SATSA Mukhapatra - Annual Technical Issue **27** : 2023 ISSN 0971-975X

# Roots and Tuber Crops as Nutraceuticals : A Review on Phytochemicals and their Potential Health Benefits

*Nilima Karmakar[1*] and Jayanta Tarafdar[2]*

(Received : November 09, 2022; Revised : December 21, 2022; Accepted : January 16, 2023)

**ABSTRACT**

The starchy roots and tuber crops play an important role in human diet. Even within the same geographic area, there are several types of roots and tubers that contribute to a rich biodiversity. These tubers offer a wide range of nutritional and health advantages in addition to adding diversity to the human diet. A variety of bioactive ingredients, such as, phenolic compounds, saponins, bioactive proteins, glycoalkaloids, and phytic acids had already been reported in tuber crops. There is still much to learn about the nutritional and health benefits of many starchy tuber crops, with the exception of cassava, sweet potatoes and regular potatoes. Tubers can be used to make a number of dishes and may also be used in industrial usage. The bioactivities of the constituent chemicals may be impacted by processing. The use of tubers as functional foods and nutraceutical ingredients for disease risk reduction and wellness is very much promising in present days.

**Key words :** Bioactive ingredients, Root crops, Tuber crops, Nutraceutical

## Introduction :

Starchy root and tuber crops are the major source of carbohydrates in the world only after cereals. They contribute significantly to the world's food supply and are a significant source of processed goods for both domestic and commercial use as well as animal feed. Plants that store edible starch material in underground stems, roots, rhizomes, corms, and tubers are known as starchy roots and tubers. They come from a variety of botanical sources. While taro and cocoyams are generated from corms, subterranean stems, and swollen hypocotyls, potatoes and yams are tubers. Storage roots include cassava and sweet potatoes, while edible rhizomes include canna and arrowroot. Vegetative portions, which include tubers (potatoes and yams), stem cuttings (cassava), vine cuttings (sweet potatoes), side shoots, stolons or corm heads, can be used to reproduce all of these crops (taro and cocoyam). In terms of nutrition, tubers and roots have a lot of potential to offer affordable sources of nutritional energy in the form of carbohydrates. Due to the high moisture content of tubers, their energy

[1]Department of Soil Science and Agricultural Chemistry, N M College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, India; [2]Department of Plant Pathology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India. *E-mail : nilimanau13@gmail.com

content is roughly one-third that of rice or wheat of the same weight. In contrast to cereal grains, high yields of roots and tubers provide more calories per land unit per day. Generally speaking, the dry weight basis protein content of roots and tubers ranges from 1 to 2% (FAO, 1990). Among other tubers, potatoes and yams have significant protein content. The limiting amino acids in root crop proteins include methionine and cystine, which contain sulphur. Some amount of vitamin C can be found in cassava, sweet potatoes, potatoes, and yam. Yellow sweet potatoes, yam, and cassava also contain beta-carotene. A good source of potassium is taro. While lacking in the majority of other vitamins and minerals, roots and tubers are rich in dietary fibre. Similar to other crops, the nutritional value of roots and tubers varies depending on factors like variety, location, soil type and farming techniques. It is of great interest to identify specific plant components that have positive health effects. Plant-based foods contain a variety of nonnutrient phytochemicals. They are produced in house in plants as secondary metabolites and have a variety of ecological functions (Naczk and Shahidi, 2006). A range of substances, including saponins, phenolic compounds, glycoalkaloids, phytic acids, carotenoids, and ascorbic acid, are abundant in tubers and root crops. For tubers and root crops, a number of bioactivities have been identified, including antioxidant, immunemodulatory, antibacterial, antidiabetic, antiobesity, and hypocholesterolemic activities.

**Types of roots and tuber crops :**

***I. Potatoes (Solanum tuberosum L.)***

As opposed to underdeveloped countries, industrialised nations' diets place a greater emphasis on potatoes. Individuals in rich and underdeveloped nations consumed 130 and 41 kcal/day of energy from potatoes, respectively (Burlingame *et al.*, 2009). In the diet, potatoes significantly contribute to the intake of carbohydrates, potassium, and ascorbic acid (Hale *et al.*, 2008). Additionally, the ascorbic acid found in potatoes prevents the oxidative degradation of folates (McNulty and Pentieva, 2004). An amount of 250 g of potatoes enhanced with genetically produced carotenoids may offer around 50% of the RDA for vitamin A (Diretto *et al.*,2007). Numerous secondary metabolites found in potatoes have shown antioxidant and other bioactivities (Ezekiel *et al.*, 2013).

***II. Sweet Potatoes (Ipomoea batatas L.)***

Under ideal climatic conditions, sweet potatoes can be cultivated all year round. Complete crop loss due to unfavourable climatic conditions is uncommon in sweet potatoes. For this reason sweet potatoes are called as "insurance crops." Southeast Asia, Oceania, and Latin America are key growing locations for the crop, with China accounting for roughly 90% of global output. In case of children, vitamin A status is improved when they consume 125 g of orange-fleshed sweet potatoes, especially in underdeveloped nations (van Jaarsveld *et al.*, 2006). Additionally, sweet potatoes are a good source of dietary fibre, vitamins, minerals, and bioactive substances including phenolic acids and anthocyanins (Laverino-santos *et al.*, 2022), which are also responsible for the flesh's colour.

### *III. Cassava (Manihot esculenta Crantz.)*

The most extensively grown root crop in the tropics is cassava, which can only be produced in tropical and subtropical areas of the world due to its lengthy growth season (8 to 24 months). Due to its high carbohydrate content, cassava serves as a vital staple food for more than 500 million people worldwide (Bayoumi *et al.*, 2010). Cassava roots have been shown to contain a variety of bioactive substances, including terpenoids, flavonoids, hydroxycoumarins like scopoletin, cyanogenic glucosides like linamarin and lotaustralin, noncyanogenic glucosides, and glucosides (Chandrasekara and Kumar, 2016).

### *IV. Yams (Dioscorea sp.)*

Yam is a monocotyledonous plant that belongs to the Dioscoreaceae family and is a common cuisine in West Africa, Southeast Asia, and the Caribbean (Liu *et al.*, 2007). Yam tubers contain a variety of beneficial substances, including carotenoids, tocopherols, diosgenin, dioscin, allantoin, choline, polyphenols, and mucin (Bhandari *et al.*, 2003). Soluble glycoprotein and dietary fibre are both present in the mucilage of yam tubers.

### *V. Aroids*

Aroids are tuber or underground stem bearing species under the family Araceae . Taro (Colocasia), gigantic taro (Alocasia), tannia or yautia (Xanthosoma), elephant foot yam (Amorphophallus), and swamp taro are some of the edible tubers and stems (Cyrtosperma). Originating in Southeast Asia and India, colocasia is a common dish in several South Pacific islands, including Papua New Guinea, Tonga, and Western Samoa. Taro is also the most extensively grown crop in the Caribbean Islands, Asia, Africa, and the Pacific.

### *VI. Minor Tuber Crops*

The rhizomatous type tuber known as canna is widely cultivated in the tropics and subtropics. The Cannaceae family includes the genus Canna. In Australia, it is grown for commercial purposes to make starch. The edible rhizomes of *Maranta arundinacea* L., often known as West Indian arrowroot, are grown for food. It is a member of the Marantaceae family and is thought to have come from South America's Northwestern region. Arrowroot is readily available in tropical nations including India, Sri Lanka, Indonesia, the Philippines, Australia, and the West Indies.

## Bioactive compounds in tuber crops :

Secondary metabolites known as bioactive chemicals are found in plants and have pharmacological or toxicological effects on both humans and animals. In addition to the main biosynthesis related to growth and development, secondary metabolites are created by plants. The chemical manufacture of corticosteroids, related hormones, and birth control tablets (which contain progesterone and oestrogen) begins with saponins with a steroid structure (Podolak *et al.*, 2010). The tuber crop like yam is rich in this type of compounds. Crops with roots and tubers vary in their protein content. Less than 3% of the diet's total protein intake comes from roots and tubers. However, this contribution can range from 5 to 15% in African nations (FAO, 1999). The primary storage protein in tropical Dioscorea yams is called dioscorin. Nearly about 90% of the water-extractable soluble proteins in the majority of Dioscorea species are made up of it. Dioscorin was said to have trypsin and carbonic anhydrase inhibitory properties (Hou *et al.*, 1999). In addition, dioscorin has been shown to have dehydroascorbate reductase and monodehydroascorbate reductase activity when glutathione is present (Hou *et al.*, 2000). Fresh yam (*Dioscorea batatas*) dioscorin had DPPH radical scavenging activity (Hou *et al.*, 1999) and had positive benefits on reducing blood pressure (Hou *et al.*, 2000). A significant group of phytochemicals called glycoalkaloids is present in a large number of species of the genera Solanum and Veratrum (Dale *et al.*, 1993). Various tumour cell lines were sensitive to the cytotoxic effects of the steroidal alkaloid glycosides (Ikeda *et al.*, 2003). Carotenoids are abundant in yellow sweet potatoes and yam variants. A water-soluble vitamin is ascorbic acid, usually referred to as vitamin C. According to the 1983 Nutritional Food Survey Committee, 19.4% of the total requirement for vitamin C is provided by potatoes, which are the main source of vitamin C in British diets (FAO, 1990).

**Bioactivities of phytochemicals in roots and tubers :**

Previous study evidence shows that oxidative stress is a crucial factor in the development of a number of chronic diseases, including various cancers, cardiovascular diseases, diabetes, arthritis, and autoimmune and neurological disorders. According to several studies, the phytoconstituents in sweet potato peels have the potential to scavenge free radicals and block lipid oxidation, which may explain their powerful ability to heal wounds (Panda *et al.*, 2011). In a rat model, sweet potato fibre was shown to have a healing impact on burns or decubital wounds, leading to changes in the quantity and quality of the wounds (Suzuki *et al.*, 1996). Among a variety of selected tuber crops, including sweet potato, potato, coco yam, and other *Dioscorea* yams, water yam (*Dioscorea alata*) was shown to have the greatest DPPH radical scavenging activity of 96% (Dilworth *et al.*, 2012). Yam phytochemicals appear to boost endogenous antioxidant enzyme activity. In rats with carbon tetrachloride-induced hepatic fibrosis, yam supplementation reduced the levels of ã-glutamyl transpeptidase (GGT), low density lipoprotein, and triacylglycerol in serum (Chan *et al.*, 2010). The largest cause of death in the world is cancer, which is primarily brought on by poor dietary choices and lifestyle choices. Yam dioscorin displayed immunomodulatory properties through the innate immune system, a generalised immune system that consists of cells and mechanisms that protect the host against infection by other organisms in a generalised way. Dioscorin was said to increase phagocytosis and to induce the generation of cytokines. Furthermore, phytohemagglutinin (PHA), a lectin present in plants that promotes splenocyte growth, may work in concert with the released cytokines to increase their effects ((Liu *et al.*, 2007). The chronic condition known as diabetes mellitus is characterised by high blood glucose levels and potentially fatal consequences. Patients with diabetes who consumed sweet potato peel extracts had lower plasma glucose levels (Ludvik *et al.*, 2002). In postmenopausal women, yam (*Dioscorea*) has the power to lower the risk of cancer and cardiovascular disorders (Liu *et al.*, 2007).

**Effect of processing on pioactivities of roots and rubers :**

The bioactivities and quantity of phytochemicals vary depending on the conditions under which food is processed. The physiochemical characteristics and nutritional value of sweet potato flour may vary as a result of processing procedures such peeling, drying, and sulphite treatment (Ahmed *et al.*, 2010). As well as adding nutrients, sweet potato flour is frequently used to improve the appearance, flavour, and sweetness of food products. It also acts as a replacement for grain flours, which are particularly high in gluten and unsuitable for those with celiac disease (Caperuto *et al.*, 2000). In comparison to yellow sweet potatoes, the freeze-dried samples of orange potatoes had higher levels of phenolics, beta-carotene, and anthocyanins, as well as free radical scavenging abilities. When compared to samples of freeze-dried yellow sweet potatoes, hot air dried samples had a higher level of DPPH radical scavenging activity, but the tendency was the opposite for orange sweet potatoes. The bioactivities that have been reported may be caused by phenolic compounds, anthocyanins, and beta-carotene (Shih *et al.*, 2009). With the duration of boiling, steaming, and microwave cooking, the retention of â-carotene got reduced (Wu *et al.*, 2005). The phenolic content of potatoes varies depending on the cooking process. During boiling and baking, a sizable loss in the phenolic content of peeled and unpeeled potatoes was noted. Furthermore, the protocatechuic and caffeoylquinic acids in peeled potatoes were lost during boiling by 86 and 26%, respectively. Additionally, microwave cooking caused peeled potatoes to lose 50–83% of protocatechuic acid and 27–64% of caffeoylquinic acids. It's interesting to note that losses were reported to be lower for potatoes that hadn't been peeled (Barba *et al.*, 2008). Investigation found that the anthocyanin content of raw potatoes was higher than that of deep-fried French fries and potato chips (Fang *et al.*, 2011).

**Conclusions :**

Humans need roots and tubers in their diets because they bring diversity and are essential nutrients. Aside from their primary function as a source of energy, they also have a number of other beneficial nutritional and physiological advantages, including antioxidative, hypoglycemic, hypocholesterolemic, antibacterial, and immunomodulatory actions. Tubers can be used to make a variety of cuisines, and the type and application varies by nation and location. The bioactivities of the component chemicals are impacted by processing. Due to the prevention of chronic noncommunicable illnesses and for wellness maintenance, tubers can be used as functional foods and nutraceutical components.

**References :**

Ahmed, M., Akter, M. S. and Eun, J.-B. 2010. Peeling, drying temperatures, and sulphite-treatment affect physicochemical properties and nutritional quality of sweet potato flour, *Food Chemistry* **121**( 1): 112–118.

Barba, A.A., Calabretti, A. , d'Amore, M. and Rastrelli L. 2008. Phenolic constituents levels in cv. Agria potato under microwave processing. *Lebensmittel-Wissenschaft und-Technologie* **41**(10):1919-1926

Bhandari, M. R., Kasai, T. and Kawabata, J. 2003. Nutritional evaluation of wild yam (Dioscorea spp.) tubers of Nepal, *Food Chemistry* **82**(4): 619–623.

Burlingame, B., Mouille, B. and Charrondi ´ ere, R. 2009. Nutrients, ' bioactive non-nutrients and anti-nutrients in potatoes, *Journal of Food Composition and Analysis* **22**( 6) : 494–502

Bayoumi, S.A.L., Rowan, M.G., Beeching, J.R. and Blagbrough, I.S. 2010. Constituents and secondary metabolite natural products in fresh and deteriorated cassava roots. *Phytochemistry* **71**: 598-604.

Caperuto, L., Amaya-Farfan, J. and Camargo, C., 2000. Performance of quinoa (Chenopodium quinoa wild) flour in the manufacture of gluten-free spaghetti, *Journal of the Science of Food and Agriculture* **81**: 95–101.

Chan, Y.C., Chang, S.C., Liu, S.Y., Yang, H.L., Hseu, Y.C. and Liao, J.W. 2010. Beneficial effects of yam on carbon tetrachloride-induced hepatic fibrosis in rats. *Journal of the Science of Food and Agriculture* **15**:90(1):161-7. doi: 10.1002/jsfa.3801. PMID: 20355026.

Chandrasekara, A. and Kumar, T. J. 2016. Roots and Tuber Crops as Functional Foods: A Review on Phytochemical Constituents and Their Potential Health Benefits. *International Journal of Food Science and Technology* 3631647.

Dale, M. F. B., Griffiths, D. W, Bain, H. and Todd, D. 1993. Glycoalkaloid increase in Solarium tuberosum on exposure to light, *Annals of Applied Biology* **123**( 2): 411–418.

Dilworth, L., Brown, K., Wright, R., Oliver, M., Hall, S. and Asemota, H. 2012. Antioxidants, minerals and bioactive compounds in tropical staples, *African Journal of Food Science and Technology* **3**( 4):90–98.

Diretto, G., Al-Babili, S., Tavazza, R., Papacchioli, V., Beyer, P., and Giuliano, G. 2007. Metabolic engineering of potato carotenoid content through tuber-specific overexpression of a bacterial mini-pathway, *PLoS ONE* **2**(4): article e350.

Ezekiel, R., Singh, N., Sharma, S. and Kaur, A. 2013. Beneficial phytochemicals in potato-a review, *Food Research International*, **50**(2)487–496.

Fang, Z., Wu, D., Yu, D., Ye, X., Liu, D. and Chen, J. 2011. Phenolic compounds in Chinese purple yam and changes during vacuum frying, *Food Chemistry*, **128** (4)943–948.

FAo, Production Year Book, vol. 53, *Food and Agriculture Organization*, Rome, Italy, 1999

Food and Agriculture Organization (FAO), 1990. Roots, Tubers, Plantains and Bananas in Human Nutrition, vol. 24 of *Food and Nutrition Series, Food and Agriculture Organization*, Rome, Italy

Hale, A. L., Reddivari, L., Nzaramba, M. N., Bamberg, J. B. and Miller Jr., J. C. 2008. Interspecific variability for antioxidant activity and phenolic content among Solanum species, *American Journal of Potato Research* **85**(5):332–341.

Hou, W.-C., Chen, H.-J. and Lin, Y.-H. 1999. Dioscorins, the major tuber storage proteins of yam (Dioscorea batatas Decne), with dehydroascorbate reductase and monodehydroascorbate reductase activities, *Plant Science* **149** (2):151–156.

Hou, W.-C., Chen, H.-J. and Lin, Y.-H. 2000. Dioscorins from different Dioscorea species all exhibit both carbonic anhydrase and trypsin inhibitor activities, *Botanical Bulletin of Academia Sinica* **41**(3):191–196.

Ikeda, T., Tsumagari, H., Honbu, T. and Nohara, T. 2003.Cytotoxic activity of steroidal glycosides from solanum plants, *Biological and Pharmaceutical Bulletin* **26**(8):1198–1201.

Laveriano-Santos, E. P., López-Yerena, A., Jaime-Rodríguez, C., González-Coria, J., Lamuela-Raventós, R. M., Vallverdú-Queralt, A., Romanyà, J. and Pérez, M.2022. Sweet Potato Is Not Simply an Abundant Food Crop: A Comprehensive Review of Its Phytochemical Constituents, Biological Activities, and the Effects of Processing. *Antioxidants* **11**(9): 1648; https://doi.org/10.3390/antiox11091648.

Liu, Y.-W., Shang, H.-F., Wang, C.-K., Hsu, F.-L. and Hou, W.-C. 2007. Immunomodulatory activity of dioscorin, the storage protein of yam (Dioscorea alata cv. Tainong No. 1) tuber, *Food and Chemical Toxicology* **45**(11):2312–2318.

Ludvik, B. H., Mahdjoobian, K., Waldhaeusl W. 2002. The effect of Ipomoea batatas (Caiapo) on glucose metabolism and serum cholesterol in patients with type 2 diabetes: a randomized study, *Diabetes Care* **25** (1):239–240.

McNulty, H. and Pentieva, K. 2004. Folate bioavailability, *Proceedings of the Nutrition Society* **63**(4):529–536.

Naczk M. and Shahidi, F. 2006. Phenolics in cereals, fruits and vegetables: occurrence, extraction and analysis, *Journal of Pharmaceutical and Biomedical Analysis* **41**:1523–1542

Panda V., Sonkamble, M., and Patil, S. 2011. Wound healing activity of Ipomoea batatas tubers (sweet potato). *Functional Foods in Health and Disease* **10**:403-415

Podolak, I., Galanty, A., and Sobolewska, D. 2010. "Saponins as cytotoxic agents: a review," *Phytochemistry Reviews* **9**(3): 425–474,

Shih, M.-C., Kuo, C.-C. and Chiang, W. 2009. Effects of drying and extrusion on colour, chemical composition, antioxidant activities and mitogenic response of spleen lymphocytes of sweet potatoes, *Food Chemistry* **117**(1):114–121.

Suzuki, T., Tada, H., Sato, E. and Sagae, Y. 1996. Application of sweet potato fiber to skin wound in rat, *Biological and Pharmaceutical Bulletin* **19**(7):977–983.

van Jaarsveld, P. J., Marais, D. W. , Harmse, E., Nestel, P. and Rodriguez-Amaya, D. B. 2006. Retention of 5ØýÞ-carotene in boiled, mashed orange-fleshed sweet potato, *Journal of Food Composition and Analysis* **19**(4): 321–329.

Wu, W.H., Liu, L.Y., Chung, C.J., Jou, H.-J. and Wang, T.A. 2005. Estrogenic effect of yam ingestion in healthy postmenopausal women, *Journal of the American College of Nutrition* **24**(4):235–243.