Review Article

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Roots And Tubers Crops: Nutritional Value And Functional Food Potential – A Comprehensive Review.

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ABSTRACT

Every nutritional value of food matters to us in order to maintain a healthy diet. Every food has a nutritional value that should be understood for our overall health. For a healthy lifestyle and a balanced diet, functional foods play a crucial role. Roots and tuber crops like turmeric, ginger, and ashwagandha have been used in India since ancient ages as functional foods for various therapeutic uses. The major tuber crops of India are cassava, sweet potato, yams, elephant foot yam, taro, tannia, yam bean, arrow root, etc. They played a key role in the diet of the early human population before the evolution of settled agriculture. Numerous phytochemical components of tuber crops have antioxidant and antibacterial effects that should be explored for improving health and reducing the risk of disease.

Keywords: Roots and tuber crops, Functonal food, Antioxidant, Vitamins, phytochemicals

1. INTRODUCTION

The ‘functional food’ concept was developed in Japan in the early 1980sand ‘food for specified health use’ (FOSHU) was established in 1991. It is defined as any food or ingredient that has a positive impact on an individual's health, physical performance, or state of mind, in addition to its nutritive value. They should be naturally occurring, can be consumed as part of the daily dietandwhen ingested, should enhance or regulate a particular biological process or mechanism to prevent or control specific diseases. A functional food is a food claimed to have an additional function (often one related to health promotion or disease prevention) by adding new ingredients or more existing ingredients(5).
The food should be rich in complex carbohydrates, bioactive protein, all essential fatty acids, dietary fibers, vitaminsand minerals, but not a single item cannot provide all these qualities. However, not even milk or eggs, which are referred to as "complete foods," In order to have a nutritionally balanced diet and to satisfy our demand for energy and nutrients, it is therefore advisable to eat a variety of foods.
Depending on the nation, different populations' contributions of roots and tubers to the energy source varied. The world produced 906 million tonesof roots and tubers in 2022. The production of roots and tubers worldwide increased at an average yearly rate of 0.95% from 583 million tons in 1973 to 906 million tons in 2022(1).Asia is one of the largest producers of roots and tuber crops, after Africa, Europe and America.
Dietary fiber content is also high in tuber crops including sweet potatoes, yams and cassava. Consuming these tubers therefore wards off constipation and related ailments like piles and stomach and colon cancer.It's significant to notice that higher yields of roots and tubers than cereal grains provide more calories per land unit per day (88). Most of the tuber crops are low in protein except aroids. For this reason, adding protein-rich supplements to a diet that mostly consists

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of tubers is essential to achieving nutritional balance(79). Root crop proteins are deficient in sulfur-containing amino acids like methionine and cystine. Cassava, sweet potato,potato and yam contain starch, vitamin C, Vitamin B and sufficient amount of mineral (22) (Table 1).

Nutritionally, roots and tuber crops provide a main energy source in the form of carbohydrates and dietary fibers. The primary necessity of human is energy, nutrition comes in secondary. More people die from hunger in developing and undeveloped nations than from illness. The primary benefit of tuber crops is their high energy content, which has greatly aided humanity in many instances of famine.Dietary energy is obtained from roots and tubers in the form of vitamins, minerals and dietary fiber(Table No. 1).

Table 1: Biochemical composition of some roots and tuber crops.

Component	Potato, raw	Sweet potato, raw	Taro, raw	Cassava, raw	Yam, raw
Carbohydrates	60-70	20g (100g)	15.1	38.1	27.9
Proteins	1.7-2	1.6	0.17	1.4	1.5
Total fat	0.1	0.1	0.17	0.3	0.2
Dietary Fibers	1.7-2.5	3g (100g)	2.76	1.8	4.1
Sugar	1.2-1.3	4.2	0.42	1.7	0.5
Calcium	9-10	30	93	16	17
Magnesium	21-22	25	52	21	21
Potassium	400-460	337	653	271	816
Phosphorus	60-62	47	100	27	55
Vitamin C	14.4 mg	2.40	3.62	20.60	17.10
Vitamin B1	0.6 mg (B6)	0.08	0.099	0.09	0.11
Vitamin B6	0.173-0.275	0.209	0.294	0.08	0.293
Vitamin K	1.6-3.0	1.8	1.0	1.9	2.3
Vitamin A (IU)	7-8	14187	-	13	138

Phytochemicals helps to improve our immune system (16). Numerous bioactive substances, including phenolic compounds, glycoalkaloids, phytic acids, carotenoids, ascorbic acid and saponins, are found in tubers and root crops. For tubers and root crops, a variety of bioactivities have been identified, including antioxident, immunomodulatory, antibacterial, antidiabetic, anti-obesity and hypocholesterolemic properties (20).

Since people's interest in natural products has significantly increased over the past few decades due to their potential as potent antioxidants, bioactive compounds and natural medications. For this reason, this review more focuses on the bioactivities of phytochemicals and their distribution in starchy roots and tuber crops.

2. STARCHY ROOTS AND TUBER CROPS AND THEIR NUTRITIONAL COMPONENT

Some plants organ modified as edible storage food like roots, stem and leaf. It is crucial for nutrition and health for human being. Modified storage roots are found in food crops such as sweet potatoes, carrots, and beets. Food crops like potatoes, ginger, colocasia (Taro) are example of modified stem (Tubers). In addition,they are also used in animal feed, production of starch, alcohol and fermented foods and beverages.

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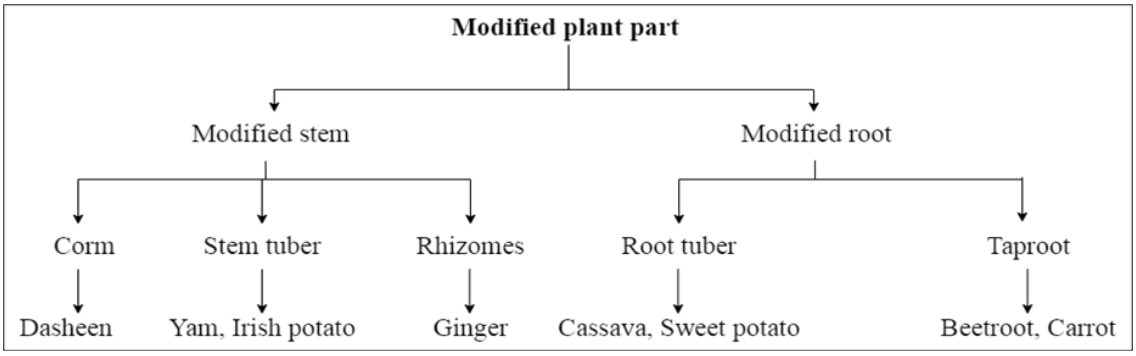

Fig. 1 Image of some modified edible roots and tubers.

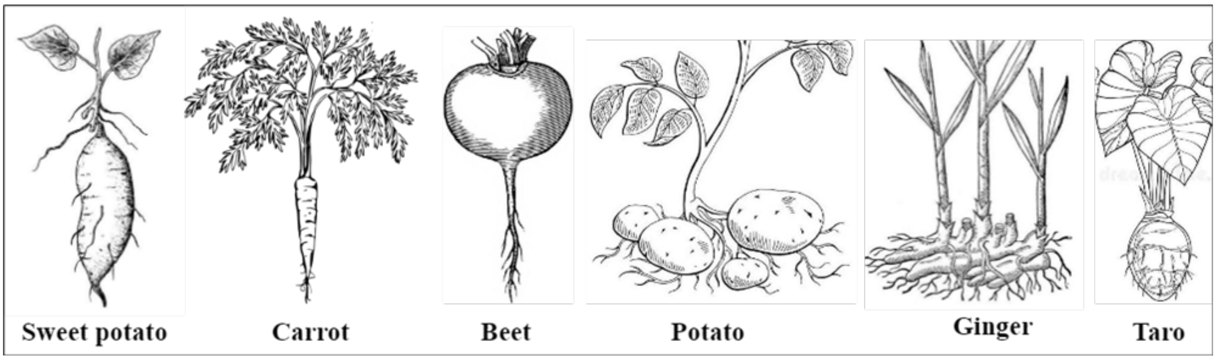

Table 2 Various information about roots and tuber crops

Name	Botanical Name	Family	Edible part	Common name	Origin	Main Chemical composition
Sweet potato	Ipomoea batatas	Convolvulaceae	Adventitious root	Shakarkand; Batata	South America	flavonoids, terpenoids, tannins, saponins, glycosides, alkaloids, steroids and phenolic acids
Potato	Solanum tuberosum	Solanaceae	Stem (Tuber)	Aloo	Peru	phenolics, flavonoids, polyamines, and carotenoids
Beetroot	Beta vulgaris	Amaranthaceae	Taproot	Chukandar; Palak	Celtic (Western Europe)	betanin, saponins, polyphenols, and organic acids

Carrot	Daucus carota subsp. sativus	Umbellifer or Apiaceae	Taproot	Gajar	Central Asia	phenolics, carotenoids, polyacetylenes, and ascorbic acid,
Taro	Colocasia esculenta (L.) Schott	Araceae	Corm	Cocoyam; Dasheen; Elephant's Ear	South-East Asia	saponins, tannins, flavonoids, and phenolic acids
Ginger	Zingiber officinale	Zingiberaceae	Stem (Rhizome)	Adi; Adrack (fresh); Sonth (dried)	-	flavones, isoflavones, flavonoids, anthocyanin, coumarin, lignans, catechins and isocatechins
Turmeric	Curcuma longaL.	Zingiberaceae	Stem (Rhizome)	Haldi	Southeast Asia	Curcuminoids
Elephant foot yam	Amorphophallus Paeoniifolius	Araceae	Corm	Suran	South-East Asia	anthraquinone, carotenoid, cardiac glyco-side, glycoside, phlobotanin, phenol, saponin, and tannin
Yam	Dioscoreaalata	Dioscoreaceae	Stem (Corm)	KaachilKaavuth; Ban Aalu	West Africa	mucin, dioscin, dioscorin, allantoin, choline, polyphenols

2.1.Taro(Colocasia esculenta L.)

In Southeast Asia and the Pacific, taro (ColocasiaesculentaL. Schott) is a crop of significant socioeconomic value (49). Nutritionally, the tubers of Colocasiaesculenta have the following contents: 56.8% moisture, 1.22% ash, 3000 mg of carbohydrates, 824 mg of proteinand 2700 mg of starch (44). It has a high nutritional content. Additionally, taro has a greater amount of vitamin B complex than whole milk(83). Furthermore, people who are sensitive to milk can eat taro, which is particularly helpful for those with cereal allergies (40).

Zinc deficiency is currently common among humans all over the world. The cause of zinc deficiency in many countries is the poor diet of animal sources and in countries where primarily cereal proteins are consumed by the population (72,73).Tarois one of the few non-animal sources of zinc. Its use should be investigated to help alleviate this problem(84).

Tubers of Colocasiaesculenta also contain photochemical constituents like alkaloids, glycosides, flavonoids, terpenoids, saponins and phenols.

Table 3. Various photochemical constituents found in Colocasiaesculenta (67)

Sr. No.	Compound	Average contain
1	Polyphenols (mg GAE/100 g dw)	17.956 ± 20.80
2	Flavonoids (mg QE/ 100 g dw)	0.394 ± 0.28
3	DPPH (%)	73.180 ± 16.65
4	FRAP (mg AAE/100 g dw)	3.112 ± 2.73

2.2 Yam (Dioscoreaalata L.)

In tropical countries, millions of people depend on cultivated yams (Dioscoreaspp.) as their primary source of nutrition.The annual rejuvenation and production of tubers serves as the underground storage organ. Every season, they are harvested and tuber parts are used to transplant them for following season. Yam tubers have various nutritional compositions like starch, sugar, dietary fibers, minerals and organic compounds.Bioactive components found in yam tubers include dioscin, mucin, dioscorin, choline, polyphenols, diosgenin, and vitamins such tocopherols and carotenoids. Dietary fiber and soluble glycoprotein are found in the mucilage of yams. Yam extracts were identified as having hypoglycemic, antibacterial and antioxidant properties in a number of investigations. Yams may increase the activity of digestive enzymes in the small intestine and promote the growth of stomach epithelial cells(43,27, 87,76).

2.3 Ginger

According to the FAO, Asia is the largest producer of ginger throughout the world. The underground stem (Rhizome) of the ginger plant is useful for both vegetative propagation and edible food storage. The rhizome of ginger includes a variety of substances, including 8% ash, 9%–12% water, 3%–6% fatty oil, 9% protein, 60%–70% carbs and 2%–3% volatile oil.

It should be noted that different factors, like processing (cooking, drying, and steaming), storageand harvesting, affect the various compositions of rhizomes.The volatile oil is composed of monoterpenes like cineole (1.3%), linalool (1.3%), borneol (2.2%), geranial (citral a, 1.4%),neral (citral b, 0.8%) and sesquiterpenes such zingiberene (36% w/w), curcumene (18%)and farnesene (10%). Among the nonvolatile components are the principal biologically active substances, including zingerone, paradols, shogaols, and gingerols (42,53).

2.4 Turmeric

Turmeric is one of the most popularly investigated functional foods. India is the largest producer and has the highest genetic diversity of turmeric in the world. Since ancient times, turmeric has been used for medicinal purposes as well as dye.

The nutritional value and phytomedicinal characteristics of dried turmeric (Curcuma longa) rhizomes were observed: moisture content (9.55%), carbohydrate (57.30%), ash (24.70%), crude fiber (1.12%), proteins (2.15%) and fat (5.32%). Mineral composition analyses showed that turmeric rhizomes had higher contents of calcium, magnesium, potassium, and sodium in parts per million (ppm) at 38.68 ± 0.114, 19.75 ± 0.001, 9.20 ± 0.002 and 7.06 ± 0.014 respectively. According to amino acid profiling, essential (aspartate) and non-essential (glutamate) were found, with the greatest concentrations at 9.78 g/100 g and 9.65 g/100 g, respectively (30).

2.5 Beetroot

Beetroot (Betavulgaris L.) is commonly known as garden beet or chukandar. It is a part of the beet plant. It is widely grown in North America, Europe and Asia. Beetroot has historically been used as juice, cooked into vegetables and processed for a variety of uses in cuisine. However, nowadays, it's recognized as a “functional food” due to its important role in the growth and development of the human body. It is also a good source of carbohydrates, proteins, fatty acids, vitaminsand fibers. The beetroot of the plant is an excellent source of carbohydrates (sucrose) and due to that, it can be utilized in the industrial production of sugar. For the extraction of raw sugar, after Saccharumofficinarum, beetroot is the most commonly utilized plant. Additionally, it also containsanti-diabetic, anti-bacterial and anti-cancer agent (19,61,1)

2.6 Carrot

China is the largest producer and exporter of carrots in the world. Root of carrot (Daucuscarota L.) plant has significant role in cooking due to the high content of carotenoid pigment, dietary fiber, vitamin A, Vitamin C and a variety of other minerals. Carrot roots are traditionally used in Indian salads. Today, it has been used professionally in processed foods, including concentrate, dried powder, juice, pickled vegetables, candy, protectantsand gazrailla, which are high in nutrients. Biohemical compositions like carbohydrates (fructose, glucose and sucrose), dietary fibers and vitamins have been found in the roots of carrots. It has also had nutraceutical values like anti-inflammatory activity, anti-diabetic activity, and antinutritional activity (55,75).

2.7 Potato

Potato is a starchy vegetable cause of high nutritonal value of starch. After China, India is the world's second-largest producer of potatoes. The nutritional composition of medium-sized potatoe is total carbohydrates (26g), dietary fiber (2 g), and total sugars (1g) (54).Potato chemistry research is crucial to understand the potential health benefits of this vegetable for human beings.Makinen (2014) evaluated the potato proteins are high in lysine content and nutritionally equivalent to those of a whole egg.Ascorbic acid amounts ranged from 217.70 to 689.47 μg/g DW while α-tocopherol levels ranged from 3 to 20 μg/g DW. Similarly, in 11 Indian potato varieties, vitamin C varied from 0.0828 to 0.2416 mg/g FW (33).

3. BIOACTIVE PHYTOCHEMICAL IN ROOTS AND TUBER CROPS

3.1 Phenolic compound

Plants produce phenolic compounds as secondary metabolites and these compounds have antioxidant properties. The structure of phenolic compounds is aromatic ring attached with one or more hydroxyl groups. Based on their molecular structure, these substances can be categorized as flavonoids, phenolic acids, tannins, stilbenes, coumarins, and lignans.They are produced by pentose phosphate, shikimate and phenylpropanoid metabolic pathways from biosynthetic precursors such as pyruvate, acetate, a few amino acids, acetyl-CoA and malonyl-CoA. Phenolic compounds play a significant role in the nutritional and commercial qualities of agricultural goods by influencing sensory attributes including flavor and color (66,57). The amount of phenolic compound present in a species depends on number of factors, including the cultivar, environmental factors, cultural methods, postharvest procedures, processing and storage conditions, and others.Taro powder has highest phenolic content as compared to raw form (3) (Table 4).

Table 4: Comparison of phytochemicals and antioxidant activity between raw taro and taro powder.

Sr. No	Components	Raw taro	Taro powder
1	Antioxidant Activity (% LP)1	74.68 ± 0.44 b	81.77 ± 0.47 a
2	Phenols (mg/100g expressed as g/catechin eq/g)	34.83 ± 0.28 b	78.33 ± 0.66 a
3	Tannins (mg/100g expressed as vanillin eq/g)	32.24 ± 0.35 a	32.24 ± 0.35 a
4	Flavonoids (mg/100g expressed as mg gallic acid eq/g)	28.56 ± 0.23 b	64.23 ± 0.54 a
5	Saponins (mg/100g saponins)	14.22 ± 0.36 b	26.96 ± 0.61 a

Certain species of Dioscorea have been discovered as potential sources of both phenols and phenolic acids. The phenolic and flavonoid content of Dioscoreaalata (Yam) is 63.846 Â± 1.83 mg/g and 8.213 mg/g dry extract (DE), respectively, in the plant.
Twenty-nine phenolic compounds were identified from the root bark of fresh Yunnan ginger (68) thoroughly described their structures. The effects of the extracted phenolic compounds on cytotoxicity, cytoprotection and antioxidants were also examined. Zingerone (ZO), an active phenolic agent derived from Zingiberofficinale (Ginger), has many pharmacological properties such as antioxidant, antiangiogenic, and antitumor (46,92,81).
In salald, beet root is typically utilized. The fractionated 80% aqueous methanol peel extracts (acetonitrile fraction) of beetroot included four flavonoids (betagarin, betavulgarin, cochliophilin A and dihydroisorhamnetin) and two phenolic amides (N-trans-feruloyltyramine and N-trans-feruloylhomovanillylamine) (45,9). Thetotal amount of phenolic acids in beetroot is between 50 and 60 μmol/g dry weight(24).
Carrot phenolic content varies depending on the color of the roots. Spectrophotometric measurements showed the range between 19.8 to 342.2 mg /100g FW in UV/V. The average total phenol content determined in Folin–Ciocalteu assay, on average, lower by 21–41% depending on root color.The study reveals that the polyphenol content in carrot juices varies based on the type and extraction techniques used, with dark juices having the highest TPC (2) concentration, while black juices have a higher TPC (51).

3.2 Saponins and Sapogenins (P)

High-molecular-weight secondary metabolites called saponins are glycosides with a sugar moiety bonded to an aglycone of a triterpene or steroid. Sapogenin is the hydrophobic aglycone component of the saponin molecule (41). Current evidence shows that steroidal saponins may represent a unique class of prebiotics for lactic acid bacteria and are promising treatments for animal and human fungal and yeast infections (19,13).The main saponin found in beetroot roots is a triglycoside derivative of oleanolic acid, which is composed of oleanolic acid or hederagenin aglycone and different amounts of sugars (17). Cultivated yam species represent a sustainable source of steroidal saponins, which could be further increased through conventional breeding (47).

3.3 Bioactive Proteins

In general, roots and tuber crops have low protein contents. For this reason, adding supplements high in protein is essential when using tubers as the main food to maintain a nutritionally balanced diet.Roots and tubers make up less than 3% of diet-related protein globally, but this percentage may range from 5 to 15% in African nations (32).

Dioscorin is the major soluble protein present in the tubers of the tropical root crop yam (Dioscorea spp.).Crude protein content in Dioscorinalata is 0.6 to 18.7 % (65). Biologically active peptides with a degree of hydrolysis (DH) of 25.46% in the gastric phase (GPH) and 27.0% in the entire gastrointestinal digestion (GIPH) can be produced during the digestion of yam proteins (26). During storage, beetroot lost some of its water content, which raised the amount of nitrogen and crude proteins in its fresh weight and in turn, improved the beetroot's nutritional value as a functional food (71).Carrotflour had good sources of fiber (18.23 ± 0.26%) and protein (6.83 ± 0.22%) (74). Sporamin, a key protein in sweet potato tubers, may serve as a protease inhibitor and storage protein, contributing to its significant amino acid sequence identity with some Kunitz-type trypsin inhibitors (93).

3.4 Glycoalkaloids (GAs)

Glycoalkaloids are naturally occurring secondary metabolites found in the solanaceae family of plants as well as microorganisms and animals (25). Commercial potatoes have been shown to have two primary glycoalkaloids. Among these are the glycosylated derivatives of the aglycone solonidine, α-chaconine and α-solanine (62). The structure of most of the alkaloids is made up of amino acids and components from other pathways, like terpenoids. Alkaloids primarily operate in plants as phytotoxins, antibactericides, fungicides and as substances that prevent insects, herbivorous animals, and mollusks from feeding on them (89). GAs has significant anticancer characteristics, such as having a potent growth-inhibiting effect on cancer cells (90).

3.5 Carotenoids

Carotenoids are the most widely accessible natural pigments in plants, which have yellow, orange, red and purple colors. Carotenoids, such as triperpenoid pigment, are found in photosynthetic bacteria, certain species of fungi and archaea, algae, plantsand animals. Carotenoids can be chemically produced or extracted from natural sources (82,59).

3.6 Ascorbic acid

Ascorbic acid or vitamin C is water soluble vitamin. It is found naturally in the tissue of plants. Many root crops have significant levels of ascorbic acid. However, the level of ascorbic acid is reduced as the roots are cooked. When prepared properly, root vegetables can significantly increase the amount of vitamin C in the diet (59).Sweet potato (86) and cassava root (23) is excellent sources of vitamin C. Furthermore, the concentration of ascorbic acid depends on species, soil type, maturity of the plant and fertilizer dose (8).

4. PROPERTIES OF BIOLOGICAL COMPOUND

4.1 Antioxidant activity

Antioxidants are phytochemicals that help prevent biological molecules from oxidizing, therefore lowering oxidative stress. In plants, generally, flavonoids and phenolic acids are abundant; they have potent antioxidant properties that protect against a range of chronic illnesses. Carrots are rich in α- and β-carotene, vitamin E and anthocyanin, which are potent antioxidants that can effectively mitigate the damaging effects of free radicals (63,23).Studiesshows that Dioscorea extracts contain antioxidant properties, promoting bioactivities and health benefits by scavenging radicals and enhancing the endogenous antioxidant system.Theamounts of 6-gingerol, 8-gingerol, 10-gingerol, and 6-shogoals in 1 g of ginger powder were found to be 2.56 mg, 0.36 mg, and 1.27 mg, respectively (23). The high potential antioxidant qualities of gingerol are well recognized and they play a vital role in both the prevention and treatment of many diseases (7). Gingerol contains anti-inflammatory and antioxidant qualities (28).

4.2 Anti-microbial activity

Today's, Microorganisms that are resistant to antibiotics are becoming increasingly common and are a serious global issue. Natural antibacterial chemicals are in high demand and during the past few decades, extensive research has been conducted in this field.The plant produces various secondary metabolites, which have antibacterial properties against some pathogenic microbes linked to gastrointestinal illnesses. Yam (Dioscorea spp.) has the potential to be an effective antimicrobial agent due to its phenolic compounds (82). Leaf of Colocasiaesculantahas strong antimicrobial and antifungal activity against S. aureus, E. coli, B. subtilis, E. coli, P. vulgaris, and P. aeruginosa (58).However, ginger oil has higher fungicide and antimicrobial activity due to the present of phenolic compounds (eugenol, shogaols, zingerone, gingerdiols, gingerols, etc.) (10,37). The disc diffusion method was used to evaluate the antibacterial properties of various turmeric extracts against Salmonella typhi, Staphylococcus aureus, Escherichia coli and Candida albicans, with water-extracted samples showing significant growth inhibition (35).

4.3 Hypoglycemic Activities

Hypoglycemia, often known as low blood sugar or low blood glucose. Numbers of phytochemical in diet can effectively prevent and treat type 2 diabetes. Diabetes mellitus is a chronic illness characterized by high blood glucose levels and potentially fatal consequences that can occur at any time. Phenolic content of sweet potato like Protocatechualdehyde, ethyl caffeate and quercetin showed the highest the strongest hypoglycemic α-glucosidase and α-amylase inhibitors.Although, the Z. officinale extract has been shown to have a hypoglycemic activity. The hypoglycemic action of commercial turmeric appears to be associated with inhibition of α-glucosidase and reduction of glucose diffusion.

4.4 Antidiabetic Activity

A set of metabolic diseases collectively known as diabetes mellitus are defined by an abnormal and persistent rise in plasma glucose levels. It is among the world's most important public health issues. D. dumetorum, also known as bitter yam, has long been shown to actively cure diabetes in traditional medicine because of its hypoglycemic activity (64).Beetroot contains bioactive compounds like betalains, particularly betanin, which exhibit hypoglycemic effects by enhancing insulin sensitivity and stimulating glucose uptake by cells (36). Furthermore, its high fiber content slows down glucose absorption, preventing spikes in blood sugar levels. Ginger exhibits antidiabetic properties due to its rich composition of bioactive compounds, such as gingerols and shogaols. These elements contribute to the plant's ability to regulate glucose metabolism, stimulate insulin secretion and exhibit antioxidant properties (56).

4.5 Hormonal activity

Yam (Dioscorea) possesses the potential to lower the risk of cancer and cardiovascular diseases in postmenopausal women Over a 30-day period, participants following a yam-based diet experienced significant increases in serum estrogen and sex hormone binding globulin (SHBG) levels (91). Inhibiting oxidative stress and modulating the levels of gonadotropin hormones (LH, FSH) and sex hormones (e.g., testosterone), ginger demonstrates a remarkable capacity to augment semen quality and enhance sperm fertility (34). Based on the findings of this investigation, it is anticipated that incorporating turmeric into the diet of individuals experiencing stress could elevate serum adiponectin levels, thereby potentially ameliorating sexual behavior and enhancing the profile of steroid hormones (77).

5. CONCLUSION

Roots and tubers play a critical role in global food security and nutrition, serving as rich sources of carbohydrates, dietary fiber, vitamins, and essential minerals. Beyond their primary function as staple crops, they are abundant in bioactive compounds such as polyphenols, flavonoids, and resistant starches, which enhance their potential as functional foods with notable health benefits. These crops contribute to the prevention and management of chronic diseases, including diabetes, cardiovascular disorders, and obesity, while also supporting gut health through their prebiotic properties. The wide variety of roots and tubers, from widely consumed staples like potatoes and cassava to lesser-utilized crops such as yams and taro, underscores their largely untapped potential in the functional food sector. However, several challenges persist, including post-harvest losses, insufficient processing technologies, and low consumer awareness of their health advantages. Addressing these issues through advancements in biotechnology, sustainable farming practices, and improved processing methods could further enhance their nutritional and functional qualities, paving the way for their greater adoption in health-focused diets.Future research should prioritize unlocking the potential of underutilized root and tuber crops, investigating their bioactive compounds, and developing innovative, value-added products to cater to the growing demand for functional foods. With their nutritional versatility and health-promoting properties, roots and tubers hold significant promise for combating malnutrition, ensuring food security, and fostering a healthier global population.

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