incanum* are under-exploited due the lack of adequate scientific knowledge of their nutritional and therapeutic properties. Although Auta and Ali (2011) reported an evaluation of the chemical and nutritional aspects of *S. incanum*, not much has been reported on its antinutritional and therapeutic potentials. The aim of this study therefore, is to evaluate the nutritional, anti-nutritional and therapeutic potentials of *S. incanum* fruits to provide a scientific basis for its consumption and use in the formulation of new pharmaceuticals or supplements that are effective, cheaper and accessible to most populations.

## Materials and Methods

### Sample Collection

Fresh *S. incanum* fruit samples used in this study were purchased from Sokoto central market, Sokoto State of Nigeria on the 17<sup>th</sup> of July 2018. They were identified and authenticated in the herbarium of the Botany Unit, Department of Biological Sciences of Usmanu Danfodiyo University, Sokoto, where a specimen with voucher number UDUH/ANS/1207 was kept for record purpose. Exactly 250 fruits were collected in a clean polythene bag and taken to the laboratory for the analyses.

### Sample preparation

Samples were washed with distilled and deionized water, wiped with tissue, separated and chopped into small pieces using a knife with sterile steel blade. Small portion of the sample was taken for the moisture content determination and the rest were air dried under shade for 5 – 6 days on a clean paper with constant turning over to prevent fungal growth. The dried portion was ground into powder using an electric blender, sieved through 20-mesh sieve and stored in a screw capped container at 4-6°C until required. The dried sample was used for all the analysis except for moisture content determination.

### Chemicals and Reagents

All chemicals and reagents used are of analytical grade, purchased from BDH Chemicals Ltd, UK.

### Determination of Proximate Chemical Composition

Proximate compositions of the samples were determined using the standard analytical techniques. Moisture content was determined by transferring exactly 5g of the fresh sample (in triplicate) into a dried, weighed flat crucible to a constant weight, in a hot air oven at 100°C. Crude protein, crude lipids, crude fibre and ash were all determined using the recommended methods of the

Association of Official Analytical Chemists (AOAC, 1999). The carbohydrates content of the samples was determined by the difference obtained after subtracting the crude protein, crude lipid, fibre and ash contents from 100% total dry weight.

### Qualitative Analysis of Phytochemical Constituents

Phytochemicals screening tests of the samples under study were carried out using the standard procedures described by Harbone (1973) and Trease and Evans (1989).

### Quantitative Analysis of Phytochemical Constituents

The phytochemicals; Alkaloids, flavonoids, glycosides and oxalates, saponins and tannins were determined by method described by Harbone, 1973. Whereas antinutritional factors; cyanide, phytic acid, nitrates were determined by the procedures described by Young and Greaves (1940) and Day and Underwood (1986) respectively.

### Antioxidant Vitamins

Determination of antioxidant vitamins A, C and E was carried out Spectrophotometrically using the method described by Rutkowski and Krzysztof (2007).

### Results and Discussion

The proximate composition, phytochemicals, antinutrients and antioxidant vitamins contents of *S. incanum* fruit has been analyzed in this study to evaluate the nutritional and therapeutic relevance of the vegetable. The results obtained have been summarized in Tables 1–5. The proximate composition of *S. incanum* fruit shows that the fruit has a relatively high content of carbohydrates, lipids, proteins, moisture and fibre in the order: carbohydrates>lipids>proteins>moisture>fibre>ash as presented in Table 1. This suggests that the fruit is a useful source of macro nutrients required for the nourishment and wellbeing of the body.

This is consistent with reports from other vegetables consumed in Nigeria (Akubugwo *et al.*, 2007; Auta and Ali, 2011; Hassan and Umar, 2006). However, the protein content of the fruit is low compared to the quantities reported in some leafy vegetables (Hassan and Umar, 2006; Isong and Idiong, 1997). Plant foods that provide >12% of its calorific value from proteins are considered as reliable source of protein and *S. incanum* fruit having met this requirement (15.11%) is therefore, a good source of protein (Pearson, 1976). The crude lipids content of *S. incanum* fruit is also higher than that of some leafy vegetables as reported by Agbo, 2004 and Akubugwo *et al.*, 2007. The crude fibre content is however, low (4.16%) compared to that of *M. balsamina* (29%) and *A. hybridus* (6.22%) as reported by Hassan and Umar (2006) and Akubugwo *et al.* (2007) respectively. This value is also below the Recommended Dietary Allowance (RDA) of fibre for pregnant women (28%), lactating mothers (29%) children (19%) and adults (21%), suggesting that *S. incanum* fruit is not a valuable source of dietary fibre for human nutrition.

**Table 1:** Proximate composition of *S. incanum* fruits.

Parameter	Concentration (%DW)
Moisture	13.50 ± 0.50
Crude protein	15.11 ± 0.45
Crude lipid	23.07 ± 7.73
Crude fibre	4.16 ± 0.58
Ash	1.08 ± 1.42
Carbohydrate	43.08 ± 7.08

Values are expressed as mean±standard deviation (±SD), (n=3).

This study revealed the presence of nine phytochemical constituents namely; alkaloids, cardiac glycosides, glycosides, flavonoids, saponins, steroids, tannins and volatile oils as shown in Table 2. Two phytochemicals; Anthraquinones and Balsams were however, not detected in the samples screened. This is contrary to the finding reported by Ponnann *et al.* (2006) that some garden egg plants were found to contain Anthraquinones. Phytochemicals are natural constituents of plants that possess both nutritional and therapeutic potentials in humans and animals (Salawu and Akindahunsi, 2007).

**Table 2:** Qualitative phytochemicals screening of *S. incanum* fruits

Parameter	Result
Flavonoids	++
Tannins	++
Saponins	+
Alkaloids	+
Glycosides	+
Steroids	+
Saponin glycosides	+
Balsams	ND
Anthraquinones	ND
Cardiac glycosides	+
Volatile oils	+

**Key:** +++ = High, ++ = moderate, + = mild concentration, and ND = not detected.

Quantitative analysis of some phytoconstituents revealed high quantities of flavonoids (13.46 mg/100g) and tannins (75.36 mg/100g), followed by saponins with alkaloids being the least as presented in Table 3. The flavonoids content is higher than 1.72 mg/100g reported from a medicinal plant *B. pinnatum* (Okwu and Josiac, 2006) and 8.82 mg/100g from *D. bellophylla* (Poornima and Ravishankar, 2009). The high content of flavonoids in *S. incanum* fruit may justify its use traditionally in the treatment of inflammatory and microbial infections as flavonoids are potent water-soluble phytochemicals with both antioxidant and anticancer activities (Okwu, 2004). The least were alkaloids and saponins which were very low compared to the quantities reported by Akubugwo *et al.*, 2007 and Okwu and Josiac, 2006. Pure isolated alkaloids are used as therapeutic agents in the treatment of fever, spasm and bacterial infections for their analgesic, antispasmodic and antibacterial properties (Okwu and Okwu, 2008). Saponins has been associated with hemolytic and cholesterol binding activities (Okwu, 2004).

**Table 3:** Phytochemical composition of *S. incanum* fruits.

Parameter	Concentration (mg/100g)
Alkaloids	5.87 ± 0.23
Flavonoids	13.46 ± 0.17
Glycosides	0.22 ± 0.03
Saponins	6.73 ± 0.12

Values are expressed as mean±standard deviation (±SD), (n=3).

Table 4 summarizes the antinutrients detected in the present study in the following order: nitrates>tannins>phytates>oxalate>cyanides. These are however, within the tolerable limits and can easily be removed by soaking or boiling (Eko

and Eddy, 2005). The tannins content obtained is also higher than 2.45 mg/100g reported from *S. incanum* by Auta and Ali (2011). Though tannins have been shown to be effective in hastening wound healing and resolution of inflamed mucous membranes, they are also antinutrient agents implicated in lowering the available proteins in foods by antagonistic competition, thereby leading to protein deficiency disorders, such as protein deficiency syndrome and marasmus (Okwu, 2004). The bitter taste of *S. incanum* fruit can be attributed to its saponins and tannins composition (Auta and Ali, 2011; Okwu, 2004).

**Table 4:** Antinutritional factors composition of *S. incanum* fruits.

Parametre	Concentration (mg/100g)
Cyanides	0.95 ± 0.03
Nitrates	96.14 ± 5.16
Oxalates	54.08 ± 1.00
Phytates	55.05 ± 4.48
Tannins	75.36 ± 0.17

Values are expressed as mean±standard deviation (±SD), (n=3).

The result of antioxidants vitamins analysis presented in Table 5 showed that *S. incanum* fruit contains substantial amounts of these vitamins in the order: vitamin C>vitamin E>vitamin A. The vitamin A (retinoic acid) content of the fruit though lowest among the tree vitamins, is higher compared to 10.50 mg/100g reported from *Pistia stratiotes* leaves by Wasagu *et al.* (2013). In addition to its importance in protecting the cell membranes from oxidative stress/damage caused by free radicals, vitamin A is also essential for normal growth, formation of strong bones and teeth in children, normal vision, protecting the lining of the respiratory, digestive, and urinary tracts against infection and for healthy skin (Damon, 2009).

Vitamin C (ascorbic acid) is the highest antioxidant vitamin in the fruit (17.75 mg/100g), Its value is higher than 6.27 mg/100g obtained by Auta and Ali (2011) from *S. incanum* and 1.67 mg/100g reported by Poornima and Ravishankar (2009) from *D. belophylla*. Vitamin C is the most important water-soluble vitamin in the extracellular fluids, where it neutralizes the reactive oxidants generated in the aqueous phase prior to lipid peroxidation (Afolabi, 2009). It was recognized as the bioactive molecule missing in the diet of sailors, that resulted in their development of scurvy (Baron, 2009). The vitamin E (tocopherol) level obtained in this study is also higher than 0.14 mg/100g obtained by Auta and Ali (2011) from *S. incanum* and that from other vegetable as reported by Akubugwo *et al.* (2007) from *A. hybridus* (0.5 mg/100g).

Vitamin E is the major fat-soluble vitamin, most effective in protecting cell membranes against free-radicals and oxidative stress/damage (Afolabi, 2009). Generally, antioxidant vitamins promote many aspects of both cellular and noncellular immunity. Their antioxidant function could promote immunity by keeping the functional and structural integrity of the immune cells. The chemical constituents in plants are responsible for most of their properties associated with nutrition, health, toxicity or safety, as well as their stability to physical, chemical or microbial changes (Akubugwo *et al.*, 2007).

**Table 5:** Antioxidant vitamins composition of *S. incanum* fruits.

Vitamin	Concentration (mg/100g)
A	12.65 ± 0.54
C	17.75 ± 9.13
E	16.01 ± 0.82

Values are expressed as mean±standard deviation (±SD), (n=3).

## Conclusion

The results obtained in this study revealed that *S. incanum* fruit is a rich nutritional source of macronutrients, important phytochemical constituents and antioxidant vitamins. It is therefore, logical to conclude that the vegetable has great nutritional and therapeutic potentials.

## Recommendations

In the light of the foregoing, consumption of *S. incanum* fruit is hereby recommended to complement other vegetables in nourishing the body for wellbeing and protection/treatment of nutrient deficiency diseases. Further research is also recommended to decipher other values of the fruit, such as the amino acid profiles and bioactive principles of therapeutic importance.

## References

- Afolabi, A.A. (2009). Biochemistry: Consequent seemingly inconsequential. Inaugural lecture series 56. FUT Akure. P 29-30.
- Agbo, J.T. (2004). Proximate nutrient composition of Sickle pod (*Cassia obtusifolia*) leaves and seeds. *Plant prod. Res. J.* 8: 13-17.
- Akubugwo, I.E., Chinyere, G.C. and Ugbogu, A.E. (2007). Nutritional and Chemical value of *Amaranthus hybridus* leaves from Afikpo, Nigeria. *African journal of Biotechnology.* 6:2833-2839.
- AOAC (1999). Methods of Analysis of Association of Officials of Analytical Chemists. 16<sup>th</sup> Ed. Washington D.C. 1: 600 – 792.
- Auta, R. and Ali, I. (2011). Nutritional and Chemical evaluation of *Solanum incanum* (Bitter Garden egg). *International Journal of tropical Medicine and Public Health.* 1(1): 96-107.
- Beaman, M.V. and Muhammed, S.I. (1976). Antibiotic Action of *Solanum incanum*.

*Antimicrobial Agents Chemotherapy*. 9(6): 920-924.

Bishnu, J.U.; Sunil, L. and Anuja, S. (2009). Antimicrobial Property of different Medicinal Plants; *Ocimum sanctum*, *Cinnamomum zeylanicum*, *xanthoxylum arimatum* and *Origanum masorana*. *Journal of Science, Engineering and Technology*. 5:143-150.

Danian, S.Y., and Muhammad, H.B. (2010). Evaluation of the Antimicrobial Activities and Phytochemical Properties of Extracts of *Tamarindus indica* Against Some Diseases Causing Bacteria. *African Journal of Biotechnology*. 714: 2451-2453.

Day, R. and Underwood, A. (1986). Quantitative Analysis. 5<sup>th</sup> Ed. Prentice-hall Publication. p: 701.

Djipa, C.D., Demee, M. and Quetin-Leclercq, J. (2000). Antimicrobial Activity of the Bark Extract of *Syzygium jambos* L. alston (myrtaceae). *Journal of Ethnopharmacology*. 71:307-313.

Ekop, A.S. and Eddy, N.O. (2005). Comparative Studies of the Levels of Toxicants in the Seeds of Indian Almond (*Terminalia acatappa*) and African Walnut (*Coulaedulis*). *Chem. Class. J.* 2: 74 – 76.

Harborne, J.B. (1973): *Phytochemical Methods*, Chapman and Hall L.T.D. London pp. 49-68.

Hassan, L.G. and Umar, K.J. (2006). Nutritional Value of Balsam Apple (*Momordica balsamina* L.) Leaves. *Pakistan Journal of Nutrition*. 5(6): 522 – 529.

Hassan, S.W., Umar, R.A., Ladan M.J., Nyemike, P., Wasagu R.S.U., Lawal, M. and Ebbo, A.A. (2007). Nutritive Value, Phytochemical and Antifungal Properties of *Pergularia tomentosa* L. (Asclepiadaceae).

*International Journal of Pharmacology* 3(4): 334-340.

Isong, E.U. and Idiong, U.I. (1997). Comparative Studies on the Nutritional and Toxic Composition of Three Varieties of *Lesianthera africana*. *Plant Foods for Human Nutr.* 51: 79 – 84.

Okwu, D.E. (2004). Phytochemicals and Vitamin Content of Indigenous Spices of South Eastern Nigeria. *J. Sustain. Agric. Environ.* 6: 30 – 34.

Okwu, D.E. and Josiah, C. (2006). Evaluation of the Chemical Composition of Two Nigerian Medicinal Plants. *Afr. J. Biotechnol.* 5(4): 357 – 361.

Okwu, D.E. and Okwu, M.E. (2004). Chemical Composition of *Spondia mombin* Linn Plant Parts. *J. Sustain. Agric. Environ.* 6(2): 140 – 147.

Panda, S.K., Thatoi, H.N. and Dutta, S.K. (2009). Antibacterial Activity and Phytochemical Screening of Leaf and Bark Extracts of *Vitex negundo* from Similipal Biosphere Reserve Orissa. *J. Med Plant Res.* 3(4): 294-300.

Pearson, D. (1976). *Chemical Analysis of Foods*. 7<sup>th</sup> Ed. Churchill. Livingstone, London. Pp: 218 – 336.

Ponnan, A., Perumal, R., Sathiyavedu, T.S. and Arabandi, R. (2006). Antioxidant Activity Measured in Different Solvent Fractions Obtained from *Mentha spicata* Linn.: An Analysis by ABTS Decolorization Assay. *Asia Pac J. Clin. Nutr.* 119 – 124.

Poornima, G.N. and Ravishankar, R.V. (2009). Evaluation of Phytonutrients and Vitamin Contents in a Wild Yam; *Diocorea bellophylla* (Prain) Haines. *African Journal of Biotechnology*. 8(6): 971 – 973.

Rutkowski, M. and Krzysztof, G. (2007). Modifications of Spectrophotometric Methods for Antioxidative Vitamins Determination Convenient in Analytic Practices. *Acta Sci. Pol. Technol. Aliment.* 6(3): 17 – 28.

Salawu, S.O. and Akindahunsi, A.A. (2007). Protective Effect of Some Tropical Vegetables Against CCL4-Induced Hepatic Damage. *J. Med. Foods.* 10(2): 350 – 355.

Stray, F. (1998). *The Natural Guide to Medicinal Herbs and Plants.* Tiger books international, London. Pp. 12 – 16.

Trease, G.E. and Evans, W.C. (1989). *Pharmacognosy.* 11<sup>th</sup> Ed. Cassell and Collier Macnillan Publ.

Wasagu, R.S.U. Lawal, M., Shehu, S., Alfa, H.H. and Muhammad, C. (2013). Nutritive Values, Minerals and Antioxidant Properties of *Pistia stratiotes* (water lettuce). *Nigerian Journal of Basic and Applied Sciences* 21(4): 253-257. DOI: <http://dx.doi.org/10.4314/njbas.v21i4.2>

Welch, R.M. and Graham, R.D. (2004). Breeding for Micronutrients in Staple Food Crops from a Human Nutrition Perspective. *J. Exp Bot.* 55(396): 353 – 64.

World Health Organization (2001). *General Guidelines for Methodologies on Research and Evaluation of Traditional Medicine.* Geneva.

Young, S.M. and Greaves, J.S. (1940). Influence of Variety and Treatment on Phytic Acid Content of Wheat. *Food Research.* 5: 103-105.