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Root and Tuber Crops for Livelihood and Nutritional Security of Farmers

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Abstract

Tuber crops are essential to the human diet, having desirable nutrients and health benefits. Root and tuber crops can provide essential nutrition and ensure nutritional security for low-income countries. Commercializing tuber crops can serve as a dietary intervention to address malnutrition and hidden hunger in underdeveloped countries. The most important aspect is their potential to provide affordable sources of food, vitamins, minerals, and energy to a poor section of the population. The bioactive constituents of tuber crops have provided a more extensive scope for their medicinal and therapeutic uses. Value addition and post-harvest processing of the crops will boost the farmers' income. The nutritional composition data of tuber crops is essential for promoting these crops. Though attempts are being made to promote the commercialization of tuber crops, more attention should be paid to these crops concerning better production technology, and more efforts should be made to develop location-specific, promising varieties.

Introduction

Tuber crops are an important component of the human diet, providing desirable nutrients and health benefits. The global production of root and tuber crops is about 876 million tonnes (FAO Stat, 2023).

Asia and Africa are the primary producers, followed by Europe and America. Small and marginal farmers generally cultivate tuber crops, and therefore, they provide nutritional and livelihood security. Tuber crops have immense potential to be cultivated in a climate-changing scenario due to their inherent resilience compared to major cereals. Due to its wider adaptability, it can be grown in a range of agro-geographical conditions and greatly impacts the economic conditions of several countries. (Lee et al., 2007). The major tuber crops, which include potato, sweet potato, yam, and cassava, are cultivated worldwide and provide major sources of food and calories, especially in Asia and Africa. Among the major tuber crops, potatoes and sweet potatoes account for 90% of the global production of tuber crops. Some minor tuber crops, such as winged bean, alocasia, and taro, have potential but must be more explored. Under the climate change scenario, these minor tubers will also serve as contingent crops because, under subsistence agriculture under the climate change scenario, these crops will serve as contingent crops. Tuber crops have the potential to alleviate poverty, hunger, and malnutrition and provide diversification in their food systems. About 4.0% of the global energy needs are met by the consumption of root and tuber crops. Nutritionally, root and tuber crops are cheap and economical sources of carbohydrates and dietary fibres. Carbohydrates are found in various storage bodies of rhizomes, corms, and enlarged underground roots. Besides dietary fibre and carbohydrates, root and tuber crops also have good sources of vitamins and minerals.

Several tuber crops have been identified for their high nutritional and health benefits, including anti-oxidative, anti-inflammatory, hypocholesterolemia, and immunomodulatory activities. Several bioactive constituent compounds have been isolated in some major tuber crops, and several are yet to be fully characterized in view of their utilization as functional foods. Developing value-added products from tuber crops expands their utilization and scope for commercialization and the food business model. Resource-poor farmers generally cultivate root and fibre crops, and attacks of disease and insect pests, weed infestations, edaphic stresses, and a lack of adequate agricultural inputs hamper their productivity. Developing varieties with a high degree of resistance to disease and insect pests would benefit farmers. The selection of varieties for specific agroecosystems and adequate agronomic practices would lead to a bumper harvest. Overall, integrated approaches are required to improve productivity and expand its scope as a nutritionally enriched staple crop.

Tuber crops

Plants that produce starchy roots and tubers are important for nutrition and health. They play a vital role in people's diets in various developing countries. These are also used in the fodder, alcohol, and fermented food industries. Tuber crops are the second-most-cultivated staple energy source in the tropical region of the world. Tuber crops have a high moisture content, and their energy content is one-third that of wheat and rice.

Major tuber crops

Major tuber crops have been used as a food source from time immemorial; they have sustained themselves during food shortages and days of famine (Chandrasekara et al. 2016). Roots and tuber crops are essential components of human diet and nutrition. People can use these tubers to prepare a variety of dishes. In terms of their supply of protein and carbohydrates, tubers have much potential to be a low-cost dietary resource.

Potatoes *(Solanum tuberosum)*

The potato is one of the most important tuber crops. It ranks third in consumption after rice and wheat. It plays a vital role in the diet of developed countries compared to developing countries. Apart from carbohydrates, potatoes are a rich source of vitamins B1, B2, B6, B9, and C, as well as minerals such as potassium (K), phosphorus (P), iron (Fe), and zinc (Zn) (Hellmann et al., 2021). It contributes about 10% of folate intake in many European countries. Recently, the introduction of pigmented varieties has attracted the interest of growers, consumers, and researchers who want to explore it in ways other than traditional energy crops. It was found that about 25% of vitamin A is provided by potatoes, which are genetically engineered with carotenoids (Coulibali et al. 2020). In addition to these nutrients, it also contains several polyphenols, flavonoids, anthocyanins, folates, and carotenoids. Potatoes are also used as raw materials in industries to make starch products and alcoholic beverages. Nutritional status varies depending on the selection of varieties, environment, and agronomic packages and practices. For profitable potato farming, integrated approaches like standard agronomic practices, selection of recommended varieties, and integrated disease and insect pest management are required.

Sweet potatoes (*Ipomoea batatas*)

Sweet potato is the seventh-largest crop grown in tropical and sub-tropical regions of the world. Under suitable climatic conditions, it can be grown throughout the year. It is a native crop of the tropical region of America. The edible part of the tuber is its tuberous root, which is of diverse shapes like spherical, oval, and fusiform. The skin and flesh of sweet potatoes are of different colours, like cream, orange, yellow, red, white, claret, and purple. Planting of the crop begins at the beginning of the rainy season and is continued for two months before the end of the rainy season. Harvesting of the crop occurs after 3–8 months of planting, depending on the crop variety. A sweet potato's plant parts, i.e., roots, stems, and leaves, are edible and contain different nutrient values. Sweet potato varieties with white or yellow skin are less sweet than those with red, pink, or orange flesh. The orange-fleshed sweet has high vitamin A content and is potentially targeted for eliminating vitamin A deficiency. Sweet potatoes are an excellent source of vitamin A, calcium, iron, potassium, and folate (Pati et al., 2021). Sweet potatoes also possess several bioactive constituents that have medicinal and therapeutic properties, such as anti-diabetics, anti-cancer, anti-ulcer, anti-fungal, anti-bacterial, and anti-inflammatory properties.

Yams *(Dioscorea sp.)*

Yams are the staple food in various countries, such as sub-Saharan Africa and Southeast Asia. It contains a high level of dietary fibre, carbohydrates, and sugar and provides approximately 200 calories per person per day to large masses of tropical birds. Among other nutrients, it is also a rich source of potassium, copper, manganese, vitamins, and other phytochemicals. In a nutraceutical or pharmacological aspect, yam is of great significance as it contains various bioactive components such as choline, mucin, dioscorin, and various carotenoids. Various studies have shown that yam extract also contains antimicrobial and antioxidant properties and could be used as a medicinal food. Variability concerning yield and nutritional aspects has been observed among different species and varieties as well as

environmental and agronomic management practices. Anti-nutritional compounds have also been associated with yam, reducing its bioavailability. However, food processing techniques like soaking, roasting, and post-harvest processing could lead to a reduction in anti-nutritional compounds to a great extent.

Cassava *(Manihot esculenta)*

Cassava is an important staple food crop for the masses because of its high carbohydrate content. It is the most significant crop in the tropics. It ranks fourth in calories after maize, rice, and sugarcane. Cassava root is long and tapering, with thick flesh. Cassavas contain high starch and are also good sources of calcium, phosphorous, and vitamins. Besides these nutrients, it contains many bioactive compounds like cyanogenic and non-cyanogenicglucosides. Being a staple food for millions of people in the tropics and subtropics, it is also used as a carbohydrate source for feeding animals and for industrial use. Several value-added products are being made from cassava and utilized as snacks. Cassava is a source of income and provides nutritional and livelihood security for many tropical countries.

Table 1. Nutritional composition of major tuber crops

Major tuber crops	Potato	Sweet potato	Yam	Cassava
Proximate Composition				
Protein (gm)	1.7	1.6	1.5	1.4
Energy (kcal)	69.0	86	118	160
Carbohydrates (gm)	15.7	20.1	27.9	38.1
Fats (gm)	0.1	0.1	0.2	0.3
(Minerals)				
Ca (mg)	9	30	17	16
P (mg)	62	47	55	27
Na (mg)	18	55	9	14
K (mg)	407	337	816	271
Fe (mg)				
Vitamins				
Vit. A (IU)	8	14187	138	13
Vit B6	0.203	0.209	0.293	0.088
Riboflavin	0.03	0.06	0.03	0.05
Thiamin	0.07	0.08	0.11	0.09
Ascorbic acid	19.7	2.40	17.10	20.60

Minor tuber crops

Underutilized tuber crops are a valuable reservoir of nutrition. They effectively combat the global problem of malnutrition. These crops possess high resistance to global warming and climate change. Due to their extensive adaptability to harsh climates, they can be used as a potent source of food.

Winged bean *(Psophocarpus tetragonolobus)*

Winged beans are grown in tropical regions of the world. It is one of the underutilized crops with edible parts: seed, pod, leaves, flowers, and tuberous roots. Winged bean seeds contain 29–37% protein and 15–18% oil. Hence, for nutritional composition, it very much resembles soybean. In the tropical world, winged beans promise an excellent scope for nutritional and livelihood security, whereas soybeans are not being grown. Winged beans can be grown in less fertile soil, and their nitrogen-fixing ability is higher than that of major popular pulses due to the size of the nodules. However, its under-production area has not increased due to poor plant architecture traits, photosensitivity, and late maturity. Anti-nutritional factors such as trypsin inhibitors, tannins, phytic acid, complex oligosaccharides, and hemagglutinating agents combine nutrients and reduce their overall digestibility. These anti-nutritional elements could be largely reduced with value addition and food processing techniques. The winged bean is a deep-leaf plant with long pods, seeds, and edible tubers, which make it suitable for animal feed.

Alocasia

Alocasia is a tuber crop generally grown in upland and drier areas. Alocasia is a tuber crop rich in carbohydrates but with a marginal protein content. It shows a moderate amount of dietary fibre with low-fat content and a good source of ascorbic acid. Alocasia contains all the essential micro- and macro-mineral nutrients (Basu et al. 2014). Traditionally, it has been used as an antioxidant, anti-inflammatory, anti-cancer, and antipyretic. The presence of many essential components in alocasia provides excellent scope for expanding its cultivation.

Taro *(Colocasia esculenta)*

Taro is an edible tuber crop that is mainly distributed in the tropical and subtropical world. It is one of the traditional tuber crops with enormous traditional properties (Aditka et al., 2021). Corm is the

principal edible part, but leaves and stems are also edible. It has high dietary fibre, carbohydrates, minerals, and vitamins, which make it a nutritionally balanced tuber crop. Protein content is also slightly higher than most of the tuber crops. The carbohydrate content in taro is form-resistant, mainly starch, and it releases sugar slowly compared to other major tuber crops. Taro is rich in mucilage and has very small starch granules, making it naturally digestible. Due to their high digestibility, several foods are prepared for babies by adding post-value to taro crops. The commercial aspects of this tuber crop are very high due to the presence of several nutrients and compounds that are amenable to processing.

Table 2. Nutritional composition of minor tuber crops

Minor tuber crops	Winged Beans	Alocasia	Taro
(Proximate composition)			
Protein (gm)	2.9	2.2	1.5
Energy (kcal)	49	102	128.97
Carbohydrates (gm)	5.8	22.5	27.1
Fats (gm)	0.2	0.1	0.2
(Minerals)			
Ca (mg)	63	16.06	43
P (mg)	37		84
Na (mg)	3	2.10	11
K (mg)	103.8		591
Fe (mg)	1.5		
(Vitamins)			3.75
Vit. A (IU)	128		4
Vit B6	0.113		0.283
Riboflavin	0.100		0.025
Thiamin	0.140		0.095
Ascorbic acid	14.5	3.14	4.5

Conclusion

With an ever-growing population under climate change conditions, root and tuber crops are significant for feeding the world population. Diversity in tuber crops has led to their cultivation in large parts of the tropical world. Nutritional and livelihood security in the developing and underdeveloped worlds could be achieved to a great extent by exploiting the tuber crops. Characterization of tuber crops for nutritional composition, including the presence of vital bioactive compounds, could lead to the development of these crops as functional foods. Post-processing and value addition will further expand its scope for commercialization and trade. A suitable package of practices and the adoption of high-yielding location-specific varieties could enhance the productivity and profitability of root and tuber crops.

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