

Status, diversity and potential of indigenous tropical tuber vegetables

Tropical tuber crops are important group of crop species which produce tubers that are used for human food and animal feed. The popular tropical tuber crops include cassava, sweet potato, greater yam, white yam, lesser yam, taro, tannia, elephant foot yam, yam bean, coleus etc. The root and tuber crops play an important roles in feeding large number of population in developing countries. They contribute substantial amount of cheap energy coupled with high quality nutrition for more than 2 million people living in developing countries. Tropical tuber crops are rich source of energy and carbohydrates although each of them also provides other important nutrients as well. They contribute 3.9% (cassava 1.9%, sweet potato 1.5% and yams and other root and tuber crops 0.3%) energy requirement of world population. Tropical tuber crops supply 28.5 kg/head/year food and 75 kcal energy/head/day. They produce large quantities of energy (carbohydrate) in relatively less time than other crops. They are most efficient in converting solar energy, for example cassava produces 250×10^3 kcal/ha and sweet potato 240×10^3 kcal/ha as compared to 76×10^3 kcal/ha for rice, 110×10^3 kcal/ha for wheat and 200×10^3 kcal/ha for maize.

TARO (*Colocasia esculenta*) was originated in India, most probably in North Eastern region. It spread by cultivation eastward into Southeast Asia, East Asia and the Pacific Islands; westward to Egypt and the eastern Mediterranean Basin; and then southward and westward from there into East Africa and West Africa, where it spread to the Caribbean and Americas. Today the plant is widely used throughout the world, in Africa, Asia, the West Indies, and South America. Taro is of great importance in many places such as the Caribbean, Hawaii, the Solomons, American Samoa, Western Samoa, the Philippines, Fiji, Sri Lanka, India, Nigeria, Indonesia, New Hebrides, Tonga, Niue, Papua New Guinea, Egypt,

and these areas many people depend heavily upon taro as a staple food.

Status of taro cultivation

Taro is one of the oldest cultivated crops grown for its edible corms and leaves. It is an important tropical tuber crop, used as a staple food or subsistence food by millions of people in the developing countries in Asia, Africa and Central America. World-wide it is the fifth most consumed root vegetable with over 25% produced in Oceania and South-East Asia. It is widely used as a tuber vegetable in India, whereas it is the staple food and also very closely associated with culture in many of the South Pacific islands. Taro is ordinarily grown in the homestead garden and its cormels, petiole and leaves serve the important purpose as an instant vegetable. In India, it is grown in Uttar Pradesh, Madhya Pradesh, Odisha, Andhra Pradesh, West Bengal, Kerala and North Eastern region. It is called Arvi in Hindi in Central and North India, which is often pronounced as Arbi. It is also called kachu in Sanskrit. In Mizoram, it is called bal; the leaves, stalks and tubers are eaten as dawl bai. The leaves and stalks are often traditionally preserved to be eaten in dry season as “dawl rep bai”. In Assam, taro is known as “kosu”. The leaf buds called “Kosu loti” are cooked with sour dried fruits called Thekera or sometimes with tamarind or elephant apple alone or with a small amount of pulses and sometimes fish. A fried dish with sour objects is also made from its flower (Kosu kala). In Manipur, taro is known as *pan*. The kuki tribes called it bal. Boiled bal is a snack at lunch along with *chutney* or hot chili-flakes



Field view of Taro crops

besides being cooked as a main dish along with smoked or dried meat, beans, and mustard leaves. They also sun-dry the leaves and keep them for future use as broth and hodge-podge. In Himachal Pradesh, taro root is known as ghandyali, and the plant is known as Kachalu in Kangra and Mandi district. The dish called patrodu is made using taro leaves rolled with corn or gram flour and boiled in water. Another dish, puiji is made with mashed leaves and the trunk of the plant and ghandyali or taro roots are prepared as a separate dish. A tall-growing variety of taro is extensively used on the western coast of India to make patrode, patrade, or patrada, literally a “leaf-pancake”. In the Dakshin Kannada district in the state of Karnataka, it is used as a morning breakfast dish, either made like fritters or steamed. In Maharashtra, the leaves, called alu che paana, are de-veined, rolled with a paste of gram flour, tamarind paste, red chili powder, turmeric, coriander, asafoetida, and salt, and then steamed. These can be eaten whole or cut into pieces, or shallow fried and eaten as a snack known as alu chi wadi. In Goa cuisine as well as the

Konkani cuisine taro leaves are very popular. In Gujarat and Maharashtra, the leaves are used to make patra a dish with gram flour, tamarind and other spices. Sindhis call it kachaloo; they fry it, compress it, and re-fry it to make a dish called tuk which complements Sindhi curry. In Kerala, taro corms are known as chembu-kizhangu. Taro is used as a staple food, as a side dish, or as an ingredient in various side dishes like sambar. As a staple food, it is steamed and eaten with spicy chutney of green chilies, tamarind, and shallots. In Tamil Nadu and Andhra Pradesh, taro corms are known as sivapan-kizhangu (seppankilangu or cheppankilangu), chamagadda, or in coastal Andhra districts as chaama dumpa in Telugu. It can be cooked in many ways, such as deep-fried in oil for a side item with rice, or cooked in a tangy tamarind sauce with spices, onion, and tomato. In West Bengal, taro roots are thinly sliced and fried to make chips called kochu bhaja. The stem is used to cook a very tasty Kochur saag with fried hilsha fish head or boiled chhola (chickpea), often eaten as a starter with hot rice. The roots are also made into a paste with spices and eaten with rice. In the Mithilanchal region of Bihar, taro root is known as Adua and its leaves are called Adua ke patte. A curry of taro leaves is made with mustard paste and Aaml (sun-dried mango pulp used for a sour taste in daal, curry and sour gravy). In Odisha, taro root is known as saru. Dishes made of taro include saru besara (taro in mustard and garlic paste). It is also an indispensable ingredient in preparing the heart of Odia cuisine, the dalma, where vegetables are cooked with dal. In Uttarakhand and neighboring Nepal, taro is considered a healthy food cooked in a variety of ways. The delicate Gaderi taro of Kumaun, especially from the Lobanj region is much sought after. Most commonly it is boiled in tamarind water until tender, then it is diced

into cubes which are stir-fried in mustard oil with methi (fenugreek) leaves. Boiling it in salty water in iron cooking pots until it becomes like porridge, is another technique. The young leaves called gaaba, are steamed, then sun-dried and stored for later use.

Potential of Taro

Taro is a widely cultivated species of family Araceae used as vegetables for its corms, leaves, and petioles. It has good potential for food security, nutritional security and as industrial crops for employment generation and development of value added products. The corms are generally used as the main starch in meals, however, snacks are prepared from taro in numerous countries and are either sweet or salty, moist or crisp. Hawaiians traditionally use taro to make poi. Like the roots of other crops, taro corms are high in carbohydrates and low in fat and protein. Human digestibility of the raw taro starch is about to be 97% and is the same as raw potato starch. The excellent digestibility suggests efficient release of nutrients



Taro corms

during digestion and absorption of this food. Taro corms contain 0.78% of oxalic acid, however, which can bind calcium in the plant as well as in the intestinal tract and render it unavailable for nutritional utilization. Some corms contain raphides, which are needles of calcium oxalate, suggesting a high concentration of oxalate. Boiling, baking, washing, and mashing of corms would reduce the oxalate content to some extent when the corms are served as prepared food. The leaves of certain cultivars of taro that are low in oxalic acid are used for green leafy vegetables. Cultivars chosen for leafy greens vary among different countries and population groups. The old favorite in Hawaii is the cultivar Apuwai, which is still being cultivated in home gardens by older residents. Ninety-nine percent of the market variety is the cultivar Bun-Long, and since it is low in acidity, both younger and older leaves may be consumed without irritation to the mucous membrane of the mouth. The vegetable variety in India appears to be similar to Bun-Long. Taro petioles are eaten raw only in the Khasi and Jaintia Hills of North Eastern region of India. After the outer thin covering is peeled off, the young stems are cut into 1 cm pieces and mixed with pieces of lemons or limes, salt, and chili pepper. Usually the mixture is used as a snack.

Nutritional quality

The nutritional composition of taro corm like other root crops is low in protein and fat, but high in the carbohydrate. It is a good source of potassium and provides moderate level of phosphorus. It is low in vitamin C and deficient in the vitamin A. Taro corm is a good source of minerals and the small granule size of its starch helps increase the bioavailability of its nutrients

due to efficiency of digestion and absorption.

Starch: Taro corm has been reported to have 70–80% (dry weight basis) starch with small granules. Because of the small sizes (1–4 µm in diameter) of its starch granules, taro is easily digestible and as such has been reported to be used for preparing of infant foods. Taro starch, in view of its small granule size, has also been used for industrial applications. Taro starch is easily digestible, the starch grains are fine and very small, it has hypoallergenic nature (low tendency to cause allergic reactions) and also the starch is gluten free. The size of the starch granules varies with the variety and ranges from 1.5–6.6 µm. They are polygonal. Taro starch contains about 50% less amylose and an amylopectin content which is higher compared to other cereals. The amylose/amylopectin ratio is 1:7. The most important sugar in taro is sucrose, but fructose, maltose, glucose and raffinose are also present. Malic acid is the most important organic acid (60%) followed by citric acid (25%) and oxalic acid (15%).

Moisture: Since taro is a root crop, its moisture content is very high and accounts two third of the total weight of the fresh crops. Moisture content of taro varies with variety, growth condition and harvest time. In general the moisture content of taro ranges from 60–83%.

Protein: Taro contains about 11% protein on a dry weight basis. This is more than yam, cassava or sweet potato. The protein fraction is rich in essential amino acids of trionine, leucine, arganine, valine and phenylalanine. Among the essential amino acids, methionine, lycine, cystine, phenylalanine and leucine are relatively abundant in the leaf than the corm. The protein content of the corm is higher towards the corm's periphery than towards its centre. This implies that care should be taken when peeling the corm; otherwise significant amount of the protein could be lost in the peeling. Concerning the leaf, like higher plant, taro leaf is rich in protein. It contains about 23% protein on a dry weight basis.

Fat: Like many other root and tuber crops, the fat content of taro is very low and its fat content is mainly composed of the lipids of the cell membrane and it is also variable among cultivars. In general the fat content of taro root ranges from 0.3–0.6%.

Crude fibre: Taro contains both dietary and non-dietary fibre. Crude fibre content of taro ranges from 0.3–3.8%. Crude fibre has many desirable functional properties. These include facilitating alimentary functions, helping in micro-component delivery and glucose metabolism and also slowing down the process of re-absorption of undesirable dietary components such as cholesterol, decrease intestinal transit time, reduce total and LDL cholesterol in the blood.

Total ash: Taro contains fairly high amount of ash. From which it can be inferred that it has good mineral content. The ash content of taro ranges from 3.54–7.78%.

Mineral: Taro is a good source of minerals including iron (8.66–10.8 mg/100g), calcium (31–132 mg/100g), sodium (82–1521.34 mg/100g), magnesium (118–415.07 mg/100g), phosphorus (72.21–340 mg/100g), zinc (2.63 mg/100g), copper (1.04 mg/100g) and an excellent source of potassium (2271–4276.06 mg/100g).

Vitamins: Vitamin C and vitamin B complex (niacin,

riboflavin and thiamin) which are important constituents of human diet, are present in appreciable quantity in corms and leaf of taro. Cooked leaf of taro contains beta carotene, iron and folic acid which protects against anemia.

Health benefits of Taro

Phytochemicals: Taro has high amount of β-carotene in the corm and will impart vitamin A and antioxidant property in the body. β-carotene differs only very slightly in terms of structure. They have potential health benefits.

Phenolic acids: Phenolic acids are widely distributed in the plant cell walls and consequently are significant components of the human diet. Yellow-fleshed cultivar of taro is associated with a high level of total phenolic compounds.

Processed food

Taro has been processed into many products which include poi (fresh or fermented paste, canned, and canned-acidified), flour, cereal base, beverage powders, chips, sun-dried slices, grits, and drum-dried flakes. Corms may be roasted, boiled, baked, steamed, or fried. Pulverized cooked corms are mixed with corn meal to make bread in Brazil. In the Philippines, the corms are boiled as vegetables or sliced thin and fried to produce chips. Taro is popular in Hawaii as poi and as a dessert, kulolo. In Samoa, taro is made into a sweet dessert.

Industrial uses

Special features of taro starch: The most conspicuous feature of taro starch that sets it apart from the more familiar commercial starches is its particle size. The rice starch has 5 µm mean diameter is the finest of the commonly available starches, while all the taro varieties so far examined have particles between 1 and 6.5 µm.

High fructose enriched syrup (HFES): Taro and related root crops can be processed into high fructose enriched syrup. High fructose enriched syrup (HFES) is a sweetener (a liquid sugar) made from starch. HFES is a very desirable sweetener, inexpensive and easy to use. The nutritional value of HFES is similar to that of sucrose. The syrup can be used for canning, jams, jellies and in soft drinks.

Alcohols for fuel: Many developing countries could reduce their dependence on imported oil considerably by replacing part of their petroleum requirement with alcohol produced from sugar or starch-containing crops. Taro would serve perfectly well as a feed material provided only that local economics were favorable. Roughly, the starch-to-alcohol conversion ratio has been accepted to be 1.76 kg of starch to 1.0 litre of alcohol.

Fillers/modifiers for plastics: It is now well established that up to 40% of plastic compounds based upon such polymers as polystyrene, polyethylene, polyvinyl chloride, and so on, can consist of starch. The incorporation of moderate amounts of starch does not materially affect the original physical properties of the plastics. When taro starch is used in the production of plastics in an appropriate formulation, the result can be a useful acceleration of the biodegradability of the parent



Muktakeshi



Pani Saru-1



Sonajuli



NEH-12



Pani Saru-2



Bastar-2



Jhankri



Megh-18



Megh-19

polymer. Such plastics will become very important as waste material becomes an increasingly difficult problem for a society moving toward affluence. Taro starch granules are likely to be superior to other starches for the production of biodegradable plastics because of their extremely small size, which is approximately one-tenth of the size of a maize starch granule.

Taro gums: A gum like substance is present in taro. It swells in water and becomes highly hydrated. The potential usefulness of this gum lies in its value as an emulsifying, thickening, and smoothing agent for creams, suspensions, and other colloidal food preparations. It is also possible that the removal of the gum would improve the properties of taro products and render them less sticky and viscous.

Diversity of Taro

Taro belongs to genus *Colocasia* and family Araceae which is made up of at least 100 genera and more than 1500 species. The two most widely cultivated taxonomic varieties include *Colocasia esculenta* *som esculenta* and *Colocasia esculenta* *som antiquorum* which is commonly known as the dasheen type (*Colocasia esculenta* *som esculenta*), which has a large central corm with suckers and stolons and the second is the eddoo type (*Colocasia esculenta* *som antiquorum*), which has a small central corm and a large number of smaller cormels. The available growing genotypes of taro categorized in to wild and cultivated type. The wild type is not used as food. The corms of wild taro cannot be used as food due to an extremely high concentration of calcium oxalate crystals. It is naturally

a perennial monocotyledonous herb, but for practical purposes is harvested after 5-12 months of growth. Taro grows to a height of 1-2 m consisting of a central corm, lying just below the soil surface, from which leaves grow upwards, roots grow downwards, while cormels, daughter corms and runners grow laterally. It has heart-shaped green or purple leaves together with long petioles, fibrous roots and cylindrical or often irregular nutrient storage organ (corm). Taro seldom flowers and when flowers occurs the inflorescence consists of a cylindrical spadix of flowers enclosed in a 12-15 cm spathe with the female flowers located at the base of a spadix and the male flowers at the top. Morphological taro characterization can be done based on its corm, stolon, leaf, petiole and floral characters and other quantitative traits. Maximum morphological variability in taro accessions is found in Southeast Asia and Oceania. The variability with regard to morphological traits includes colour, shape and size of tuber, petiole length and colour, and stolon formation. Moreover, presence of greatest morphological variability in root colour, cormel flesh colour, corm dry matter percentage, corm shape and cormel shape was reported in taro collected from Asia, Africa and America. Concentration on morphological variability study in Asia might be due to large cultivation area and growing in the region. Variability in taro has been reported from every states of India. North Eastern region of India is a rich reservoir for taro diversity. The genus *Colocasia* includes several species, of which few species are reported in Northeast India like *C. affinis*, *C. esculenta*, *C. fallax*, *C. gigantea*, *C. lihengiae* etc., among them *Colocasia esculenta* is edible. *Colocasia esculenta* is usually diploid ($2n = 28$) or triploid ($2n = 42$). More than 200 landraces have been reported from this region. Rich genetic diversity exists in jhum fields, homestead gardens, near water bodies, river banks, forests and road sides for both cultivated and wild species. Over the centuries, landraces continue to exist based on ability to survive in extreme natural calamities. Natural hybridization and introgression occur between and within species that results into new species and varieties. The resulted species or varieties vary in their ecological adaptation. In nature, evolution of new species or varieties by introgression or horizontal gene transfer is a natural phenomenon. This natural phenomenon leads to the occurrence of huge genetic diversity of *Colocasia* in this ecological niche.

ICAR-Central Tuber Crops Research Institute, Trivandrum is the sole research Institute in India

engaged in the genetic upgradation of all tropical tuber crops including taro. This Institute possesses the richest germplasm wealth of 429 edible genetic stocks of taro in its HQ at Trivandrum in the south and 507 in its Regional Centre at Bhubaneswar in East India. Genetic resources of taro are also collected and maintained by the National Bureau of Plant Genetic Resources, New Delhi in its regional station at Trichur, Kerala and the research centers/agricultural universities located in different agro climatic zones in India under the All India Coordinated Research Project on Tuber Crops. At the ICAR-CTCRI, the genetic stocks are maintained in the field gene bank for enabling the studies of plant characters, pre-breeding studies and directed crosses in addition to *in vitro* conservation of the same. Cytological and morphological screening of the genetic stocks has been done and yield attributes identified. The frequency and distribution of the different ploidy types in India were also ascertained. The frequency of the ploidy types showed clear difference in ploidy-wise distribution in the different zones of the country. Although both the types occur in all the regions, the diploids predominate in South India over the triploids while the triploids convincingly out-numbered the diploids in the North. Several factors are known to influence the frequency of polyploidy in different ecogeographical regions. It is found that polyploidy in general have larger dimensions and greater adaptability which apparently enable them to thrive better in a wide range of higher latitudinal and altitudinal zones. Characterization is based on morphological features of individual genotype as per modified IPGRI descriptor for taro. The data revealed prevalence of a wide spectrum of variability among the Indian collections with regard to several characters.

SUMMARY

Several economically desirable important genetic stocks identified from the germplasm are under advanced stages of evaluation. Taro germplasm collection, characterization and evaluation under different agro-ecology plays great role for variability identification, conservation of desirable genotypes and utilization in crop improvement through breeding.

For further interaction, please write to:

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