JOURNAL OF MEDICINAL FOOD
*J Med Food* 17 (7) 2014, 733–741

DOI: 10.1089/jmf.2013.2818

**REVIEW**

# Sweet Potato (*Ipomoea batatas* [L.] Lam) - A Valuable Medicinal Food: A Review

Remya Mohanraj and Subha Sivasankar

*Department of Biotechnology, Aarupadai Veedu Institute of Technology, Vinayaka Missions University, Kancheepuram, India.*

ABSTRACT *Ipomoea batatas* (L.) Lam, also known as sweet potato, is an extremely versatile and delicious vegetable that possesses high nutritional value. It is also a valuable medicinal plant having anti-cancer, antidiabetic, and anti-inflammatory activities. Sweet potato is now considered a valuable source of unique natural products, including some that can be used in the development of medicines against various diseases and in making industrial products. The overall objective of this review is to give a bird's-eye view of the nutritional value, health benefits, phytochemical composition, and medicinal properties of sweet potato. Specifically, this review outlines the biological activities of some of the sweet potato compounds that have been isolated, the pharmacological action of the sweet potato extract, clinical studies, and plausible medicinal applications of sweet potato (along with a safety evaluation), and demonstrates the potential of sweet potato as a medicinal food.

**KEY WORDS:** • ***anti-cancer activity*** • ***antidiabetic activity*** • ***antioxidant activity*** • ***phytochemical composition*** • ***sweet potato*** • ***4-Ipomeanol***

## INTRODUCTION

**O**VER THE PAST FEW DECADES, the search for plant-based medicines has occupied many research groups. Although a lot of research is focused on medicinal herbs, it should not be overlooked that many vegetables and fruits also possess medicinal properties. *Ipomoea batatas* (L.) Lam, commonly known as sweet potato (Fig. 1) belonging to the family Convolvulaceae, is an important root vegetable which is large, starchy, and sweet tasting.[1,2] The plant is a herbaceous perennial vine, bearing alternate heart-shaped or palmately-lobed leaves and medium-sized sympetalous flowers. The edible tuberous root is long and tapered with a smooth skin. It is valued for its short growing period of 90 to 120 days, high nutritional content, and its sweetness.

*I. batatas* has played an important role as an energy and phytochemical source in human nutrition and animal feeding. The plant has significant medicinal importance and various parts of the plant are used in traditional medicine. The leaves are used to treat type 2 diabetes by Akan tribes of Ghana,[3] and in the treatment of inflammatory and/or infectious oral diseases in Brazil.[4] In regions of Kagawa, Japan, a variety of sweet potato has been eaten raw to treat anemia, hypertension, and diabetes.[5] The stems of *I. batatas* were used for treatment of prostatitis.[6] The Monpa ethnic groups of Arunachal Pradesh, India, use the tubers of sweet potato as a staple food and the leaves as fish feed.[7]

Sweet potato, which originated in Central America, is now widely cultivated and consumed throughout the world.[8,9] European explorers introduced the crop to Africa and India by the early 1500s, China by 1594, and Taiwan and Miyako Island in Japan by 1597.[10–12] Sweet potato ranks seventh among almost all food crops worldwide, with an annual production of 115 million metric tons.[13] Approximately 92% of world's sweet potato supply is produced in Asia and the Pacific Islands: 89% of which is grown in China.[14]

With the above background in mind, this review aims at providing an insight into the nutritional value, health benefits, phytochemical composition, biological activities and medicinal properties of sweet potato, and demonstrates the potential of sweet potato as a medicinal food.

### *Biology and nutritional value of* I. batatas

*I. batatas* is grown as an annual plant by vegetative propagation using either storage roots or stem cuttings. The stem is cylindrical and its length depends on the growth habit of the cultivar and the availability of water in the soil. The leaves are simple and spirally arranged alternatively on the stem. Their color can be green, yellowish-green, or can have purple pigmentation in part or all of the leaf blades. The storage roots are the commercial part of the sweet potato plant.[15] The color of the smooth skin of the root tuber ranges between yellow, orange, red, brown, purple, and beige. Its

Manuscript received 25 February 2013. Revision accepted 16 April 2014.

*Address correspondence to: Remya Mohanraj, PhD, Department of Biotechnology, Aarupadai Veedu Institute of Technology, Vinayaka Missions University, Rajiv Gandhi Salai (OMR), Paiyanoor 603 104, Kancheepuram District, Tamil Nadu, India. E-mail:* remyam@gmail.com

**FIG 1.** Sweet potato tuber and leaf.

flesh ranges from beige to white, red, pink, violet, yellow, orange, and purple. Sweet potato varieties with white or pale yellow flesh are less sweet and moist than those with red, pink, or orange flesh.[16]

Sweet potato is used as a staple food, a root vegetable (including its fleshy roots, tender leaves, and petioles), a snack food, animal feed, a source for industrial starch extraction and fermentation, and for various processed products.[17–20] Sweet potato is high in nutritional value, with the exception of protein and niacin. It provides over 90% of nutrients per calorie required for most people.[21,22] Roots are a valuable source of carbohydrates, vitamins (providing 100% of the recommended daily allowance [RDA] for vitamin A and 49% of the RDA for vitamin C), and minerals (providing 10% of the RDA for iron and 15% of the RDA for potassium).[21,23]

Besides simple starches, sweet potatoes are rich in complex carbohydrates, dietary fiber, iron, and vitamin content such as beta-carotene (a pro-vitamin A carotenoid), vitamin $B_2$, vitamin C, and vitamin E.[24] Pink, yellow, and green varieties are also high in beta-carotene. The nutritional value of sweet potato is presented in Table 1.[25] Orange-fleshed sweet potatoes may be one of nature's unsurpassed sources of beta-carotene. Several recent studies have shown that the sweet potato has superior ability to raise blood levels of vitamin A. This benefit may be particularly true for children. In several studies from Africa, sweet potatoes were found to contain between 100–1,600 micrograms of retinol activity equivalents (RAE) of vitamin A in every 3.5 ounces; enough, on an average, to meet 35% of all vitamin A needs. In many cases, sweet potatoes contain enough RAE to meet over 90% of vitamin A needs.

For those who are involved in strenuous jobs, sweet potato is a good source of carbohydrates and it is rich in vitamins and minerals. For those suffering from stomach cancer, a diet based on the sweet potato is beneficial.[26] Research has also shown that phytonutrients in sweet potatoes may be able to help lower the potential health risk posed by free radicals.[27]

Table 1. Nutritional Value of Sweet Potato

| *Nutritional value per 100 g* | |
|---|---|
| Energy | 360 kJ (86 kcal) |
| Carbohydrates | 20.1 g |
| Starch | 12.7 g |
| Sugars | 4.2 g |
| Dietary fiber | 3.0 g |
| Fat | 0.1 g |
| Protein | 1.6 g |
| Vitamin A equivalent | 709 $\mu$g (89%) |
| - beta-carotene | 8509 $\mu$g (79%) |
| - lutein and zeaxanthin | 0 $\mu$g |
| Thiamine (vitamin $B_1$) | 0.1 mg (9%) |
| Riboflavin (vitamin $B_2$) | 0.1 mg (8%) |
| Niacin (vitamin $B_3$) | 0.61 mg (4%) |
| Pantothenic acid (vitamin $B_5$) | 0.8 mg (16%) |
| Vitamin $B_6$ | 0.2 mg (15%) |
| Folate (vitamin $B_9$) | 11 $\mu$g (3%) |
| Vitamin C | 2.4 mg (3%) |
| Vitamin E | 0.26 mg (2%) |
| Calcium | 30.0 mg (3%) |
| Iron | 0.6 mg (5%) |
| Magnesium | 25.0 mg (7%) |
| Phosphorus | 47.0 mg (7%) |
| Potassium | 337 mg (7%) |
| Sodium | 55 mg (4%) |
| Zinc | 0.3 mg (3%) |

Starch is considered to be the main component of the sweet potato root, followed by simple sugars such as sucrose, glucose, fructose, and maltose.[28] Sweet potato leaves are indeed more nutritious than the tuber itself. The leaves contain appreciable amount of nutrients (crude protein, crude fat, crude fiber, ash, carbohydrates, moisture contents, and energy), vitamins (vitamin A and vitamin C), mineral elements (zinc, potassium, sodium, manganese, calcium, magnesium, and iron), low levels of toxicants (phytic acid, cyanide, tannins, and total oxalate), and may be included in diets to supplement dietary allowances of essential nutrients.[29]

### *Health benefits of* I. batatas

*Root tuber.* Sweet potato is one of the average calorie starch foods and provides 90 calories/100 g vs. 70 calories/100 g of other types of potatoes (*Solanum tuberosum*). The tuber, however, contains no saturated fats or cholesterol and is a rich source of dietary fiber, anti-oxidants, vitamins, and minerals. Its energy content mainly comes from starch, a complex carbohydrate. Sweet potato has a higher amylose to the amylopectin ratio when compared to *S. turberosum*. Amylose raises the blood sugar levels slowly in comparison to simple sugars, and is recommended as a healthy food substance, even for patients with diabetes.

The tuber is an excellent source of flavonoids, phenolic compounds such as beta-carotene, and vitamin A. A 100 g tuber provides 14187 IU of vitamin A and 8509 $\mu$g of $\beta$-carotene. The value is one of the highest in the root-vegetables category. These compounds are powerful natural antioxidants. Vitamin A is also required by the body to maintain the integrity of healthy mucus membranes and skin. It is a vital nutrient for visual acuity. Consumption of natural vegetables and fruits rich in flavonoids helps protect from lung and oral cavity cancers. The tubers are packed with many essential vitamins such as pantothenic acid (vitamin B5), pyridoxine (vitamin B6), and thiamin (vitamin B1), as well as niacin and riboflavin. These vitamins are essential in the sense that the body requires them from external sources in order to be replenished. These vitamins function as co-factors for various enzymes during metabolism. Sweet potato is a rich source of vital minerals such as iron, calcium, magnesium, manganese, and potassium that are essential for enzyme, protein, and carbohydrate metabolism.[2]

*Shoot.* Sweet potato leaves are high in lutein[30] which is said to have a number of benefits for the eye, especially in the prevention of age-related macular degeneration and cataracts.[31] Sweet potato leaves are rich in potent antioxidants and also vitamin C, which helps fight free radicals, thus preventing premature aging and disease. They boost the immune system and help prevent infections and diseases. The polyphenolics present in the leaves showed various kinds of physiological functions, radical scavenging activity, antimutagenic activity, anticancer, antidiabetes, and antibacterial activity *in vitro* and *in vivo*, which may be helpful for maintaining and promoting human health. Sweet potato leaves are a physiologically functional food that offers protection from diseases linked to oxidation such as cancer, allergies, aging, HIV, and cardiovascular problems.[32]

### *Phytochemistry and biological activity*

The major phytochemicals present in the leaves of sweet potato are triterpenes/steroids, alkaloids, anthraquinones, coumarins, flavonoids, saponins, tannins, and phenolic acids.[4] Sweet potatoes also contain specific phytochemicals such as quercetin and chlorogenic acid that act to fight cancer and protect the heart. They are rich in beta-carotene, which is an interceptor of free radicals. Carotenoids have antioxidant capabilities and reduce or inhibit mutagenesis in cells, and terpenoids reduce low-density lipoprotein (LDL) cholesterol levels and act as anticarcinogens. Thus, eating certain foods such as sweet potatoes may contribute to protective levels against cancers.[33]

*Anthocyanins.* Genes in purple sweet potatoes (*IbMYB1* and *IbMYB2*) are activated to produce the purple anthocyanin pigments responsible for the rich purple tones of the flesh. The purple-fleshed sweet potato anthocyanins—primarily peonidins and cyanidins—have important antioxidant and anti-inflammatory properties, particularly when passing through our digestive tract. They may be able to lower the potential health risk posed by heavy metals and oxygen radicals.[24] They may also be used as part of an antihypertensive diet and may prevent atherosclerosis. As they contain abundant nutrients, minerals, and functional polyphenols, purple sweet potatoes can be used as a functional food material.[34] Sweet potato leaves are consumed primarily in the islands of the Pacific Ocean and in Asian and African countries, whereas limited consumption occurs in the United States.[35]

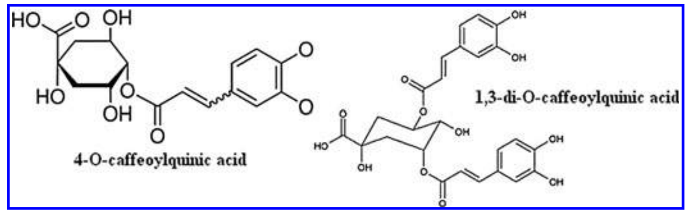


**FIG 2.** Structures of compounds isolated from sweet potato tubers.

*Phenolics.* Alkaloids, phenolic compounds, and glycolipids are the most common biologically-active constituents of *I. batatas*. Different polyphenolic compounds 4-O-caffeoylquinic acid, 1,3-di-O-caffeoylquinic acid (Fig. 2) and 3,5-di-O-caffeoylquinic acid, possessing potent antioxidant activities, have been isolated by chromatographic methods from methanolic and hydromethanolic extracts of *I. batatas* tuber flour.[36] These compounds possess a broad range of pharmacological properties including hepatoprotectant, anti-bacterial, antihistamine, and other biological effects.[37] These compounds are also inhibitors of HIV replication[38] and exhibit hypoglycemic,[39] radical scavenging,[40] and antimutagenic[41] activities. The stem also contains three feruloylquinic acids and small amounts of at least four caffeoyl-feruloylquinic acids.[42]

*Caffeoylquinic acid derivatives.* From the sweet potato leaf, the caffeoylquinic acid derivatives such as 3-mono-O-caffeoylquinic acid (Chlorogenic acid [ChA]), 3,4-di-O-caffeoylquinic acid (3,4-diCQA), 3,5-di-O-caffeoylquinic acid (3,5-diCQA), 4,5-di-O-caffeoylquinic acid (4,5-diCQA), 3,4,5-tri-O-caffeoylquinic acid (3,4,5-triCQA), and Caffeic acid (CA) have been isolated (Fig. 3). These compounds have demonstrated antimutagenicity.[43] They were also found to prevent proliferation of human cancer cells arising from stomach cancer, colon cancer, and promyelocytic leukemia cell.[44]

*Coumarins.* The roots of *I. batatas* contain the coumarins aesculetin,[45] scopoletin, and umbelliferon which have anti-coagulation properties and inhibit HIV replication.[46] Scopoletin also possesses hepatoprotective,[47] antioxidant,[48] spasmolytic,[49] and acetylcholinesterase inhibitory activities,[50] as well as inhibited proliferation by inducing apoptosis of human adrogen-independent prostate adenocarcinoma cells (PC3).[51] Scopoletin is one of the phytoalexins of *I. batatas.*[52] Vitamin C, caffeic acid, flavonoids such as rutin, quercetin,[53] tiliroside, astragalin, rhamnocitrin, rhamnetin, and kaempferol,[54] as well as cyanidins and peonidins[40,55–61] are also found in this species.

*Triterpenes.* The bioactive triterpenes found in *I. batatas* are: boehmeryl acetates, which act as ovipositional stimulants for the sweet potato weevil; *Cylas formicarius elegantulus* (Summers);[62] friedelin, which demonstrates

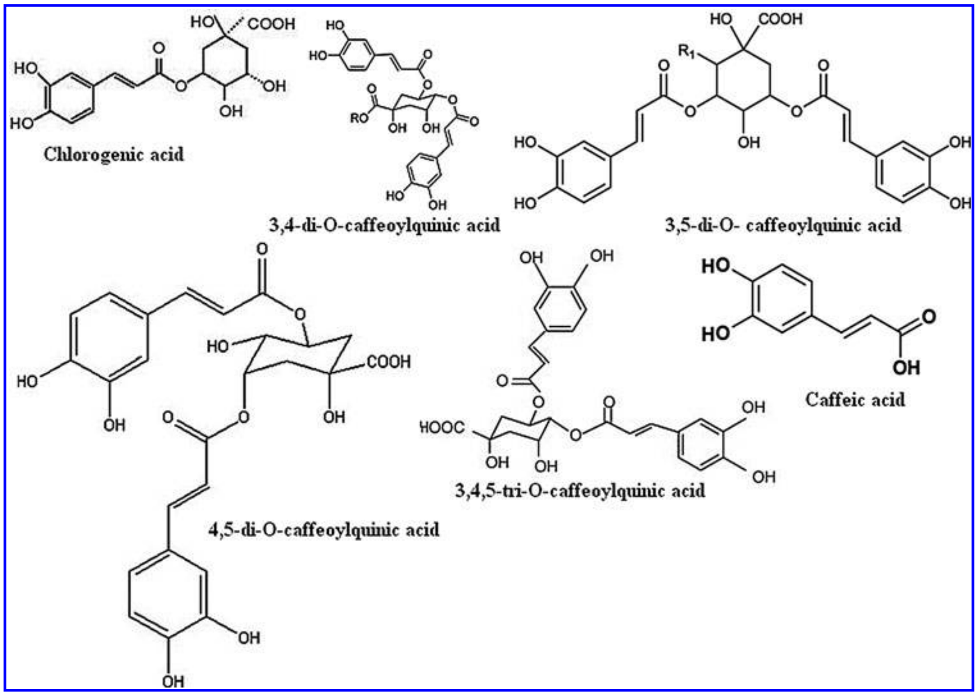


**FIG 3.** Structures of compounds isolated from sweet potato leaves.

good activity against *S. aureus*, compared with ampicillin and amoxicillin, and good antifungal activity against *Pseudallescheria boydii*.[63,64] $\beta$-amyrin acetate showed pronounced antinociceptive properties in the writhing test and formalin test in mice.[64,65]

*Furanoterpenoids.* A group of 9-carbon furanoterpenoids (1-Ipomeanol, 4-Ipomeanol, 1,4-Ipomeadiol, and Ipomeanine [Fig. 4]) have been isolated from sweet potato tissue infected with *Fusarium solani.*[66,67] 4-Ipomeanol is a well-known cytotoxic metabolite of *F. solani*-infected sweet potatoes which was first isolated in 1972 by Boyd and co-workers.[68]

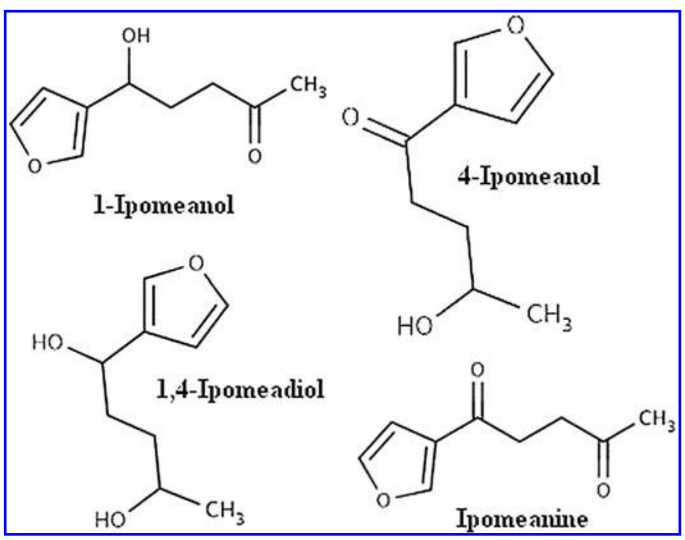


**FIG 4.** Structures of furanoterpenoids isolated from *F. solani* infected sweet potatoes.

The list of biologically active compounds from sweet potato, along with their pharmacological actions, is shown in the flowchart in Figure 5.

## *Pharmacological properties of* I. batatas

*Ipomoea* species are used in different parts of the world for the treatment of several diseases, such as diabetes, hypertension, dysentery, constipation, fatigue, arthritis, rheumatoid diseases, hydrocephaly, meningitis, kidney ailments, and inflammations. They also possess antimicrobial, analgesic, spasmolitic, spasmogenic, hypoglycemic, hypotensive, anticoagulant, anti-inflammatory, psychotomimetic, and anticancer activities.[37] Sweet potato is potent in the fight against cancer. It is rich in beta-carotene, which is good in fighting free radicals. Fluid and electrolyte balance is maintained by sweet potatoes.

*I. batatas* is good for cardiovascular health.[41] It is also used for treatment of tumors of the mouth and throat, asthma, bug bites, burns, catarrh, ciguatera, convalescence, dyslactea, fever, nausea, renosis, splenosis, stomach distress, and whitlows.[69] Leaf decoctions are used as an alterative, aphrodisiac, astringent, bactericide, demulcent, fungicide, laxative, and tonic.[5] Tuber flour of sweet potato was found to potentially prevent ethanol-induced gastric ulceration by suppressing edema formation and partially protecting gastric mucosa wrinkles and to heal wounds.[70] Because of its proven anti-ulcerative activity, it could be considered when treating gastric ulcers.[71]

*Antioxidant activity.* The total antioxidant capacity of sweet potato has been reported to be 42.94% as compared to ascorbic acid.[4] The total antioxidant activity of purple-fleshed sweet potatoes was higher than the white-fleshed. Their total phenolic content can serve as a useful indicator

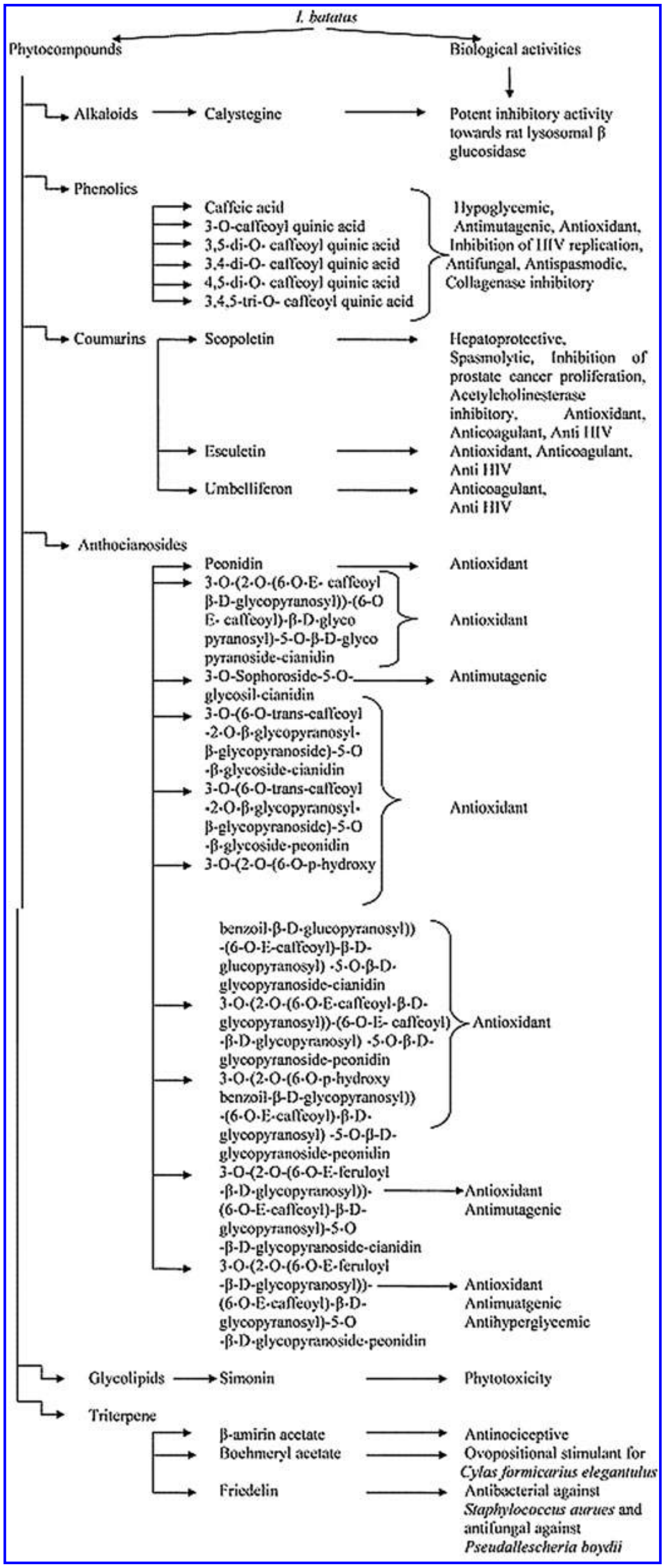


**FIG 5.** Biologically active compounds from *I. batatas* and their pharmacological actions.

for the antioxidant activities of sweet potatoes.[72] Total phenolic content has been found to be highest in the leaves and in the stem end of the roots of sweet potato.[73] One study shows the antioxidant activity in purple sweet potatoes as 3.2 times higher than that of a type of blueberry. Surprisingly, sweet potatoes have potent antioxidant capacity in all of their parts. Recent research has shown different genes to be at work in the flesh versus skin of the sweet potato producing different concentrations of anthocyanin antioxidants.

A recent study established baseline data on the total phenolic content and antioxidant activities of five sweet potato varieties grown in the Philippines including Dakol, Emelda, Haponita, PSBSP, and Violet. Antioxidant activities were highest for Dakol. However, Haponita had the best inhibitory action on linoleic acid oxidation. Methanolic sweet potato extracts had higher radical scavenging activity, reducing power and oxidation inhibition than α-tocopherol and higher iron-chelating capacity than ethylenediamine tetraacetic acid (EDTA).[74] The total antioxidant strength of raw sweet potato measured in terms of oxygen radical absorbance capacity is 902 $\mu$mol TE/100 g.

Dong *et al.,* studied the total antioxidant activity by DPPH (1,1-diphenyl-2-picrylhydrazyl) staining, reducing power method, metal ion-dependent hydroxyl radical, ferric thiocyanate (FTC) method, and protection of calf thymus DNA against hydroxyl radical-induced damage on sweet potato storage root mucilage. He suggested that the mucilage might contribute its antioxidant activities against both hydroxyl and peroxyl radicals.[27]

*Antidiabetic activity.* Sweet potato exhibits potent antidiabetic property, and its activity was shown to be higher than that of diabense, a standard drug for treating diabetes. A study has revealed that consumption of sweet potato, a high-polyphenol diet, for 7 days can modulate antioxidative status and decrease exercise-induced oxidative damage and pro-inflammatory cytokine secretion.[75] Researchers found that the protein content of the flesh of the sweet potato was higher than that of the peel. This suggests that the entire vegetable could play a role in lowering blood glucose in diabetics: the peel, as processed into a nutritional supplement like Caiapo; and the flesh, as a simple addition to the everyday diet. Adiponectin is a protein hormone produced by fat cells. People with diabetes tend to have lower levels of adiponectin, and sweet potato extracts have been shown to significantly increase adiponectin levels in persons with type 2 diabetes.

In a study involving rats to determine sweet potato's effects on several markers of diabetes, the vegetable showed significant abilities to decrease some of the more harmful markers. Using white-fleshed sweet potatoes for the study, the rats showed impressive improvement in pancreatic cell function, lipid levels, and glucose management. They also showed decreased insulin resistance in just eight weeks. Improved insulin sensitivity was also observed in a human study when sweet potatoes were added to the diet.[76] Other research has confirmed that sweet potatoes are a low-glycemic index (GI) food, which could be good for use by diabetics. With further research in this area, it may be possible to recommend that people with diabetes or insulin resistance consume sweet potatoes or use its extracts to help control blood glucose. This therapy should cost less than conventional drugs, and it may have fewer side effects.[77]

*Anticancer activity.* Researchers have found that eating sweet potatoes will decrease the risk of breast, colorectal, gallbladder and kidney cancer. A recent study evaluating the risk factors for kidney cancer death included 47,997 males and 66,520 females aged 40 years and older. Taking into account medical history, anthropometry, dietary, and lifestyle considerations over the 10-year study, the researchers concluded that eating sweet potatoes and potatoes regularly was associated with a decreased risk of the disease.[78]

4-Ipomeanol from infected sweet potatoes is reported to possess cytotoxic and anticancer properties.[79] It was the first agent to be developed by the National Cancer Institute based on a biochemical-biological rationale as an anticancer agent targeted specifically against lung cancer.[80] Several human tumor types, including many non-small cell lung lines and the MCF 7 breast cancer line, as well as its doxorubicin-resistant variant are relatively sensitive to 4-Ipomeanol[81]. Because of the specific lung toxicity 4-Ipomeanol is being tested as a new drug for the treatment of lung carcinoma. On the other hand, 4-Ipomeanol is metabolized by liver cells too. It was recently tested in phase II studies in patients with hepatocellular carcinoma[82,83] and it showed hepatotoxicity. Since, 4-Ipomeanol is reported to be present only in infected sweet potatoes, its occurrence is unlikely in normal tubers that are consumed as food. However, since the compound exhibits significant cytotoxic activity, it could be used as a lead in drug discovery for lung cancer.

*Cardiovascular effects.* When an extract of sweet potato was examined for its relaxant activity on isolated rat vascular aortic preparations, it showed 97% relaxation activity for endothelium-intact aortic ring preparations but only 35% in the mesenteric vascular bed. It showed good cardiovascular effect and its vasorelaxation mechanism of action was similar to that of the pharmacological agent acetylcholine.[84]

*Immune system effects.* Sweet potato fiber may be useful in combination with other therapeutic agents for skin wound therapy. The healing effect of sweet potato fiber was evaluated for burns and decubital wounds in rats over 19 days. Outcome measures included reduction in size and differences in wound severity. Rats treated with the sweet potato fiber covering had decreased wound areas.[85]

In a mouse model, purified sweet potato polysaccharide (PSPP) isolated from the roots acted as a biological response modifier. In a dose-dependent manner, mice treated with PSPP (50, 150, and 250 mg/kg body weight for 7 days) had increased phagocytic function, hemolytic activity, and serum immunoglobulin (IgG) concentration.[86]

*Anti-ulcer activity.* The anti-ulcer activity of the tubers of sweet potato was studied in cold stress and aspirin-induced gastric ulcers in Wistar rats. Methanolic extracts of *I. batatas* tubers were evaluated in cold stress and aspirin-induced gastric ulcer models using cimetidine and omeprazole respectively as standards for 7 days in the cold stress model and for 1 day in the aspirin-induced gastric ulcer model. Gastroprotective potential, status of the antioxidant enzymes (superoxide dismutase, catalase, glutathione peroxidase and glutathione reductase), along with glutathione and lipid peroxidation, were studied in both models. The results showed that *I. batatas* tubers possessed gastroprotective activity, as evidenced by its significant inhibition of mean ulcer score and ulcer index, and a marked increase in glutathione, superoxide dismutase, catalase, glutathione peroxidase, and glutathione reductase levels, as well as reduction in lipid peroxidation in a dose dependent manner.[87]

### *Safety evaluation*

Sweet potatoes contain oxalic acid, a naturally-occurring substance found in some vegetables which may crystallize as oxalate stones in the urinary tract in some people.[88] Therefore, individuals with a known history of oxalate urinary tract stones may be advised to avoid eating them.[89] Adequate intake of water is also advised to maintain normal urine output in these individuals to minimize stone risk.

## CONCLUSION

Sweet potato is an extremely versatile vegetable and is wonderfully healthy for children and adults alike. It is a healthy alternative to other potatoes. They are not only sweet but also good for cardiovascular health, longevity, prevention of diabetes, and reduce the risk of cancer.

## ACKNOWLEDGMENT

We are grateful to The Department of Biotechnology, Government of India, New Delhi, for their financial support.

## AUTHOR DISCLOSURE STATEMENT

The authors declare that no competing financial interests exist.

## REFERENCES


1. Purseglove JW: *Tropical crops: Dicotyledons. Vol. 1.* Longman, London, 1972, pp. 82–91.
2. Woolfe JA: Sweet Potato–Past and Present. In: *Sweet Potato: An Untapped Food Resource,* Cambridge University Press, Cambridge, 1992, pp. 15–40.
3. Abel C, Busia K: An exploratory ethno botanical study of the practice of herbal medicine by the Akan peoples of Ghana. *Altern Med Rev* 2005;10:112–122.
4. Pochapski MT, Fosquiera EC, Esmerino LA, Santos EB, Farago PV, Santos FA, *et al*.: Phytochemical screening, antioxidant, and antimicrobial activities of the crude leaves' extract from *Ipomoea batatas* (L.) Lam. *Pharmacogn Mag* 2011;7:165–170.
5. Ludvik B, Neuffer B, Pacini G: Efficacy of *Ipomoea batatas* (Caiapo) on diabetes control in type 2 diabetic subjects treated with diet. *Diabetes Care* 2004;27:436–440.
6. Emmanuel N: Ethno medicines used for treatment of prostatic disease in Foumban, Cameroon. *Afr J Pharm Pharmacol* 2010; 4:793–805.

7. Namsa ND, Mandal M, Tangjang S, Mandal SC: Ethnobotany of the Monpa ethnic group at Arunachal Pradesh, India. *J Ethnobiol Ethnomed* 2011;7:31–39.
8. Zhao G, Kan J, Li Z, Chen Z: Characterization and immunostimulatory activity of an (1→6)-α-D-glucan from the root of *Ipomoea batatas*. *Int Immunopharmacol* 2005;5:1436–1445.
9. Bovell-Benjamin AC: Sweet Potato: A review of its past, present, and future role in human nutrition. *Adv Food Nutr Res* 2007;52: 1–59.
10. Yen DE: *The Sweet Potato and Oceania*. Bishop Mus. Bull, Honolulu, 1974, pp. 236–389.
11. Yen DE: Sweet potato in historical perspective. In: *Sweet Potato. Proceedings of the 1st International Symposium.* (Villareal RL, Griggs TD, ed.) Asian Vegetable Research and Development Center, Taiwan, 1982, pp. 17–30.
12. Tarumoto I: Sweet Potato breeding in Japan: Its past, present and future. In: *Improvement of Sweet Potato (Ipomoea batatas) in Asia*, 1989, pp. 137–146.
13. FAO: *FAO Production Yearbook*, Rome, 1984.
14. Horton DE: World patterns and trends in sweet potato production. *Trop Agric* 1988;65:268–270.
15. Huaman Z: Systematic botany and morphology of the sweet potato plant. Lima, Peru: *International Potato Center (CIP)*, 1992, pp. 5–11.
16. Loebenstein G, Thottappilly G: The Sweet Potato. *Springer Verlag,* 2009, pp. 391–425.
17. Bouwkamp JC: Introduction part – 1. In: *Sweet potato products: a natural resource for the tropics,* (Bouwkamp JC ed.) CRC press, Boca Raton, Florida, 1985, pp. 3–7.
18. Kays SJ: Formulated Sweet potato products. In: *Sweet potato products a natural resource for tropics* (Bouwkamp JC, ed.). CRC Press, Boca Raton, Florida, 1985, pp. 205–218.
19. Lin SSM, Peet CC, Chen DM, Lo HF: Sweet potato production and utilization in Asia and the Pacific. In: *Sweet potato products: a natural resource for the tropics* (Bouwkamp JC, ed.). CRC Press, Boca Raton, Florida, 1985, pp. 139–148.
20. Sakamoto S, Bouwkamp JC: Industrial products from sweet potatoes. In: *Sweet Potato Products: A Natural Resource for the Tropics* (Bouwkamp JC, ed.), CRC Press, Boca Raton, Florida, 1985, pp. 219–234.
21. Food and Nutrition Board (FNB): Recommended Dietary Allowances — 1980. *Nutrition Reviews*, 1980;38:290–294
22. Watt BK, Merrill AL: Composition of foods: raw, processed, prepared. In: *Agriculture Handbook No. 8*, U.S. Government Printing Office, Washington D.C, 1975.
23. Anon.: Sweet Potato Quality. In: *U.S.D.A. Southern Cooperative Series Bulletin No. 249*, Russell Research Centre, Athens, Georgia, 1980
24. Ishida H, Suzuno H, Sugiyama N, Innami S, Tadokoro T, Maekawa A: Nutritive evaluation on chemical components of leaves, stalks, and stems of sweet potatoes (*Ipomoea batatas* Poir). *Food Chem* 2000;68:359–367.
25. U.S.D.A. National Nutrient Database for Standard Reference, Release 26. http://ndb.nal.usda.gov/ndb/foods/show/3254?fg=&format=&offset=&sort=(accessed January 2013).
26. You WC, Blot WJ, Chang YS, Ershow AG, Yang ZT, An Q, *et al.*: Diet and high risk of stomach cancer in Shandong, China. *Cancer Res* 1988;48:3518–3523.
27. Huang DJ, Lin CD, Chen HJ, Lin YH: Antioxidant and antiproliferative activities of sweet potato (*Ipomoea batatas* [L.] Lam ''Tainong 57'') constituents. *Bot Bull Acad Sin* 2004;45:179–186.
28. Cereda MP, Franco CML, Daiuto ER, Demiate JM, Carvalho LJCB, Leonel M, *et al.*: *Propriedades gerais do amido*, Fundação Cargill, Campinas, Brasil, 2001, pp. 21.
29. Antia BS, Akpan EJ, Okon PA, Umoren IU: Nutritive and antinutritive evaluation of sweet potatoes (*Ipomoea batatas*) Leaves. *Pak J Nutr* 2006;5:166–168.
30. Chandrika UG, Basnayake BMLB, Athukorala I, Colombagama PWNM, Goonetilleke A: Carotenoid content and *in vitro* bioaccessibility of lutein in some leafy vegetables popular in Sri Lanka. *J Nutr Sci Vitaminol (Tokyo)* 2010;56:203–207.
31. Trumbo RP, Ellwood KC: Lutein and zeaxanthin intakes and risk of age-related macular degeneration and cataracts: an evaluation using the Food and Drug Administration's evidence-based review system for health claims. *Am J Clin Nutr* 2006;84: 971–974.
32. Islam S: Sweet potato (*Ipomoea batatas* L.) Leaf: Its potential effect on human health and nutrition. *J Food Sci* 2006;71:R13–R21.
33. How Stuff Works: The Phytochemical Collection. http://health.howstuffworks.com/framed.htm?parent=phytochemical.htm&url=http://micro.magnet.fsu.edu/micro/gallery/phytochemicals/phytochemical.html (accesses June 2013)
34. Taira J, Taira K, Ohmine W, Nagata J: Mineral determination and anti-LDL oxidation activity of sweet potato (*Ipomoea batatas* L.) leaves. *J Food Comp Anal* 2013;29:117–125.
35. Johnson M, Pace RD: Sweet Potato leaves: properties and synergistic interactions that promote health and prevent disease. *Nutr Rev* 2010;68:604–615.
36. Jung JK, Lee SU, Kozukue N, Levin CE, Friedman M: Distribution of phenolic compounds and antioxidative activities in parts of sweet potato (*Ipomoea batata* L.) plants and in home processed roots. *J Food Comp Anal* 2011;24:29–37.
37. Meira M, Pereira da Silva E, David JM, David JP: Review of the genus *Ipomoea*: traditional uses, chemistry and biological activities. *Rev Bras Farmacogn* 2012;22:682–713.
38. Mahmood N, Moore PS, Tommasi ND, Simone FD, Colman S, Hay AJ, *et al.*: Inhibition of HIV infection by caffeoylquinic acid derivatives. *Antiviral Chem Chemother* 1993;4:235–240.
39. Okudaira R, Kyanbu H, Ichiba T, Toyokawa T: *Ipomoea* extracts with disaccharidase-inhibiting activities. *Jpn Kokai Tokkyo Koho JP* 2005;5:213–221.
40. Islam S, Yoshimoto M, Ishiguro K, Yamakawa O: Bioactive compounds in *Ipomoea batatas* leaves. *ISHS Acta Hortic* 2003; 2:693–699.
41. Yoshimoto M, Yahara S, Okuno S, Islam MS, Ishiguro K, Yamakawa O: Antimutagenicity of mono-, di-, and tricaffeoylquinic acid derivatives isolated from sweetpotato (*Ipomoea batatas* L.) leaf. *Biosci Biotechnol Biochem* 2002;66:2336–2341.
42. Zheng W, Clifford MN: Profiling the chlorogenic acids of sweet potato (*Ipomoea batatas*) from China. *Food Chem* 2008;106: 147–152.
43. Dini I, Tenore GC, Dini A: New polyphenol derivative in *Ipomoea batatas* tubers and its antioxidant activity. *J Agric Food Chem* 2006;54:8733–8737.
44. Basnet P, Matsushige K, Hase K, Kadota S, Namba T: Four di-O-caffeoyl quinic acid derivatives from propolis potent

hepatoprotective activity in experimental liver injury models. *Biol Pharm Bull* 1996;19:1479–1484.
45. Minamikawa T, Akazawa T, Uritani I: Isolation of esculetin from sweet potato roots with black rot. *Nature* 1962;195:726.
46. Cambie RC, Ferguson LR: Potential functional foods in the traditional Maori diet. *Mutat Res* 2003;523–524:109–117.
47. Kang SY, Sung SH, Park JH, Kim YC: Hepatoprotective activity of scopoletin, a constituent of Solanum lyratum. *Arch Pharm Res* 1998;21:718–722.
48. Shaw CY, Chen CH, Hsu CC, Chen CC, Tsai YC: Antioxidant properties of scopoletin isolated from Sinomonium acutum. *Phytother Res* 2003;17:823–825.
49. Oliveira EJ, Romero MA, Silva MS, Silva BA, Medeiros IA: Intracellular calcium mobilization as a target for the spasmolytic action of scopoletin. *Planta Med* 2001;67:605–608.
50. Lee JH, Lee KT, Yang JH, Baek NI, Kim DK: Acetylcholinesterase inhibitors from the twigs of *Vaccinium oldhami* Miquel. *Arch Pharm Res* 2004;27:53–56.
51. Liu XL, Zhang L, Fu XL, Chen K, Qian BC: Effect of scopoletin on PC3 cell proliferation and apoptosis. *Acta Pharmacol Sin* 2001;22:929–933.
52. Lima OOA, Braz-Filho R: Dibenzylbutyrolactone lignans and coumarins from *Ipomoea cairica*. *J Braz Chem Soc* 1997;8: 235–238.
53. Guan Y, Wu T, Lin M, Lin M, Ye J: Determination of pharmacologically active ingredients in sweet potato (*Ipomoea batatas*) by capillary electrophoresis with electrochemical detection. *J Agric Food Chem* 2006;54:24–28.
54. Luo JG, Kong LY: Study on flavonoids from leaf of *Ipomoea batatas*. *Zhongguo Zhong Yao Za Zhi* 2005;30:516–518.
55. Islam MS, Yoshimoto M, Terahara N, Yamakawa O: Anthocyanin composition in sweetpotato (*Ipomoea batatas* L.) leaves. *Biosci Biotechnol Biochem* 2002;66:2483–2486.
56. Terahara N, Shimizu T, Kato Y, Nakamura M, Maitani T, Yamaguchi M, *et al*.: Six diacylated anthocyanins from the storage roots of purple sweet potato, *Ipomoea batatas*. *Biosci Biotechnol Biochem* 1999;63:1420–1424.
57. Yang C, Tsai T: Four acylated anthocyanins from red skin sweet potatoes (*Ipomoea batatas*). *Shipin Kexue (Tapei)* 1999;26: 182–192.
58. Lee L, Cheng E, Rhim J, Ko B, Choi S: Isolation and identification of anthocyanins from purple sweet potatoes. *J Food Sci Nutr* 1997;2:83–88.
59. Goda Y, Shimizu T, Kato Y, Nakamura M, Maitani T, Yamada T, Terahara N, Yamaguchi M: Two acylated anthocyanins from purple sweet potato. *Phytochemistry* 1997;44: 183–186.
60. Odake K, Terahara N, Saito N, Toki K, Honda T: Chemical structures of two anthocyanins from purple sweet potato, *Ipomoea batatas*. *Phytochemistry* 1992;31:2127–2130.
61. Tsukui A, Kuwano K, Mitamura T: Anthocyanin pigment isolated from purple root of sweet potato. *Kaseigaku Zasshi* 1983;34:153–159.
62. Son K, Severson RF, Arrendale RF, Kays SJ: Isolation and characterization of pentacyclic triterpene ovipositional stimulant for the sweet potato weevil from *Ipomoea batatas* (L.) Lam. *J Agric Food Chem* 1990;38:134–137.
63. Kilham C: Tamanu oil: a tropical topical remedy. *HerbalGram* 2004;63:26–31.
64. Tan G, Xu P, Dai Z, Tang G: Studies on the chemical components of *Ipomoea batatas* Lam. *Tianran Chanwu Yanjiu Yu Haifa* 1995;7:44–46.
65. Krogh R, Krogh R, Berti C, Madeira AO, Souza MM, Cechinel-Filho V, *et al*.: Isolation and identification of compounds with antinociceptive action from *Ipomoea pes-caprae* (L.) *Die Pharmazie* 1999;54:464–466.
66. Boyd MR, Burka LT, Harris TM, Wilson BJ: Lung-toxic furanoterpenoids produced by sweet potatoes (*Ipomoea batatas*) following microbial infection. *Biochem Biophys Acta* 1974;337: 184–195.
67. Wilson BJ, Boyd MR, Harris TM, Yang DT: A lung oedema factor from moldy sweet potatoes (*Ipomoea batatas*). *Nature* 1971;231:52–53.
68. Boyd MR, Wilson BJ: Isolation and characterization of 4-Ipomeanol, a lung-toxic furanoterpenoid produced by sweet potatoes (*Ipomoea batatas*). *J Agric Food Chem* 1972;20: 428–430.
69. Duke JA, Wain KK: *Medicinal Plants of the World*. Computer index with more than 85,000 entries. 3 vols. Agriculture Research Service, Beltsville, Maryland, 1981.
70. Hermes D, Dudek DN, Maria M, Horta LP, Lima EN, Fatima A, *et al*.: *In vivo* wound healing and antiulcer properties of white sweet potato (*Ipomoea batatas*). *J Adv Res* 2013;4:411–415.
71. Rengarajan S, Rani M, Kumaresapillai N: Study of ulcer protective effect of *Ipomea batatas* (L.) dietary tuberous roots (Sweet Potato). *Iranian J Pharmacol Therap* 2012;11:36–39.
72. Teow CC, Truong VD, McFeeters RF, Thompson RL, Pecota KV, Yencho GC: Antioxidant activities, phenolic and $\beta$-carotene contents of sweet potato genotypes with varying flesh colors. *Food Chem* 2007;103:829–838.
73. Chang WH, Hu SP, Huang YF, Yeh TS, Liu JF: Effect of purple sweet potato leaves consumption on exercise-induced oxidative stress and IL-6 and HSP72 levels. *J Appl Physiol (1985)* 2010;109:1710–1715.
74. Rumbaoa RGO, Cornago DF, Geronimo IM: Phenolic content and antioxidant capacity of Philippine sweet potato (*Ipomoea batatas*) varieties. *Food Chem* 2009;113:1133–1138.
75. Oke JM, Oladosu B, Okunola MC: Sweet potato (*Ipomoea batatas*) tuber - potential oral antidiabetic agent. *Afr J Biomed Res* 1999;2:13–17.
76. Grotto, D: *101 Foods That Could Save Your Life*. Bantam Bell, New York, 2008.
77. Stanard S: Perspectives Online: Researchers reveal sweet potato as weapon against diabetes. http://www.cals.ncsu.edu/agcomm/magazine/winter07/diabetes.html (accessed April 2011)
78. Washio M, Mori M, Sakauchi F, Watanabe Y, Ozasa K, Hayashi K, *et al*.: Risk Factors for kidney cancer in a Japanese population: findings from the JACC Study. *J Epidemiol* 2005;15 Suppl 2:S203–S211.
79. Baer BR, Rettie AE, Henne KR: Bioactivation of 4-Ipomeanol by CYP4B1: adduct characterization and evidence for an enedial intermediate. *Chem Res Toxicol* 2005;18:855–864.
80. Lakhanpal S, Donehower RC, Rowinsky EK: Phase II study of 4-Ipomeanol, a naturally occurring alkylating furan, in patients with advanced hepatocellular carcinoma. *Invest New Drugs* 2001;19:69–76.
81. Falzon M, McMahon JB, Schuller HM, Boyd MR: Metabolic activation and cytotoxicity of 4-Ipomeanol in human non-small cell lung cancer cell lines. *Cancer Res* 1986;46:3484–3489.

82. Smiley-Jewell SM, Plopper CG: Proliferation during early phases of bronchiolar repair in neonatal rabbits following lung injury by 4-Ipomeanol. *Toxicol Appl Pharmacol* 2003;192: 69–77.
83. Hsu H, Rainov NG, Quinones A, Eling DJ, Sakamoto KM, Spear MA: Combined radiation and cytochrome CYP4B1/4-Ipomeanol gene therapy using the EGR1 promoter. *Anticancer Res* 2003; 23:2723–2728.
84. Runnie I, Salleh MN, Mohamed S, Head RJ, Abeywardena MY: Vasorelaxation induced by common edible tropical plant extracts in isolated rat aorta and mesenteric vascular bed. *J Ethnopharmacol* 2004;92:311–316.
85. Suzuki T, Tada H, Sato E, Sagae Y: Application of sweet potato fiber to skin wound in rat. *Biol Pharm Bull* 1996;19:977–983.
86. Zhao G, Kan J, Li Z, Chen Z: Characterization and immunostimulatory activity of an $(1 \rightarrow 6)$-$\alpha$-D-glucan from the root of *Ipomoea batatas*. *Int Immunopharmacol* 2005;5:1436–1445.
87. Panda V, Sonkamble M: Anti-ulcer activity of *Ipomoea batatas* tubers (sweet potato). *Functional Foods in Health and Disease* 2012;2:48–61.
88. Faboya O, Ikotun T, Fatoki OS: Production of oxalic acid by some fungi infected tubers. *Z Allg Mikrobiol* 1983;23:621–624.
89. Noonan SC, Savage GP: Oxalate content of foods and its effect on humans. *Asia Pac J Clin Nutr* 1999;8:64–74.