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# *Solanum nigrum* L., a Nutraceutical Enriched Herb or Invasive Weed?

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**Abstract.** Nutraceuticals properties of *Solanum nigrum* were investigated and the results obtained were compared with Chinese chive and Roselle plant. The seeds contain oil (36.5%), dietary fibre (1.3%) and crude protein (7%). Vitamin analysis in mg/kg (DW) indicated that seed contains thiamine (3.5), riboflavin (1.8) and niacin (36.2). The most abundant fatty acids were linoleic (65.45%) and palmitic (10.19%) present in seeds. Seeds contain Fe (3.8), Ca (73) and Zn (14) in mg/100g (DW). The calorific value (kcal/100 g sample) for leaves (60.70); berries (73.98) and for seed (126.84). Anti nutritional factors in mg/100g (DW) for seeds were found at parity with Chinese chive and Roselle plants e.g. trypsin (1.01±0.74), phytic acid (0.13±0.32) and tannins (0.17±0.09) were moderate. This species is predominantly used as a culinary in Africa and SE Asia who reside in the underdeveloped countryside. Despite plenty of nutraceuticals, this species is still recognised as invasive weed. The focus of this paper is to highlight the nutraceutical aspects, so that the usability of this plant could be advanced.

**Keywords:** nutraceuticals, dietary fibre, minerals, oil, *S. nigrum,* linoleic, niacin

## 1. Introduction

A disquieting phenomenon in the form of nutraceutical food shortage has gripped many countries now, and the problem stands to worsen in the days to come. As the population continue to expand at rapid pace, so does the demand for food. The scientist is always inquisitive to identify the alternate source to meet up the need for growing nutraceuticals food demand. Nutraceutical can be defined as a food (or part of a food) that provides medical and health benefit, including or treatment of diseases.

In the present study we selected *Solanum nigrum* L. which belongs to the solanaceae family being reported as ancient famine plant of China (Henderson 1974).The herb is 10 to 60 cm high with a green, smooth and semi-climbing stem. The plant is indigenous to Eurasia but naturalised throughout Africa and SE Asia. This species is acclimatized under poor resource base conditions and therefore, distributed all over mainland of northeast India and young leaves and berries are eaten as vegetables by some rural people but not cultivated as in Nigeria (Gbile and Adesine 1988). In several African countries, the vegetable is an important food in rural areas (where more than 80% of the total population of most of these countries occur). This plant is sold in some rural and urban markets, especially in the African countries of Kenya, Cameroon, Ghana, Madagascar, Nigeria and South Africa as well as in Guatemala, New Guinea, and Mediterranean region, Hawaii, Trinidad, Suriname, India, Indonesia, China and the Philippines (Fortuin and Omta 1980).

The situation was such that the people who relied on this species, as affordable food were actually not fleeced to the financial burden of managing food, but they must aware about the nutraceutical aspects. The species has great importance as it contributes significantly to the amount of calories and other nutrients in the diet which boost human health and also cure various ailments. The species was reported in different parts of the world as a culinary herb viz. India, China, East Africa, Hawaii, Japan, Kenya, Mauritius, North America,

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Pakistan, South America and Zimbabwe. Many researches had highlighted that the plant possessed numerous medicinal values. However, the information of nutritional aspect had received scant attentions, because the species is medicinal rather than food.

The objective of the present study is to systematically characterise the different edible parts and detail estimation of the quantitative nutritional value so that the usability of this plant could be advanced. Besides it also aims to ascertain the nutraceuticals with a hope that pharmaceutical and biotechnological companies will hold this with great commitments.

# 2. Materials

## 2.1. Plant materials

The leaves and mature berries were obtained from the author's home garden (26º30'27.3''N and 91º11'041''E). The species was sampled and separated into edible leaves and berries. The leaves and mature berries were freshly analyzed and before chemical analysis, the seed was milled into fine powder. A part of the sample was freeze-dried and sieved in mesh and kept in a container. All the determinations were prepared in duplicates.

## 2.2. Chemicals

HPLC grade methanol, benzene, 2, 2-dimethoxypropane, n-hexane and n-heptanes were obtained from Sigma (St. Louis, Missouri, USA). The vitamin standards were purchased from Sigma (St. Louis, Missouri, USA). The other chemicals were of analytical grade.

# 3. Methods

## 3.1. Analytical Determination of crude protein, moisture, ash, oil, and dietary fibre

The levels of crude protein, moisture, ash, and oil were determined according to the recommended methods of the Association of Official Analytical Chemists (AOAC 1984). Nitrogen content was determined by using the Kjeldahl method (Kjeldahl 1883) and multiplied by a factor 6.25 to determine the crude protein content. Ash was determined by the incineration of 1.0 g samples placed in a muffle furnace, maintained at 500 °C for 5 h. Crude fat was determined in triplicate using a Soxhlet system (Egan et al. 1981). Dietary fibre content was analyzed by the AOAC enzymatic–gravimetric method using protease, heat-stable R-amylase, and amyloglucosidase to remove protein and starch. Total carbohydrate was obtained by Anthron Method. The energy content was determined by multiplying the percentages of crude protein, crude fat and total carbohydrate using the factors of 4, 9 and 4, respectively (Osborne and Voogt 1978).

## 3.2. Determination of minerals

Open-vessel digestion procedure was used for preparation of plant digest for mineral composition analysis. Plant extracts were analyzed for trace elements, viz., Zn, Ca, K, Mn, Fe, and Cu using a Perkin Elmer 3110. The concentrations of different elements in these samples were determined by the corresponding standard calibration curves obtained by using standard AR grade solutions.

## 3.3. Determination of vitamins

The berries (03g) were mixed with 5 ml n-hexane and 20 ml High-purity Milli-Q water. The mixture was homogenized using centrifuged at 3500 rpm for 30 min. The aqueous phase was filtered through a Whatman 42 filter paper and 15µl of supernatant was injected into the HPLC system equipped with a UV–Vis detector, which was set to 254 nm in absorbance mode. The vitamin standards were prepared in mobile phase. Peaks were verified and calculated in relation to the standard vitamin peak.

## 3.4. Determination of fatty acids

Fatty acids were determined by gas-liquid chromatography (Varion model 3700) of the methyl esters. A reaction mixture consisting of methanol, benzene, 2, 2-dimethoxypropane (37:20:5:2) and n-heptanes, as outlined previously (Erbas et al., 2005; Garces and Mancha, 1993) were prepared and used. The seeds (250 mg) were weighed and added 3: 2 ml of reaction mixture and n-heptane. The tube was filled with $CO_2$ gas and covered with a lid. The tube was placed in a water bath at 80°C for 2 h. Then, the tube was allowed to reach room temperature until two phases formed. The upper phase (n-heptane), containing methyl esters of fatty acids, was injected into a gas chromatography. The percent fatty acid composition was calculated from the ratio of individual peak area to total definable peak area.

### 3.5. Determination of Antinutritional factors

Phytic acid was determined according to the method of Wheeler and Ferrel (1971). Trypsin inhibitor activity determination was done by the method outlined by Liu and Markakis (1989). Total tannins were determined calorimetrically, as described by AOAC (1990).

## 4. Results and discussion

The leaves, seeds and mature berries were analysed for their nutritive value (Table 1). The calorific value (kcal/100 g sample) for leaves (60.70), berries (73.98) and for seed (126.84). The fresh berries had a high amount of dietary fibre (1.5%) in comparison to leaves (1.2%) and seeds (1.3%). Dietary fibre, currently re-designated as non starch polysaccharides, refers to the indigestible residue of plant foods which includes large spectrum of molecules viz; cellulose, non-starch polysaccharides and lignin. The seed was richer in crude fat (8.56%), protein (7%) and carbohydrate (5.45%). These values were found to be comparable with or higher than those of commonly used vegetables such as Chinese chive and Roselle plant.

Table: 1 Chemical composition of the *Solanum nigrum* leaves, berries and seed

| Components | [a]Value (%) | | |
|---|---|---|---|
| | Leaves | Berries | seed |
| Moisture (%) | 78±1.32 | 60.30±0.28 | 8.1±0.78 |
| Dietary Fiber (%) | 1.2±0.11 | 1.5±3.56 | 1.3±0.09 |
| Ash* (%) | 7.8±0.23 | 5.3±0.59 | 3.6±0.12 |
| Crude fat (%) | 2.59±0.57 | 3.50±0.17 | 8.56±0.64 |
| Crude protein | 5.2±0.14 | 5.5±0.06 | 7±1.12 |
| Total carbohydrate | 4.36± 1.06 | 5.12± 0.04 | 5.45±0.86 |
| Calorific value (kcal/100 g sample) | 60.75 | 73.98 | 126.84 |

* Dried Sample

Values are means ± standard deviations of triplicate determinations.

The seed oil content (36.5%) is similar to *Canarium schwenfurthii* (36.1%) and richer to Cotton (16-28%) (Kapseu 1997) and Chinese chive (15.8%) (Hu et al. 2006). The most abundant unsaturated fatty acid was linoleic (65.45%) is comparable with Chinese chive seed (Table 2). The seed oil linoleic (65.45%) and palmitic (10.19%) acids were the most abundant unsaturated and saturated fatty acids respectively. The high content of oil in seed (36.5 %), with a high proportion of unsaturated fatty acids, is desirable attribute for human nutrition. The oil contains many essential fatty acids, and therefore, has potential nutritional value and therefore this can be used as nutraceuticals. The presence of unsaturated fatty acids, namely, linoleic and oleic reflects considerable nutritional value.

Table: 2 Characteristics of *Solanum nigrum* seed oil and fatty acid compositions

| Parameter | [a] Value (%) | |
|---|---|---|
| | *Solanum nigrum* | Chinese chive seed [b] |
| Oil Content | 36.5±0.11 | 15.8 |
| Iodine value (g/100 g) | 102.6±0.08 | 136.3 |
| Peroxide value (mEq/kg) | 7.8±0.61 | 17.8 |
| Saponification value (mg KOH) | 160±2.61 | 176 |
| Palmitic* | 10.19±0.34 | 7 |
| Linoleic** | 65.45±0.25 | 69.1 |
| Linolenic** | 0.85±0.12 | *** |
| Oleic** | 16±0.31 | 20.4 |
| Stearic* | 4.8±0.27 | 1.2 |
| Palmitic* | 10.19±0.34 | 7 |

a Values are means ± standard deviations of triplicate determinations.

b Hu et al. (2005)

* saturated fatty acid

Thiamine (B1) and riboflavin (B2) are present in the seed (Table 3) but the concentration is lower than Chinese chive seed. However, the results revealed that Niacin (36.2±0.25 mg/kg) is higher than Chinese chive seed and therefore seeds are beneficial and could be used as a good source of niacin.

Table: 3 B vitamin contents of mature *Solanum nigrum* seed and Chinese chive seed

| Vitamina[a] | [b] Value | |
|---|---|---|
| | Black nightshade seed | Chinese chive seed [c] |
| Thiamine (B1) | 3.5± 0.12 | 7.6 |
| Riboflavin (B2) | 1.8± 0.34 | 3.0 |
| Niacin | 36.2±0.25 | 32.6 |

a Values are means ± standard deviations of triplicate determinations

b Data is reported on a dry mater basis (mg/kg).

c Hu et al. (2005)

Elemental analysis (Table 4) in mg/100g (DW) indicated that the seeds contain Fe (3.8), Ca (73) and Zn (14). Metal as micronutrient is important for the normal functioning of vital organs and is present in many enzymes which activate them, thereby influence the biochemical processes that are required in our diet.

Anti nutritional factors in mg/100g (DW) for seeds found at parity with Chinese chive and Roselle plants e.g. trypsin (1.01±0.74), phytic acid (0.13±0.32) and tannins (0.17±0.09) were moderate. Screening for ant nutritive components, such as trypsin, revealed little measurable activity in seed. The contents of tannins and phytic acid in S. *nigrum* were found to be lower than Chinese chive and Roselle plants. Considering the amount of available nutraceuticals, this plant could be valuable and important contributor to the human diet.

Table: 4 Mineral contents and Antinutritional factors of *Solanum nigrum* seed

| Mineral | Content [a] | | |
|---|---|---|---|
| | *Solanum nigrum* seed mg/100 g | Chinese chive seed (mg/kg) [b] | Roselle seed(mg/kg) [c] |
| Na | 6.18±1.20 | 245 | 620 |
| Mg | 182.3±2.61 | 228 | 460 |
| K | 34.41±1.23 | 7417 | 1300 |
| Ca | 73±2.60 | 1328 | 390 |
| Fe | 3.8±2.14 | 580 | 9.10 |
| Cu | 10±2.51 | 46.7 | trace |
| Zn | 14±2.01 | 80.8 | 5.60 |
| | | (g/100 g dry weight) | |
| Trypsin (TUI/mg protein) | 1.01±0.74 | 1.29 | *** |
| Phytic acid | 0.13±0.32 | 0.15 | 1.10 |
| Tannins | 0.17±0.09 | 0.11 | 1.37 |

a Values are means ± standard deviations of triplicate determinations.

b Hu et al. (2006)

c Ei-Adawy and Ali (1994)

The species *S. nigrum* is still documented as invasive weed not only in India but also in other parts of the world with a reorganisation of low status vegetable associated with poverty. This attitude of the people invariably hamstrings development of alternative food source and sheer wastage of research findings contributed by many researchers but unfortunately we have perfected a system in which the research accountability holds no meaning. This is mainly because, many scientists are advocating that wide scale planting or introduction of invasive elements will be a mistake and there is a possibility to destroy the ecosystem. This is perhaps true, for the notorious weeds, but to the best of our knowledge this concept is totally unwarranted for such weeds which possess broad spectrum nutraceuticals.

A nutraceutical is a product isolated or purified from food that is generally sold in medicinal form not usually associated with food. The use of nutraceuticals as attempts to accomplish desirable therapeutic outcomes with reduced side effects, as compared with other therapeutic agents has met with great success. So we may conclude that the usability of *S. nigrum* could be advanced if this herb is used for the processing of nutraceuticals by way of giving proper resource management, the wealth of this weed can be capitalised for the benefit of human beings. Moreover, eco-friendly utilization of this species is also possible in those countries where this weed already exists. The pharmaceutical and biotechnological companies should hold this with great commitments and need to address it in the urgency it deserves.

## 5. Conclusions

*S. nigrum* holds great potential as an alternate source to nutraceuticals with many advantages. The seed oil and vitamins are at parity with many food value species. Hence there is a great scope to identify suitable techniques to exploit *S.nigrum* for different purpose. While scientists are advocating a change in food use behaviour, this can be materialized only when an interrogated, sustainable approach is a matter of policy and implemented accordingly. This is extremely disquieting that *S. nigrum* is still considered as weed and people continue to be in the grip of perpetual backwardness despite plenty of research findings due to lack of awareness. However, the government agency is not unaware of the scenario that the scientific investigations has brought into focus in this species, but it has chosen to remain silent for long and the species is still recognised as weed.

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## 7. References

[1] AOAC. *Official Methods of Analysis*. (14th Ed.). Washington DC: Association of Official Analytical Chemists, 1984.

[2] AOAC. *Official Methods of Analysis.* (15th Ed.). Washington DC: Association of Official Analytical Chemists, 1990.

[3] C. Kapseu, M. Parmentier. Fatty acid composition of some vegetable oils from Cameroon*. Science des Aliments*, 1997, **17:** 325-31.

[4] D. R. Osborne, P. Voogt. The analysis of nutrients in food, New York: Academic Press, 1978.

[5] E. I. Wheeler, R. E. Ferrel. A method for phytic acid determination in wheat and wheat fractions. *Cereal Chemistry*. 1971, **48**: 312–316.

[6] F.T.J.M. Fortuin, S.W.P. Omta. Growth analysis and shade experiment with Solanum nigrum L., the black nightshade, a leaf and a fruit vegetable in West Java. *Netherlands Journal of Agricultural Science*. 1980, **28**: 199-210.

[7] G**.** Hu, Y Lu**,** W. Donghi (2006). Chemical characterization of Chinese chive seed (Allium tuberosum Rottl.), Food chemistry, 99, 693-697

[8] H. Egan, R. S. Kirk, R. Sayer. *Pearson's. Chemical Analysis of Foods,* (8th Ed.). Edinburgh: Churchill Livingstone, 1981.

[9] J. Kjeldahl. Determination of protein nitrogen in food products. In: *Encyclopedia of Food Science.* 1983, 439–441.

[10] K. Liu, P. Markakis. An improved colorimetric method for determining antitryptic activity in soybean products. *Cereal Chemistry.* 1989, **66**, 415–422.

[11] R. Garces, M. Mancha. One step lipid extraction and fatty acids methyl esters preparation from tee plant tissue. *Analytical Chemistry*. 1993, **211**: 139–143.

[12] R.J.F. Henderson. Solanum nigrum L. (Solanaceae) and related species in Australia. *Contributions from the Queensland Herbarium*. 1974, **16**: 1-78.

[13] T A Ei-Adawy, K H Ali . Characteristic of Roselle Seeds as a New Source of Protein and Liipid. *Journal of Agriculture and Food Chemistry*, 1994, **42**:1896-1900.

[14] Z.O. Gbile, S. K. Adesina. Nigerian Solanum species of economic importance. *Annals of the Missouri Botanical Garden*. 1988, **75**: 862-865.