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Assay of Nutritional Potential of the Fruits of *Solanum indicum L.* in Iran

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The proximate and phytochemical composition of the Fruits of *Solanum indicum* was investigated. The proximate composition includes crude fibre (8% wet weight), total carbohydrate (40.67% wet weight), crude protein (23.47% wet weight), total ash (22.66% wet weight), crude fat (5.26% wet weight) and caloric value of (303.9 wet weight). The phytochemical screening revealed the presence of alkaloids, polyphenols(7.02mg/g), and saponins. This result support the medicinal use of the plant, and in addition, unveils the possibility of its acting as a potential source of food nutrients and nutraceuticals.

Key words: Plants food, *Solanum indicu,* Nutritional values

Introduction

Solanum indicum belongs to the family Solanaceae. Its other name includes *angirak*. Iron deficiencies and infectious diseases continue to devastate people of the developing world; non-communicable diseases attributable to obesity are increasingly common in developed and developing countries. Diets rich in vegetables and fruits providing micronutrients and health-promoting phytochemicals could alleviate both under-nutrition and obesity (Ezzati *et al.* 2002). Most people in the world lack adequate access to vegetables even though they are essential for good health. Insufficient vegetable and fruit consumption causes 2.7 million deaths annually worldwide and belongs to the top 10 risk factors contributing to mortality (Ezzati *et al.* 2002). Malnutrition is rampant in the tropics where per capita vegetable supplies in most countries falls far short of the minimum recommended 73 kg/person/year. In Iran, per capita vegetable supplies are only 43% of what are needed, leading to widespread malnutrition. (Freiberger *et al.* 1998).

There are hundreds of plant species consumed as vegetables, but only about 20 crops are produced in intensive cropping systems (Siemonsma and Piluek, 1997). Indigenous vegetables (IVs) are native to a particular region or introduced to the region from another geographical area over a long period of time. They are grown locally in a small scale, often resistant to diseases and tolerant to environmental stresses, very nutritious and contain a vast range of phytochemicals; however, most are neglected or under-utilized. IVs have potential for introduction or greater use as cash crops in peri-urban systems, vegetables for daily sustenance in home gardens, and a means to diversify production systems and diets. *Solanum indicum* were found among the most promising species according to their high antioxidant activity, high contents of micronutrients and phytochemicals, processing properties, ease of growing and palatability. In this paper, we present nutritional and bioactive values of *solanum indicum* Fruits from germplasm, to field, to plate and to health outcome (Kachik *et al.* 1992). In the present study, we investigated the proximate and phytochemical composition of *solanum indicum* with a view to unveiling its nutritional potential.

Materials and methods

Plant material

Plant foods used as experimental material were collected from farm lands in around Behbahan, South Iran. The collected plant material was placed in a polyethylene bag to prevent loss of moisture during transportation to the laboratory.

Determination of the proximate composition

A part was immediately used for determining the proximate composition of the plant. The crude protein, fat, ash, fiber and total carbohydrate contents of the samples were determined in triplicates according to standard methods (AOAC, 2006). The energy value was calculated using the Atwater factors of 4, 9 and 4 for protein, fat and carbohydrate respectively.

Preliminary screening of the phytochemical profile

The phytochemical screening of the sample was carried out as described by Harbone (1973) and Sofowora (1980). It was screened for alkaloids, saponins. Quantitative determination of polyphenols were carried out in triplicates, using the method of AOAC (2006).

Results and discussion

The proximate composition of *Solanum indicum* is given in Table 2. Species, habitat and consumption of *S. indicum* are shown in Table 1. Result of the Preliminary Qualitative Phytochemical Screening of *S. indicum* shown in Table 3.

Table 1. Species, habitat and consumption of *Solanum indicum L.*

Botanica name	Family	Plant part(s) used	Habitat	Typical consumption	Country
Solanum indicum Linn.	Solanaceae	Fruits	Disturbed	Regularly	Iran

Table 2. Proximate composition of *Solanum indicum L.*

Parameters	**Concent. (% DW)**
Ash	22.66± 0.80
Crude Protein	23.47± 0.27
Crude fat	5.26± 0.50
Fibre	8.0± 0.35
Carbohydrates	40.67±0.68
Calorific value (kcal/100g)	303.9±5.31
Total (mg/g)	7.02
Phenols	±2.1

*The data are mean values± deviation(SD) of three replicates. * Values expressed as % wet weigh

Table 3. Result of the Preliminary Qualitative Phytochemical Screening of *Solanum indicum*

Phytochemical	**Status**
Alkaloids	+
Saponins	++

Key: += moderately present; ++= highly present

Nutrient and phytochemical contents plant food

We compared antioxidant and nutritional values of eight plant foods (Yang *et al.* 2006). *Solanum indicum* and other highly nutritious plant resources: Strategies, standards and markets for a better impact on nutrition in Iran (Olson, 2001).

Nutritional Quality of the solanum indicum

Solanum indicum contained the highest amount of fibre. This edible plant grows faster than the other species under the subtropical low lands in Iran, and this specie is commonly consumed as a vegetable in South Asia (Freiberger *et al.* 1998).

Antioxidant Content of plant food

Concentrations of total antioxidants were measured. Antioxidant content of *S. indicum* was high even compared to vegetables and fruits known for high antioxidant contents. *S. indicum* is an excellent source of a wide spectrum of dietary antioxidants.

Nutrient and phytochemical contents in solanum indicum leaves as affected by different accessions, harvesting seasons and leaf stages

Ten *S.indicum* accessions, selected from a survey of 60 *S. indicum* accessions for yield and growth performance, were used in the study. The plants, collected from Iran, were sown on 30 March 2004, and transplanted to the field on 26 April 2004. Plants were grown on 6-m-long x 1.5-m-wide x 30-cm-high raised beds, in double rows with 30 cm between rows and plants within rows. Accessions were arranged in a RCBD with 40 plants per plot and 3 replications. No pesticide was applied. Plots were harvested for young shoots 1-2 times per week from three harvest periods: 30 June − 7 December 2004, 24 Jan – 30 March 2005, and 25 April − 15 December 2005 with about one month interval of each harvesting period to allow mature leaves growth. The average air temperatures and rain falls were 29.2°C (23.9 − 34.6°C) and 13.9 mm in June 2004 as hot-wet season, 17.7°C (6.7−27.4°C) and 0.1 mm in January 2005 as cool-dry season, and 24.7°C (15.4−32.8°C) and 1.1 mm in April 2005. Young shoots and mature leaves were collected separately from the branches harvested the first day of the three harvest periods and sent to laboratory. Nutrient contents and antioxidants were measured. The averaged values are shown in Table 2. This study indicated that: (1) Variation among 10 *S. indicum* accessions for nutrient contents was small (data not shown) so breeding for higher nutrient content is not worthwhile. Varietal selection should focus on horticultural traits. (2) Mature leaves were more nutritious than young shoots and could be quickly dried with minimum nutrient loss; however, young shoots exhibited better eating quality and more acceptable for the fresh market.

Nutrient and phytochemical contents in solanum indicum fruits as affected by processing temperature and simulated gastrointestinal digestion

Sun-drying in direct sunshine and under shade are the common practices used in most parts of Iran to preserve vegetables for dry season consumption (Lyimo *et al.* 1991). However ways of food preparation and preservation may affect significantly the concentration and availability of minerals, vitamins and other essential compounds in food. Some reports have documented the losses of nutrients from vegetables during drying and cooking (Kachik *et al.* 1992 and Kidmose *et al.* 2006). A low temperature oven drying process was applied to dehydrate *solanum indicum* fruits.

Our previous study on *in vitro* iron bioavailability (IB) of vegetables indicated that cooking increases IB of certain vegetables 2−10 times (Yang *et al.*, 2002). The cooking enhancing effect can be achieved with different heating processes including boiling, stir-frying and hot-air drying. Prolonged storage of cooked vegetables will reduce the availability of iron. In the case of cabbage, the cooking enhancing effect was due to the reduction of iron-polyphenol interaction, which commonly occurs during plant cell destruction. The nature of the enhancing factors in these vegetables was similar to the effect of EDTA, which stabilizes iron when it is released from cell (Yang and Tsou, 2006). In he case of *solanum indicum*, boiling in water enhanced the *in vitro* IB of fresh leaves and dried powder by 3.5 and 3 times, respectively. Cooking *solanum indicum* fruits also raised total available iron of mixtures with other food items (Yang *et al.* 2006). In addition, boiling *solanum indicum* fruits in water enhanced aqueous antioxidant activity (AOA), and the AOA was maintained after simulated digestion.

Immune modulation of dried solanum indicum powder in diets for human use and livestock production

Intervention with a diet containing 5% *solanum indicum* powder was investigated using a rat model and compared to a 5% common cabbage diet, and a nutrient-sufficient diet without vegetable. After 3 weeks, the preliminary result (data not shown) indicated that the *Solanum indicum* diet lightly reduced blood triglycerides and enhanced immune response due to increased peripheral and splenocyte T-cell proliferations. The preliminary study implies the consumption of *Solanum indicum* may increase immune response of nutrient-sufficient subjects. In addition, consumption of nutrient and phytochemical-rich vegetables, like *solanum indicum*, leads to a better immune response compared to consumption of vegetables that are rich in fiber but lower in nutrient or phytochemical content, like common cabbage. *Solanum indicum* should be promoted for greater consumption for human use to improve nutrition and strengthen immune functions. The effects of dehydrated leaves of *solanum indicum* in the diets of broilers were also investigated. The trial included 5 treatments (diet without *solanum indicum* and diets containing 0.5%, 1%, 2% and 3% dried leaves) with 3 replications and 4 broilers per replication. Twenty-one day old broilers were housed in wire cages for one week adaptation followed by a 3-week-experimental feeding period. Growth performance, immune function and ileum microflora were evaluated. The results (data not shown) indicated that *solanum indicum* diets significantly (1) enhanced duodenum traits; (2) increased concentrations of total globulin, γ-globulin and IgA, lymphocyte ratio, antibody titer to sheep erythrocytes, and delayed type hypersensitivity (3) reduced *E. coli* and increased *Lactobacillus* counts in ileum. In conclusion, *S. indicum* leaves are potential plant material to enhance immune responses and improve intestinal health of broilers. The efficacy of *S. indicum* as bioceutical agents to substitute for antibiotic use for broiler production would be further examined.

Promotion of solanum indicum for greater production and consumption

High nutrients and antioxidants are common features of *S. indicum*. However, leaf stages and harvesting seasons can change their nutritional values 1.5 − 3 times. Variation among *S. indicum* accessions for nutrient contents were small, varietal selection should focus on horticulture traits. Cooked *S. indicum* provide more bio-available iron. Mild-heat drying process (50 °C/ 16 hours) maintained most nutrients and bioactives in *S. indicum* and could be achieved by low-cost household preparation as a simple and effective way for continuous nutrients/bioactives supply. The dried leaves provide many kinds and types of nutrients and bioactives, which would lead to better nutrition and health.

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