EXPLOITATION OF ARROWROOT GENOTYPES IN ODISHA STATE OF INDIA

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Starch is a major energy source in human diet. The use of starch products as a food ingredient is usually not based on their nutritional value but on their functional value. All most all major industries (food and non-food) have found some application of starch. The Indian starch and starch derivatives market is segmented such as maltodextrin, cyclodextrin, glucose syrups, hydrolysates, modified starch, and others; and its wide application in different end-user industries such as food and beverage, feed, paper industry, pharmaceutical industry, bio-ethanol, cosmetics, and others. In India, starch is produced in 3,75,000 tonnes. Out of which 1,87,000 tonnes used by the food sectors and the remaining goes to non-food sectors. In India, starch and starch derivative market is projected to grow at a CAGR of 5.1% during the forecast period 2020-2025. In India, small scale firms are important players in the starch industry especially for root and tuber crops starch processing and utilization.

In this paper, contribution of arrowroot to starch industries and their cultivation techniques are discussed. In India, three types of arrowroots are cultivated for starch purposes. They are (1) West Indian arrowroot (*Maranta arundinacea* L.), (2) East Indian arrowroot (*Curcuma* spp.) and (3) Queensland arrowroot (*Canna edulis* L.). The starch is extracted by traditional methods from the above three arrowroot crops by the farmers as an off-seasonal activity and marketed locally. The starch is mainly used as a functional food.

West Indian Arrowroot

West Indian arrowroot (*Maranta arundinacea* L.) is grown for its edible rhizomes andstarch extraction.

Importance and uses

The high quality starch content of arrowroot is used as food for infants. Arrowroot biscuits are known in every corner in India. Its starch is also used as special glue and paste as a base for face powder and ice-cream stabilizer. Arrowroot starch possesses demulcent properties and is used in the treatment of intestinal disorders. In the middle of 18th century arrowroot was mainly used to cure the wounds from poisoned arrows and also started to be used as a source of starch (Stutervant, 1969). Recently it is also used in production of carbonless paper for computer printout. Arrowroot starch is

also used in pharmaceutical industries such as barium meals and in manufacture of tablets. The fibrous material which remains after the extraction of starch is used as a cattle feed or manure (Kay, 1987; Villamayor and Jukeme, 1996). The rhizomes are also eaten after baking or boiling.

The starch is a fine white powder and it is tasteless and odourless. The starch granulesare ovoid or ellipsoid in shape. The starch is easily digestible and it is valued as food especially for infants, invalids and convalescents. It forms an important ingredient for the preparation of barium meals and preferred in tablet making since it disintegrates fast. Arrowroot starch is also used as a base for powder and in the preparation of special glues (CSIR, 1962).

Nutritive value

The dry matter content varied between 29.5-31.6%. The chemically estimated starch content ranged from 19.1 to 23.0%, whereas extractable starch varied between 16.1 and 19.9% (Vimala and Bala Nambisan, 2010). Srinivas et al. (2002) reported that at commercial level, the recovery of arrowroot starch was only 14%.

Origin and history

The crop is native of tropical America and has long been cultivated in West Indies particularly St. Vincent.

Area and distribution

Its cultivation has spread extensively to many tropical countries like India, Ceylon, Indo-China, Indonesia, Philippines Queensland (Australia) etc. In India, it is grown in North Eastern States, Odisha, West Bengal, Assam and in Southern India mostly in Kerala as a rainfed crop in limited areas in homesteads.

In Odisha, it is cultivated in Khurdha and Nayagarh districts commercially, and homestead garden in Puri, Cuttack, Ganjam, Kendrapada, Bhadrak, Balasore and Jagatsinghpur districts. It is cultivated around 75 ha in Odisha.

Climate and soil

The crop grows best at temperature of 20-30° C with a minimum annual rainfall of 95-150 cm favours its growth. The availability of sufficient soil moisture throughout the growth period is essential for it. However water logged condition is unfavourable for its growth. A slightly acidic fertile, deep, sandy loam to loam soil with better drainage facility is most-suited for its cultivation. Partial shade is ideal for its growth (CSIR, 1962).

Varieties

Generally yellow coloured local cultivars are grown. However, cultivars having

bluerhizomes give higher yield of starch than yellow coloured cultivars.

Seed and planting material

Small pieces of rhizomes (known as bits), 4-7 cm long, having 2-4 nodes each is planted in well manured pits. Suckers are also used as planting material. They are separated from clump and planted at a distance of 30-45 cm in nursery during off season. These suckers grow to new plants which are uprooted and foliages are detached to keep 10cm shoot with intact roots. This is used as planting material. Normally 2 clumps are planted at a distance of 45 cm. about 3 tons of planting material is enough for a hectare of land.

Sowing and planting

The land should be prepared by deep ploughing and bringing soil to fine tilth. Raised beds of 15-20 cm high are prepared. The size of the bed is kept 50 x 50 cm. the bits/suckers are planted at 30 cm distance at a depth of 5.0-7.5 cm and covered with soil. Planting is done just before the onset of the monsoon during early-June. Rhizome pieces of 15-20 g were planted on raised bed at a spacing of 30 cm x 15 cm under Kerala conditions (Suja andNayar, 2005).

Nutritional requirement

If the soil is clay it is made friable by incorporating organic matter or compost. Suja and Nair (2005) reported mulching of the crop with dry leaves 15 t/ha increase rhizome yields. Application of farmyard manure @ 10 t/ha along with NPK @ 50:25:75 kg/ha is recommended. Suja et al. (2006) studied the influence of nutrient management on arrowroot yield, nutrient uptake and soil nutrient status and found that application of N, P and K @ 50:25:75 kg/ha was ideal to obtain better yield (23.3 t/ha), higher uptake of nutrients and substantial improvement in the nutrient status. Suja et al. (2003) reported that fertilizer application of 50 kg N and 75 kg K produced significantly higher starch yield.

Interculture operation

After planting of suckers care is taken to keep the field weed-free up to first 3-4 months of crop growth. As the duration of the crop is relatively longer the field requires weeding and shallow earthing-up from time to time. If growth is poor add nitrogenous fertilizers at the time of early intercultural operations. After 4 months its crop forms a good canopy cover. The weed infestations become less severe by that time.

Water management

The crop is predominantly grown as a rainfed crop. During tuberization and tuber development phase of first 3-4 months in case of irregular rainfall, supplementary irrigation is essential at 10-15 days intervals as per condition of the soil. Optimum

moisture supplythroughout the growth period gives better yield.

Plant protection

It was observed that *Maranta* species was not infested with pest and diseases.

Intercropping

Arrowroot is a versatile crop, which can adapt relatively quickly and fit well in diverse cropping systems etc. (Nayar and Suja, 2004). Arrowroot recorded highest biomass yield as an intercrop in horticulture, plantation and forestry plantations. Maheswarappa et al. (2000) and Veena (2000) reported highest uptake of N and K at the highest level of fertilization in arrowroot intercropped in coconut gardens. Application of FYM 15 t/ha + biofertilizers (*Azospirillum* + phosphobacteria 3 .0 kg each) before planting was sufficient for higher rhizome yield and improved quality under intercropping in coconut gardens (Swadijaet al., 2013).

Harvesting and yield

The rhizomes become ready for harvesting 10-11 months after planting. Plants are dug up manually and rhizomes are separated from the plants. Vimala and Bala Nambisan (2010) reported rhizome yield of 37.5-40.7 t/ha under Kerala, India conditions.

Post harvest and processing

Small rhizomes are used for generating planting material whereas bigger sized rhizomes are mainly used for starch production through further processing. The rhizomes are normally free from decomposition under ordinary storage environment. At some places rhizomes are stored embedded in dry sand layers in dark. Physical damage to rhizomes during harvesting enhances the chances of deterioration under normal storage condition.

East Indian Arrowroot

East Indian arrowroot (*Curcuma* spp.) is a perennial herb and grown for its starchy rhizomes. In India, it is locally known as 'Shoti'. About 30 *Curcuma* species occurs in India, of which *Curcuma angustifolia* Roxb. and *Curcuma zedoaria* Rosc. are useful in the production of starch (Kundu, 1967).

***Curcuma angustifolia* Roxb.**

The tubers are used for starch extraction. The tubers are washed, pulped and the starch separated from fibre and other impurities by repeated washing and straining through cloth. It is sun dried and ground into flour. The product resembles arrowroot

Species	Rhizome yield (t/ha)	Flesh colour of rhizome	Dry matter (%)	Starch (%)	Sugar (%)	Lipids (%)
C. angustifolia	20	Pale yellow	24.6	14.0	1.10	0.62
C. zedoaria	24.0	Yellow-orange	25.2	14.1	1.30	0.78

(*Maranta arundinaceae* Linn.) starch and is easily digestible (Kundu, 1967). It is used in the preparation of milk puddings and is recommended for children and invalids.

This species occurs in the hilly tracts of the Central Provinces, Bengal, Bombay, Madras and some of the lower Himalayan ranges.

The plant grows wild in many places. It is found in moist and cool situations at altitudes of about 1500 ft and is cultivated to a small extent. The tubers are planted in late autum and water occasionally during the dry period and harvested in January. A yield of 45 t/ha has been reported from experimental farms in Madras (CSIR, 1950).

***Curcuma zedoaria* Rosc**

The young rhizomes can be eaten fresh or after being cooked as vegetable. They are also cut into thin transverse sections and dried. The sliced and dried rhizomes are used for medicines and cosmetics. They have a pungent and somewhat bitter taste. The tubers are mainly used for starch extraction.

Importance and uses

The tubers are rich in starch. The 'Shoti' starch of commerce is a product extracted from the tubers and is used as substitute for arrowroot and barley (Kundu, 1967). It is highly valued as an article of diet, especially for infants and convalescents. The rhizome administered along with long pepper, cinnamon and honey is beneficial for cold. It has a local effect on the digestive organs similar to but milder than ginger and has been occasionally employed as a gastrointestinal stimulant in flatulent colic. *C. zedoaria* is used in the manufacture of liquors, stomach essences and bitters and in the perfumery and cosmetics.

Nutritive values

Area and distribution

The genus *Curcuma* has about 80 species of rhizomatous herbs which are distributed in India, Siam, Malaya, Archipelago and North Australia. In India, it is mostly confined to East, North-East and South India, and Andaman and Nicobar islands.

It was observed that Curcuma species was not infested with pest and diseases. Considering the rhizome yield and characteristic aroma, all the Curcuma species may contain some or other medicinal properties and warrants a thorough biochemical and

therapeutic or clinical investigation which may be highly useful. Organized cultivation of these starch species was not practiced though the tubers are rich source for product development a cosmetics, pharmaceuticals and nutraceuticals. They are excellent crop species that can be used in developing the waste land and as intercrops of economic importance in plantations and orchards.In Odisha, it is cultivated in Keonjhar and Mayurbanjh districts commercially, and homestead garden in Kandhamal and Koraput districts. It is cultivated around 50 ha in Odisha.

Climate and soil: It is widely cultivated in many parts of Ceylon and China. It grows well upto 3000 ft altitudes and requires 100-125 cm rain/year. It can be grown as a crop after summer fallows

Varieties: Local land races are in cultivation in traditional cultivated areas.

Seed and planting material: The plant is propagated by rhizomes. The seed materials are large mother rhizomescut into small pieces bearing buds.

Sowing and planting: The land should be prepared by deep ploughing and bringing soil to fine tilth during February-March. Ridge and furrow should be made at 45-60 cm spacing. Planting is done justbefore the onset of the monsoon during early-June. Rhizome pieces of 15-20 g were planted on raised bed at a spacing of 20-30 cm.

Nutritional requirement: Application of farmyard manure @ 10 t/ha along with NPK @ 50:25:75 kg/ha is recommended.

Plant protection: No pest and diseases incidence was noticed in this crop.

Harvesting and yield: The plant withers and dries upwards in December-January. The rhizomes are large, fleshy branched and the inner part of which is pale yellowish brown. The yield of tubers varies from 20-22 t/ha.

Post harvest and processing: 'Shoti' starch is produced in Odisha and West Bengal on a cottage industry basis. For preparing 'Shoti' starch, the rhizomes are washed, cleaned and made into a paste in a grinding stone. The starch gives highly viscous paste with water. The paste is stirred up with water and starch is allowed to settle. The supernatant liquid is decanted residue again stirred up with water strained through muslin and starch allowed to settle. The process is repeated several times until the bitter taste is removed and a white product is obtained. The flour is finely dried in the sun. Steam distillation of the rhizome yields 1-2 per cent light yellow oil.

Queensland Arrowroot

Queensland arrowroot (*Canna edulis* L.) is a perennial herb and grown for the branched fleshy rhizomes (Joseph and Peter, 1985). The plant is hardy and in view of the low incidence of pests and diseases and wind resistance of the crop in the typhoon prone regions, it is considered easy to grow (Kurtia, 1967).

Importance and uses: The tuber and top of the plant are used as livestock feed. The starch extracted from the Queensland arrowroot is easy to digest and hence used as a food for children and invalids.The young rhizomes are eaten as vegetable. The cooked tubers are delicious whereas the young shoots and petioles are used as fodder.

Nutritive value: The dry matter and starch content of *Canna* was similar to cassava and sweet potato (Moorthy, 1994). Vimala et al. (2012) reported that in *Canna*, dry matter ranged from 34.5 to 36.4%, whereas starch ranged between 26.2 to 27.9%.

Origin and history: It is native of tropical America. The genus *Canna* contains about 65 species and widely distributed in the tropics and subtropics particularly in the western hemisphere (IBPGR, 1981). It is commercially cultivated in Australia for its starch.

Area and distribution: In India, it is cultivated in Odisha and Kerala. In Odisha, around 125 ha cultivated in Koraput and Rayagada districts.

Climate and soil: It grows in most of the soils except gravelly and heavy wet clay soils.

Varieties: Local land races are in cultivation in traditional cultivated areas.

Seed and planting material: The plant is propagated by rhizomes. The seed materials are large mature rhizomescut into small pieces bearing buds.

Sowing and planting: The land should be prepared by deep ploughing and bringing soil to fine tilth during February-March. Ridge and furrow should be made at 60 cm spacing. Planting is done just before the onset of the monsoon during early-June. Rhizome pieces of 15-20 g were planted on raised bed at a spacing of 30-60 cm at 5 cm depth.

Nutritional requirement

Application of farmyard manure @ 10 t/ha along with NPK @ 50:25:75 kg/ha is recommended. Arbuscular mycorrhizal fungal (*Glomus microcarpum*) is found association with the *Canna* and possess the potential to boost rhizome yield even in unfertilized fields (Jayakumari and Potty, 2008, 2009). Jayakuamri and Potty (2008) studied the effect of AM fungal inoculation in arrowroot and found the potential of this fungal endophyte in transforming more roots to tubers.

Plant protection: It was observed that *Canna* species was not infested with pest and diseases.

Intercropping : Maize is intercropped in *Canna* to increase farm productivity and income. In Odisha, *Canna* is planted at 60 x 60 cm spacing. *Canna* being a long duration crop gives return after 7-8 months. Wide spacing allows short duration intercrops. Maize being short duration crop is sown in intra-rows at a spacing of 60 cm i.e. 1:1 ratio. Thus full population of *Canna* (27,777 plants/ha) and 27,777 plants/ha of maize is accommodated. Maize is harvested 3 months after sowing at physiological maturity to facilitate *Canna* to grow

without any competition at the later stage.

Harvesting and yield: The plant withers and dries upwards in December-January. The rhizomes are large, fleshy branched purple in colour. The yield of tubers varies from 20-25 t/ha. For cooking purposes the rhizomes can be harvested after 5 months but for starch production the harvest should be done after 8-12 months. Under favourable conditions heavy yield of rhizomes are obtained. The fleshy rhizomes are formed in compact mass. Vimala et al. (2012) reported thata 10 months duration *Canna* dark purple type has yielded 32.7 t/ha whereas green type has yielded 24.7 t/ha. The rhizomes of green types were cream in colour whereas the rhizomes of dark purple accession possessed dark puple tinge and the rhizomes were covered with purple scales.

Post harvest and processing: *Canna* starch is obtained from the tubers by a process of rasping, washing, and straining. The final product is a shiny cream coloured powder. The starch granules are oval or polyhedral in shape (Kay, 1987). The viscosity of the *Canna* starch was higher than that of cassava. The green accession had slightly higher viscosity (4419 cP) compared to dark purpleaccessions (3560 cP) with break down viscosity ranged from 973 to 1302 BU which is lower compared to cassava starch (Vimala et al., 2012). Cooled paste was non-cohesive in texture and set in to a strong gel free from syneresis. The most of the functional properties of *Canna* starch is resembled with yam starch. Thus the starch has higher stability, set back viscosity and relatively low viscosity breakdown, which are useful properties that can lead to very good applications in food industry (Soni et al., 1990; Moorthy et al., 2002). Bakery products like biscuits, cakes and cookies can be prepared from *Canna* starch (Vimala et al., 2012). Hermann (1994) reported that the bakery products prepared from *Canna* starch was much lighter and crispier than similar products from wheat. The waste product of rhizomes after starch extraction can be used as manure (CSIR, 1950).

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