Environment and Ecology 42 (4B) : 1793—1800, October—December 2024
Article DOI: https://doi.org/10.60151/envec/FTOZ8778
ISSN 0970-0420

A Review of Tropical Root and Tuber Crops for Livelihood Security and Nutrition

J. Suresh Kumar, S. Sunitha, Namrata A. Giri

Received 12 January 2024, Accepted 7 November 2024, Published on 29 November 2024

ABSTRACT

Root and tuber crops (RTCs) are an essential source of food for many developing and underdeveloped countries, providing a substantial part of the world's food supply. With the global population projected to reach 9.8 billion by 2050, the importance of RTCs is likely to increase. These crops are not only a cheap source of food and energy but also exhibit high biological efficiency and can withstand biotic and abiotic challenges. RTCs namely sweet potato, cassava, yams, and taro are rich in nutrients. The bioactive compounds present in these crops have been shown to have medicinal properties. The glutin free, and low glycemic indices of RTCs make them suitable foods for celiac and diabetic patients. These crops are able to grow under different climatic conditions and fit well with different cropping systems for year-round production and employment generation in lower economic populace. This review highlights the importance of RTCs as a sustainable food and industrial corps and their potential to alleviate malnutrition and improve public health.

Keywords Biofuel, Food security, Health, Nutrition, Tuber crops.

INTRODUCTION

Root and tuber crops (RTCs) are becoming important sources of food for developing and underdeveloped countries (Ugwu 2009). RTCs provide a substantial part of the world's food supply and are processed products for human consumption and industrial use. The present world population is increasing and expected to reach 9.8 billion by 2050 (Anonymous 2019). It appears that there is movement toward a global food crisis due to climate vagaries and the reduced availability of land for cultivation due to urbanization (Onis *et al.* 2011). Root and tuber crops are often preferred over cereals by farmers and consumers and are important components of various programs, policies and strategies aimed at improving the economic wellbeing of rural populaces. The RTCs included sweet potato (*Ipomoea batatas* (L.) Lam.), cassava (*Manihot esculenta* Crantz.), taro (*Colocasia esculenta* (L.) Schott.), yam (*Dioscorea* spp.), elephant foot yam (Amorphophallus paeoniifolius (Dennst.) Nicolson), yam bean [*Pachyrrhizus erosus* (L.) Urb.], and arrowroot (*Maranta arundinaceae*

Dr J. Suresh Kumar[1]*, Dr S. Sunitha[2], Dr Namrata A. Giri[3]

[1]Scientist, Vegetable Science, [2]Principal Scientist, Agronomy, [1,2] Division of Crop Production, ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram 695017, Kerala, India

[3]Scientist, Food Technology
ICAR- Directorate of Pomegranate, NH-65, Solapur-Pune Highway, PO, Kegaon, Maharashtra 413255 (formerly with ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram 695017, Kerala, India

Email: sureshkumar.jabu@gmail.com
*Corresponding author

L.). Some RTCs store edible starch in subterranean stems and roots. Edible portions of yams (*Dioscorea* spp.) are tubers, whereas taro (*Colocasia esculenta* (L.) Schott.) and the cocoyams *Xanthosoma sagittifolium* (L.) Schott are derived from corms, cormels, underground stems and swollen hypocotyls, leaves. Cassava and sweet potato are storage roots and canna (*Canna edulis* Ker-Gawler/*Canna indica* L.) and arrowroots are edible rhizomes. All these plants can be propagated vegetatively by tubers (yam), stem cuttings (cassava), vine cuttings (sweet potato) and side shoots, stolons, corms and cormels (taro and cocoyam). RTCs constitute a cheap source of food and energy and are capable of withstand biotic and abiotic challenges. Cassava and greater yam plants are resistant to drought and high temperature (Nedunchezhiyan *et al.* 2012), and taro has flood tolerance. Sweet potato can tolerate flash floods and mid-season drought and is considered 'famine relief crop'crops' (Mukhopadhyay *et al.* 2011). Root and tuber crops are rich in minerals and vitamins. Elephant foot yam and taro are rich in P and Ca (Lenka and Nedunchezhiyan 2013). Nutritionally rich (β-carotene, anthocyanin) sweet potatoes can alleviate malnutrition (Mukhopadhyay *et al.* 2011, Mitra 2012, Nedunchezhiyan *et al*. 2013). RTCs are rich in nutrients, have high biological efficiency and exhibit the highest rate of dry matter production per day per unit area (Nedunchezhiyan and Misra 2013). Edible energy production is estimated to be 152 mega joules ha^{-1} day^{-1} for sweet potato, 121 mega joules ha^{-1} day^{-1} for cassava and 182 mega joules ha^{-1} day^{-1} for yam; these values are comparable to those for row crops (Edison 2006).

RTCs have extensive ecological adaptability and can be cultivated on marginal lands, grow in different seasons and fit in multiple cropping systems for year-round production (Nedunchezhiyan *et al.* 2018). Most root crops are tolerant to cyclones and resistant to mid-season drought (Archana and Ravi 2016). Sweet potato has also played an important role in recovery following disasters on the Pacific Islands during two cyclone hits and during famine following droughts in Papua New Guinea (Green 2005).

RTCs production status

Root and tuber crops are cultivated throughout the world, especially in Africa and Asia. Cassava is grown for industrial starch production and consumption. The global production of cassava is 26.34 million hectares, with a production of 291.99 million tonnes. The world production of sweet potato is 112.84 million tons from 9.20 million hectares. Taro (cocoyam) is produced on 1.72 million hectares with a production of 10.22 million tonnes. Yams were produced on 85.61 million hectares with a production of 730.19 million tonnes (FAOSTAT 2023). In India, cassava is grown on an area of 0.183 million ha, producing 6.94 million tons, and sweet potatoes are cultivated on an area of 0.11 million ha, producing 1.12 million tons. Elephant foot yam is cultivated on 0.042 million ha, producing 1.04 million tons (INDIASTAT 2023).

Ways RTCs are consumed

Cassava and sweet potato are secondary staples for a large number of people. Cassava is consumed cooked, flakes, cassava flour, macaroni, fufu, composite flour and bread. Cassava is available in industrial products: starch, alcohol, glucose, acetone, dextrins, glues and pastes, binders, stabilizers, fillers, dusting agents, and sago. Elephant foot yam, greater yam and taro are used as vegetables (Nedunchezhiyan and Sankaran 2013). The use of various RTC dishes evolved from links to food habits and religious importance. Preparations of RTCs can be linked to religious beliefs where people refrain from cereals under certain conditions. Thiruvathira puzhukku, made from different tubers, was a preparation in Kerala during the Thiruvathira and Shivaratri festivals. Yams, taro and sweet potato are offered as 'bhog' (holy offering) to the lord Jagannath of Puri temple in Odisha state. The Odiya meal is incomplete without Dalmah, which has tubers as the major ingredient. Many local recipes are available for RTCs (Sunitha *et al.* 2016).

Tribes and tuber crops are interlinked. RTCs are indispensable in tribal areas, where they play a crucial role in food and nutrition. Various foods are prepared with RTCs. The Konyak tribes prepare semiprocessed taro leaf products such as Teangyakwan/Anishi (dried taro leaf cakes), Teangwan (dried taro tubers), Fluo (dried taro leaves), Shouhwan (dried taro petioles) and Teangkhoi during the harvest season, which are consumed throughout the year. These semiprocessed

taro products are stored in a wooden structure placed above an earthen stove in the kitchen. Heat and smoke during cooking prevent spoilage (Sethuraman *et al.* 2013). Local foods are made from boiled cassava tubers, fresh colocasia leaves and water snails, fresh colocasia leaves, fresh yam tubers, swamp taro stolons, elephant foot yam corms, colocasia cormels, and elephant foot yam corms (Namrata *et al.* 2020). Many traditional methods have been used for the preparation of cassava products (gari, fufu, fuku, chickwangue, ntuka, moteke) in Central and West Africa (Oke 1983). Worldwide, different cuisines are made with tropical tuber crops.

RTC nutritional status and health benefits

Nutritionally, roots and tubers have the potential to provide sources of dietary energy in the form of carbohydrates (Table 1). The nutritional value of RTC varies with variety, location, soil type, and agricultural practices.

Table 1. Nutritional composition of major tuber crops (Sunitha *et al.* 2018).

Nutrients (per 100 g)	Sweet potato (raw)	Cassava (raw)	Yam (raw)
Proximate composition			
Energy (kcal)	86.0	160.0	118.0
Protein (g)	1.6	1.4	1.5
Total lipid (fat) (g)	0.1	0.3	0.2
Carbohydrate (g)	20.1	38.1	27.9
Fibre, total dietary (g)	3.0	1.8	4.1
Sugars, total (g)	4.2	1.7	0.5
Minerals			
Calcium- Ca (mg)	30	16	17
Magnesium- Mg (mg)	25	21	21
Potassium- K (mg)	337	271	816
Phosphorus- P (mg)	47	27	55
Sodium- Na (mg)	55	14	09
Vitamins			
Total ascorbic acid (mg)	2.40	20.60	17.10
Thiamine (mg)	0.08	0.09	0.11
Riboflavin (mg)	0.06	0.05	0.03
Niacin (mg)	0.56	0.85	0.55
Vitamin B-6 (mg)	0.209	0.088	0.293
Folate (µg -DFE)	11	27	23
Vitamin E (mg)	0.26	0.19	0.35
Vitamin K (µg)	1.8	1.9	2.3
Vitamin A (International Unit)	14187	13	138

Starchy roots and tuber crops provide antioxidative, hypoglycemic, hypocholesterolemic, antimicrobial, and immunomodulatory activities, which are likely due to the bioactive constituents phenolic compounds, saponins, bioactive proteins, glycoalkaloids, and phytic acids. Phytochemicals have demonstrated anticancer effects in carcinoma cell lines and animal models (Chandrasekara and Kumar 2016). The glycemic indices of many tuber crops are lower than those of other crops, and these crops are good for consumption by diabetic patients (Namrata *et al.* 2020).

Approximately 15 million consumers worldwide suffer from CD (Reilly and Green 2012). Tropical tuber crop flour is suitable for the preparation of food for celiac patients (Rekha and Padmaja 2002). Ingestion of gluten by celiac patients leads to damage of microvilli in the small intestine, leading to cramping, bloating, diarrhea, weight loss, and vitamin and mineral deficiencies (Green and Cellier 2007). The consumption of a gluten-free diet as a lifelong strategy is the only treatment for celiac disease, as trace amounts of gluten can trigger immune responses (Rubio-Tapia and Murray 2010). Tropical tuber crops can be potential sources of antioxidants.

Sweet potato

Sweet potatoes have anti-inflammatory properties primarily due to the presence of β-carotene, anthocyanins, vitamin C and magnesium. The roots of yellow and orange sweet potato varieties contain high amounts of β-carotenes (a precursor of vitamin A, Mitra 2012), and purple varieties are rich in anthocyanins. β-Carotenes and anthocyanins may exert antioxidative effects when consumed and reduce oxidative stress and inflammation. These compounds possess potential suppressive anticancer activities and promote immunity (Chandrasekara and Kumar 2016). Anthocyanin-enriched sweet potato may protect against colorectal cancer due to its antiproliferative effects (Lim *et al.* 2013). A single serving of 100-150 grams of boiled orange-fleshed sweet potatoes provides the recommended daily intake of vitamin A, helping to prevent blindness in young children. The

nutrients in sweet potato plants are immune system boosters. The glycemic index of sweet potato is low, and sweet potato is recommended for use in diabetic patients (Dahl and Stewart 2015). A reduction in plasma glucose levels in diabetic patients occurs with extracts of sweet potato peel (Ludvik *et al.* 2002). Sweet potato peels possess a potent wound healing factor (Panda and Sonkamble 2011).

Cassava

Cassava plays an important role as staple foods for more than 500 million people worldwide due to its high carbohydrate content (Blagbrough *et al.* 2010). Eighty percent of the carbohydrates produced are starch (Mabrouk and Sharkawy 2012). Cassava provides approximately 45% of all calories consumed in Africa and approximately 70% of the daily caloric intake of more than 50 million Nigerians (Nanbol and Namo 2019). The bioactive compounds (cyanogenic glucosides) reported in cassava roots (Blagbrough *et al.* 2010). Cassava boosts energy level, ensures healthy weight gain, help prevent Alzheimer's disease and cardiovascular diseases, are useful for muscle growth and development, and maintain optimal blood pressure (Chandrasekara and Kumar 2016). The fiber content of cassava leaves is higher than the fiber content of legumes and leafy legumes and ranges between 1 and 10 g/100 g FW (fresh weight). The rich fiber of cassava may assist intestinal peristalsis and bolus progression (Montagnac *et al.* 2009). It is estimated that 228 million children are affected and that 500,000 children become partially or totally blind every year as a result of vitamin A deficiency. β- carotene rich orange fleshed cassava is considered an important biofortified crop in many countries for alleviating vitamin A malnutrition (Tanumihardjo *et al*. 2008). Cassava is considered "all sufficient" because people get "bread" from their roots and "meat" from their leaves (Achidi *et al.* 2008). In the Congo, tropical African countries, cassava leaves constitute more than 60% of all vegetables consumed (Latif and Muller 2015). Cassava leaves (as a rich source of vitamins and minerals) are consumed by pregnant women to increase breast milk production (Aregheore 2012). Multimistura, a food supplement, was developed in Brazil to combat malnutrition, particularly among pregnant women and children, using cassava leaf powder as a key ingredient (Camara and Madruga 2001). After efficient and economical detoxification, cassava leaves can provide a source of safe and nutritional food for many people (Latif and Muller 2015).

Taro and Cocoyam

Cocoyams are among the world's most important root and tuber crops. It was domesticated in Oceania, Africa and Asia, providing sustenance for more than 400 million people (Vaneker and Slaats 2013). Taro has medicinal properties decreases the risk of developing diabetes, lung and oral cancer (Alminda and Umar 2018). Taro leaves are rich in nutrients. Taro leaves are high in calcium, phosphorus, potassium, carotene, folic acid and vitamin C, as well as iron, thiamine, riboflavin, and niacin. A one cup serving of cooked taro leaves provides 57% of the daily value (DV) of vitamin C, 34% of the DV of vitamin A, 14% of the DV of potassium, 13% of the DV of calcium, and 10% of the DV of iron (Lattimer and Haub 2010). Taro and cocoyam possess oxalates, which can cause an unpleasant taste or irritation when consumed raw. To eliminate this issue, traditional cooking methods typically involve heat-based techniques such as boiling, baking, roasting, or frying to break down the calcium oxalate crystals (Opara 2003).

Yams (*Dioscorea* spp.)

Yams are valuable sources of carbohydrates, fiber and low fat, which makes them good dietary sources. Yam is considered to be the most nutritious crop among tropical root crops. It comprises approximately four times more protein than cassava is, and it is the only main root crop that exceeds the major staple food crop rice in terms of protein content in proportion to consumable energy (Nedunchezhiyan and Misra 2013). Yam tubers contain the bioactive compounds mucin, dioscin, dioscorin (Bhandari *et al*. 2003). The mucilage of yam tubers contains soluble glycoproteins and dietary fiber. Yam extracts have hypoglycemic, antimicrobial, and antioxidant activities (Chan *et al.* 2004). Several species of yams also have medicinal properties, and the tuber is said to contain some pharmacologically active substances. Yams have a lower glycemic index (<55 GI value), yams stimulate digestive enzyme activities in the small intestine

(Chen *et al*. 2003). Yam tubers posses immunomodulatory effects. Diosgenin, a steroidal saponin of yam (Dioscorea), has been shown to have antioxidative and hypolipidaemic affects in vivo (Son *et al.* 2007). Yam saponins have ability to inhibit cholesterol absorption (Ma *et al*. 2002). Yam has been linked to a reduced risk of cancer and cardiovascular disease in postmenopausal women (Wu *et al*. 2005). Daily consumption of Dioscorea may enhance bone strength and promote bone remodelling and osteoporosis during menopause (Chen *et al.* 2008).

Elephant foot yam

Elephant foot yam is a highly nutritive vegetable and contains 78.7 g of moisture, 1.2 g of protein, 0.1 g of fat, 18.4 g of carbohydrates, 0.8 g of minerals (major elements: 50 mg of calcium, 34 mg of phosphorous and 0.6 mg of iron), 0.8 g of crude fiber and 79 kcal/100 g of energy from the edible portion (Gopalan *et al.* 1999). Corms used for preparation of different cuisines and is reported to have anti-inflammatory activity (Dey *et al.* 2016c). The corms contain flavonoids and alkaloids (Suresh *et al.* 2019). The tubers possess different medicinal properties (Dey *et al.* 2016a). The tubers have gastrokinetic (Dey *et al.* 2016b), anticolitic (Dey *et al.* 2016c), analgesic (Shilpi *et al.* 2005), CNS depressant (Das *et al.* 2009), anti-inflammatory (De *et al*. 2010), cytotoxic activity (Angayarkanni *et al*. 2007), and antibacterial, antifungal and cytotoxic effects (Khan *et al*. 2008).

Livelihood security through RTCs

RTCs are climate-resilient crops that can produce good yields under less than optimal weather conditions. They are capable of utilizing available resources more efficiently, especially in partial sunlight and residual moisture. Great flexibility in planting and harvesting are additional characteristics of these crops that are suitable for inclusion in different farming systems (Nedunchezhiyan and Misra 2013, Nedunchezhiyan *et al.* 2018). Tubers crops, as main crops or inter/mixed crops, have the unique advantage of adapting to various cropping or farming systems. Farm family income can be increased 2- to 3-fold (Nedunchezhiyan *et al.* 2018, Sunitha *et al.* 2019). Under rainfed farming, tuber crop-based integrated farming increased farm family income with an increase in employment generation from 235 to 365 days ha^{-1} $year^{-1}$ (Sunitha *et al.* 2019). Farm family income was doubled with the tuber crop-based farming system model (Sunitha *et al.* 2019). In Africa, RTCs are grown in tree crop or cereal-root crop mixed farming systems. On the southern side, plants were wetter due to the tree crop farming system, and on the northern side, they were drier due to the cereal-root crop mixed farming system. The global root and tuber crop farming system covers approximately 236 million hectares, supporting population of around 112 million people (Kassam *et al.* 2020). An advantage of RTCs is that they can be safely stored for 3-4 months in soil and consumed when other foods are scarce. The nutritive value of tuber crops also makes them invaluable, especially in resource-constrained regions.

Industrial value of tuber crops

Tropical countries are dependent mainly on root tuber crops, where row crops do not flourish. These countries completely depend on imported wheat, which leads to increased costs of wheat and puts financial pressure on poor people. Therefore, there is a need to examine the opportunity to substitute wheat flour with flour from comparatively low-priced and easy-to-produce root tubers, such as cassava, yams and sweet potato. Composite flour blends offer a potential solution to reduce reliance on imported wheat demand for the production of pasta, noodles, bread, cookies, which otherwise depend on wheat flour. Research has consistently demonstrated that wheat flour can be substituted with up to 20% root tuber flour without changing the nutritive and sensory value of the products. (Dhaka and Sangeetha 2017).

Tuber crops are processed into different industrial products in various parts of the world. The bulk of cassava and yams in Africa and Latin America are processed into fermented foods and food additives. Sweet potatoes can be fermented into various products like soy sauce, vinegar, lacto juices, lacto pickles and sochia (a 25% alcoholic drink popular in Japan). These fermented food products are predominantly functional foods, boasting a rich profile of phytochemicals, dietary fiber, antioxidant compounds, and probiotic components.

Today, starch-based bioplastics dominate 66% of the global bioplastics market. Biodegradable plastic production from cassava starch is becoming very popular due to the advantage of its environmentally friendly nature (Mulyono *et al*. 2015). The films produced from cassava starch have a biodegradability of 41.27%, whereas polythene and paper have biodegradability of 10.33% and 85.99%, respectively, additionally, the films have a tensile strength of 24.87 N/mm2 compared to 10.86 N/mm2 and 8.29 N/mm2 for polythene and paper, respectively (Ezeoha and Ezenwanne 2013). Cassava flour is a popular biopolymer for food packaging due to its unique attributes: non-toxic, biodegradable, biocompatible, cost-effective, and sustainably sourced in abundance, making it an attractive solution for eco-friendly packaging (Mulyono *et al.* 2015). Cassava-based superabsorbent polymers absorb and release water slowly, making them an eco-friendly alternative to synthetic polymers. They can be used as water reservoirs, releasing water to plant roots as needed. When added to soil, these hydrogels improve soil structure, increasing water holding capacity and porosity, and enhance nutrient levels and organic carbon content (Parvathy *et al.* 2013). Natural resources from soil, such as petroleum, are depleted and cause additional harm to the environment. Biodiesel products from plants are an alternative to petroleum and have less environmental impact. Cassava has been found to produce significantly higher yields of bioethanol than other major crops, including sugarcane, maize, and sweet sorghum, making it a promising feedstock for biofuel production (Jansson *et al*. 2009).

Summary

RTCs are important dietary components for humans. A variety of foods can be prepared using tubers and leaves, type and usage vary with country and region. In addition to their main role as energy contributors, they provide a number of desirable nutritional and health benefits. They are able to grow under different climatic conditions and fit well with different cropping systems and home stead gardens for year-round production and employment generation for social uplift of economically weaker sections. Tubers may serve as functional foods and nutraceutical ingredients to relieve noncommunicable chronic diseases and maintain wellness.

REFERENCES

Achidi AU, Ajayi OA, Maziya DB, Bokanga M (2008) The effect of processing on the nutrient content of cassava (*Manihot esculenta* Crantz) leaves. *Journal of Food Processing and Preservation* 32(3): 486-502.

Alminda MF, Umar M (2018) A review on root crops processing for food security and health. *J South Pacific Agric* 21: 26-33.

Angayarkanni J, Ramkumar KM, Poornima T, Priyadarshini U (2007) Cytotoxic activity of *Amorphophallus paeoniifolius* tuber extracts *in vitro. Am-Eurasian J Agric Environ Sci* 2(4): 395-398.

Anonymous (2019) UN World population prospects, 17 June 2019, United Nations, New York. https://www.un.org/development/desa/en/.

Archana M, Ravi V (2016) Scientists learn 'sweet' lesson from cyclone. Deccan Chronicle, 14 May 2016. https://www.deccanchronicle.com/science/science/140516/scientists-learn-sweet-lesson-from-cyclone.html.

Aregheore EM (2012) Nutritive value and inherent anti-nutritive factors in four indigenous edible leafy vegetables in human nutrition in Nigeria: A review. *Journal of Food Resource Science* 1(1): 1-14. https://doi.org/10.3923/jfrs.2012.1.14

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

Blagbrough IS, Bayoumi SAL, Rowan MG, Beeching JR (2010) Cassava: An appraisal of its phytochemistry and its biotechno logical prospects - Review. *Phytochemistry* 71(17-18): 1940-1951.

Camara FS, Madruga MS (2001) Cyanic acid, phytic acid, total tannin and aflatoxin contents of a Brazilian (Natal) multimistura preparation. *Braz J Nutr* 14(1): 33-36. http://dx.doi.or/10.1590/S1415-52732001000100005.

Chan YC, Hsu CK, Wang MF, Su TY (2004) A diet containing yam reduces the cognitive deterioration and brain lipid peroxidation in mice with senescence accelerated. *International Journal of Food Science & Technology* 39(1): 99-107.

Chandrasekara A, Kumar TJ (2016) Roots and tuber crops as functional foods: A review on phytochemical constituents and their potential health benefits. *International Journal of Food Science* 16: 1-15. https://doi.org/10.1155/2016/3631647.

Chen HL, Wang CH, Chang CT, Wang TC (2003) Effects of Taiwanese yam (*Dioscorea japonica* Thunb var. *pseudojaponica* Yamamoto) on upper gut function and lipid metabolism in Balbic mice. Nutrition 19(7-8): 646-651.

Chen JH, Wu JSS, Lin HC, Wu SL, Wang WF, Huang SK, Ho YJ (2008) Dioscorea improves the morphometric and mechanical properties of bone in ovariectomised rats. *Journal of the Science of Food and Agriculture* 88(15): 2700-2706. https://doi.org/10.1002/jsfa.3396

Dahl WJ, Stewart ML (2015) Position of the Academy of Nutrition and Dietetics: Health implications of dietary fiber. *J Acad Nutr Diet* https://doi.org/10.1016/j.jand. 2015.09.003.

Das SS, Sen M, Dey YN, De S, Ghosh AK (2009) Effects of petroleum ether extract of *Amorphophallus paeoniifolius* tuber on central nervous system in mice. *Indian Journal of Pharmaceutical Sciences* 71(6): 651-655.

De S, Dey YN, Ghosh AK (2010) Anti-inflammatory activity of methanolic extract of Amorphophallus paeoniifolius and its possible mechanism. *International Journal of Pharma and Bio Sciences* 1(3): 1-8.

Dey YN, Sharma G, Wanjari MM, Kumar D, Lomash V, Jadhav A D (2016c) Beneficial effect of *Amorphophallus paeoniifolius* tuber on experimental ulcerative colitis in rats. *Pharmaceutical Biology* 55(1): 53-62. https://doi.org/10.1080/13880209.2016.1226904.

Dey YN, Mahor S, Kumar D, Wanjari M, Gaidhani S, Jadhav A (2016b) Gastrokinetic activity of *Amorphophallus paeoniifolius* tuber in rats. *J Intercult Ethnopharmacol* 5(1): 36-42.

Dey YN, Wanjari MM, Kumar D, Lomash V, Jadhav AD (2016a) Curative effect of *Amorphophallus paeoniifolius* tuber on experimental hemorrhoids in rats. *Journal of Ethnopharma cology* 192: 183-191.

Dhaka RK, Sangeetha N (2017) Physico-chemical and baking properties of wheat-sweet potato composite flour. International *Journal of Chemical Studies* 5(3): 671-674.

Edison S (2006) Status of tropical tuber crops production, utilization and marketing in India. 14th Triennial Symposium of International Society for Tropical Root Crops, 20-26 Nov. 2006. Indian Council of Agricultural Research-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India.

Ezeoha SL, Ezenwanne JN (2013) Production of biodegradable plastic packaging film from cassava starch. *Journal of Engineering* 3(10): 2250-3021. https://doi.org/10.9790/3021-031051420.

FAOSTAT (2023) https://www.fao.org/faostat/en/. Accessed on 03 September 2023.

Gopalan C, Sastri V, Balasubramanium SC, Rao BSN, Dosthale YG, Pant KC (1999) Nutritive value of Indian foods. Indian Council of Medical Research Technological Bulletin. National Institute of Nutrition, Hyderabad, India.

Green PHR, Cellier C (2007) Coeliac disease. *New England Journal of Medicine* 357: 1731-1743.

Green RC (2005) Sweet potato transfers in Polynesian prehistory. In: C Ballard (eds).The Sweet Potato in Oceania: A reappraisal. University of Pittsburgh, Pittsburg, PA, and University of Sydney, Sydney, Australia, pp 43–62

INDIASTAT (2023) Selected statewise area, production, and productivity of tapioca, sweet potato in India (2021-2022). https://www.indiastat.com/data/agriculture. Accessed on 03 September 2023.

Jansson C, Westerbergh A, Zhang J, Hu X, Sun C (2009) Cassava, a potential biofuel crop in (the) People's Republic of China. *Applied Energy* 86(1): 595-599.

Kassam A, Kueneman E, Lott R, Friedrich T, Lutaladio N, Norman D, Bwalya M, Poisot AS, Mkomwa S (2020) The cereal-root crop mixed farming system: a potential bread basket transitioning to sustainable intensification, In: Dixon JJ, P G Dennis, B Jean-Marc, O Timothy, A Tilahun, A Christopher, L Rosemary, M George (eds). Farming Systems and Food Security in Africa: Priorities for science and policy under global change. Routledge, London. p. 214-247. https://doi.org/10.4324/9781315658841.

Khan A, Rahman M, Islam MS (2008) Antibacterial, antifungal and cytotoxic activities of amblyone isolated from *Amorphophallus campanulatus. Indian Journal of Pharmacology.* 40(1): 41-44.

Latif S, Muller J (2015) Potential of cassava leaves in human nutrition: A review. Trends in Food Science & Technology 44(2)147-158. https://doi.org/10.1016/j.tifs.2015.04.006.

Lattimer JM, Haub MD (2010) Effects of dietary fibre and its components on metabolic health. *Nutrients* 2(12): 1266-1289. https://doi.org/10.3390/nu2121266.

Lenka A, Nedunchezhiyan M (2013) Biochemical composition of two edible aroids. E-planet 10(2): 39-42.

Lim S, Xu J, Kim J, Chen TY, Su X, Standard J, Carey E, Griffin J, Herndon B, Katz B, Tomich J, Wang W(2013) Role of anthocyanin - enriched purple-fleshed sweet potato p40 in colorectal cancer prevention. *Molecular Nutrition & Food Research* 57: 1908-1919. https://doi.org/10.1002/mnfr.201300040.

Ludvik BH, Mahdjoobian K, Waldhaeusl W, Hofer A, Prager R, Kautzky WA, Pacini G (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. https://doi.org/10.2337/diacare.25.1.239. PMID: 11772921.

Mabrouk A, El-Sharkawy (2012) Stress tolerant cassava: The role of integrative ecophysiology-breeding research in crop improvement. *Journal of Soil Science* 2: 162-186. https://doi.org/10.4236/ojss.2012.22022.

Ma HY, Zhao ZT, Wang LJ, WangY, Zhou QL, Wang BX (2002) Comparative study on anti-hypercholesterolemia activity of diosgenin and total saponin of *Dioscorea panthaica. China J Chinese Mater Med* 27(7): 528-531.

Mitra S (2012) Nutritional status of orange fleshed sweet pota toes in alleviating Vitamin A malnutrition through a food based approach. Journal of Nutrition & Food Sciences 2(8): 1-3. https://doi.org/10.4172/2155-9600.1000160.

Montagnac JA, Davis CR, Tanumihardjo SA (2009) Nutritional value of Cassava for use as a staple food and recent advances for improvement. *Comprehensive Reviews in Food Science and Food Safety* 8(3): 181-194. https://doi.org/10.1111/j.1541-4337.2009.00077.x.

Mukhopadhyay SK, Chattopadhyay A, Chakraborty I, Bhattacharya I (2011) Crops that feed the world 5, Sweetpotato. Sweetpotatoes for income and food security. *J Food Secur* 3: 283-305.

Mulyono N, Suhartono MT, Angelina S (2015) Development of bioplastic based on cassava flour and its starch derivatives for food packaging. *Journal of Harmonized Research in Applied Sciences* 3(2): 125-132.

Namrata AG, Sanket JM, Murgesan P, Laxminarayan K, Visalakshi C, Suresh KJ, Sethuraman PS (2020) Tuber crops based traditional food recipes of Tripura. Technical Bulletin No. 79. Indian Council of Agricultural Research - Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India.

Nanbol KK, Namo OAT (2019) The contribution of root and tuber crops to food Security: A review. *Journal of Agricul tural Science and Technology* B 9: 221-233 https://doi.org/10.17265/2161-6264/2019.04.001.

Nedunchezhiyan M, Byju G, Ravi V (2012) Photosynthesis, dry matter production and partitioning in cassava (*Manihot esculenta* Crantz) under partial shade of a coconut plantation. *Jounal of Root Crops* 38(2): 12-20.

Nedunchezhiyan M, George J, Sunitha S, Suresh KJ (2018) Tuber crops based integrated farming systems, technical bulletin

No. 69, Indian Council of Agricultural Research - All India Coordinated Research Project on Tuber Crops, Indian Council of Agricultural Research - Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India.

Nedunchezhiyan M, Sankaran M (2013) Cormels and minicorm sett techniques for seed corm production in *Amorphophallus. Aroideana* 36: 36-145.

Nedunchezhiyan M, Misra RS (2013) Tropical tuber crops: Production and value addition. TSP Series-1, Regional Centre, Central Tuber Crops Research Institute, Indian Council of Agricultural Research, Bhubaneswar- 751019, Idisha, pp 56.

Nedunchezhiyan M, Misra RS, Mukherjee A, Sivakumar PS (2013) Livelihood security through tubers. *Indian J Hortic* 58(3):37-38.

Oke OL (1983) Processing and detoxification of cassava. In: F Delange, R Ahluwalia (eds). Cassava toxicity and thyroid: Research and public health issues. International Development Research Centre, Ottawa, Canada, pp 129-133.

Onis MD, Blossne M, Borghi E (2011) Prevalence and trends of stunting among preschool children, 1990-2020. Public Health Nutrition 15(1): 142-148. https://doi.org/10.1017/S1368980011001315.

Opara L (2003) Edible aroids: Postharvest operations. Food and Agriculture Organization of the United Nations, Rome, Italy.

Panda V, Sonkamble M (2011) Anti-ulcer activity of *Ipomoea batatas* tubers (sweet potato). *Functional Foods in Health and Disease* 2(3): 48-61.

Parvathy PC, Jyothi AN, Susan JK, Sreekumar J (2013) Cassava starch based superabsorbent polymer as soil conditioner: Impact on soil physico-chemical and biological properties and plant growth. *Clean Soil Air Water* 42(11): 1610-1617. https://doi.org/10.1002/clen.201300143.

Reilly NR, Green PHR (2012) Epidemiology and clinical presen tations of celiac disease. *Semin Immunopathol*. 34(4): 473-478. https://doi.org/10.1007/s00281-012-0311-2.

Rekha MR, Padmaja G (2002) Alpha-amylase inhibitor changes during processing of sweet potato and taro tubers. *Plant Foods for Human Nutrition* 57(3-4): 285-294.

Rubio-Tapia A, Murray JA (2010) Coeliac disease. *Current Opinion in Gastroenterology* 26: 116-122.

Sethuraman SK, Anantharaman M, Thirugananavel A, Ramanathan S, Punitha P (2013) Traditional Tuber Crops Food of North Eastern India. Indian Council of Agricultural Research-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India.

Shilpi JA, Ray PK, Sarder MM, Uddin SJ (2005) Analgesic activity of *Amorphophallus paeoniifolius* tuber. *Fitoterpia* 76(3-4): 367-369.

Son IS, Kim JH, Sohn HY, Son KH, Kim JS (2007) Antioxidative and hypolipidemic effects of diosgenin, a steroidal saponin of yam (*Dioscore*a spp.) on high-cholesterol fed rats. *Bioscience Biotechnology & Biochemistry* 71(12): 3063-3071.

Sunitha S, George J, Namrata AJ (2016) Tuber Crops recipes in India. All India Coordinated Research Project on Tuber Crops. Indian Council of Agricultural Research-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India.

Sunitha S, George J, Sheela MN, Suresh KJ, Mukherjee A (2018) Tuber crops varieties released/recommended for release by AICRP on Tuber Crops over five decades, technical bulletin number 71. Indian Council of Agricultural Research - All India Coordinated Research Project on TuberCrops, Indian Council of Agricultural Research -Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India.

Sunitha S, Suresh KJ, Ravi V (2019) Farming system studies in North East region and tribal areas. Annual Report 2018-2019, All India Coordinated Research Project on Tuber Crops, Thiruvananthapuram, India.

Sunitha S, KJ Suresh, V Ravi (2020) Farming system studies in North East region and tribal areas. Annual Report 2019- 2020, All India Coordinated Research Project on Tuber crops, Thiruvananthapuram, India.

Suresh KJ, Sanket JM, Byju G, Sunitha S, Veena SS, Nedunchezhiyan M, Ravi V (2019) Effect of new generation herbicides on weed management, corm yield and economics of elephant foot yam [*Amorphophallus paeoniifoliu*s (Dennst.) Nicolson]. *International Journal of Chemical Studies* 7(3): 1213-1218.

Tanumihardjo SA, Bouis H, Hotz C, Meenakshi JV, Clafferty BM (2008) Biofortification of staple crops: An emerging strategy to combat hidden hunger. *Comprehensive Reviews in Food Science and Food Safety* 7: 329-334.

Ugwu FM (2009) The potentials of roots and tubers as weaning foods. *Pakistan Journal of Nutrition.* 8(10): 1701-1705.

Vaneker K, Slaats E (2013) Mapping edible Aroids. *Iridescent Icograda*. 3:34-45.

Wu WH, Liu LY, Chung CJ, Jou HJ, Wang TA (2005) Estrogenic effect of yam ingestion in healthy postmenopausal women. *Journal of the American College of Nutrition* 24(4): 235-243.