



# TROPICAL MINOR TUBER CROPS

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## FOREWORD

Tuber crops form an important staple food crop in the tropics. These crops produce high level of calories and carbohydrates from a unit area and unit time and they can withstand adverse biotic and abiotic conditions. The major tropical root crops are cassava, sweet potato, yams and aroids. In addition to the major crops there are many types of tuberous and rhizomatous minor root crops which are grown and used in different parts of the country.

The Central Tuber Crops Research Institute made an intensive effort to collect and maintain different minor tuber crops in the field gene bank. The 176 accessions which belong to 9 crops are Chinese potato, Yam bean, Canna, Arrowroot, Curcuma species, Typhonium species, Costus, Tacca and Vigna. Even though flowering was observed in many of these crops, majority of them do not produce any seeds which obviously limits the scope for breeding and further improvement. Not much information is available about these crops. However, some crops have high yield potential and starch value and they are yet to be properly explored. A sincere attempt has been made to consolidate the available information and the results of the studies conducted in this Institute. It is hoped that this publication would be useful to students, researchers and scientists engaged in similar studies.

Sreekariyam  
16-05-2005



**S. Edison**  
*Director*



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## INTRODUCTION

Roots and tuber crops occupy a remarkable position in the food security of the developing world due to their high calorific value and carbohydrate content. Some of them are already cultivated, but others are grown wild as a neglected group of economic plants. They are often used as food or serve as a source of raw material for the production of alcohol and animal feed. Many wild plants form an important starchy food for the tribals inhabiting near to forest tracts. Some are important due to their medicinal as well as industrial applications. Many of these crops have not spread farther than their native habitat due to physiological constraints or lack of adaptability. In order to explore the potentialities of these unutilized and underutilized minor tuber crops, an intensive research programme was initiated at the Central Tuber Crops Research Institute, Thiruvananthapuram. In the present study an attempt was made to evaluate these crops for tuber yield, biochemical characters and the properties of starch.

As part of the exploration programme for the collection of underutilized tuber crops, several exploration trips were made separately and jointly in collaboration with National Bureau of Plant Genetic Resources, Trichur. Exploration trips were carried out in different parts of Kerala, Tamil Nadu, Karnataka, Bihar, Jharkand, Madhya Pradesh, Uttar Pradesh, Assam, Meghalaya and Nagaland. Apart from the tribal settlements, some rural villages were also visited for collecting the indigenous knowledge about the utilization of these minor tuber crops. A total of 176 accessions, belonging to 9 crops which included 87 accessions of Chinese potato, 63 accessions of Yam bean, 5 accessions of Canna, 4 accessions of Arrowroot, 2 accessions of Costus and one accession each of Tacca, Vigna, 3 species of Typhonium and 10 Curcuma species were collected and maintained in the field gene bank. All these crops were evaluated for tuber yield. Biochemical characters like dry matter, starch, sugar and lipid content were estimated according to the standard methods (AOAC, 1975). Starch was extracted from the tubers and studied for their rheological properties. The starch granule size was

examined using Scanning Electron Microscope. The available information on botany, starch properties and uses of 9 tropical minor tuber crops are presented in this bulletin.

## 1. Chinese Potato (*Solenostemon rotundifolius*) (Poir) J.K. Morton

Chinese potato is an important minor tuber crop grown extensively as a vegetable in most of the homestead gardens in Kerala and Tamil Nadu (Hrishi and Mohankumar, 1978, Doraipandian, 1973). It is a small herbaceous bushy annual with succulent stems and aromatic leaves. The plant bears a cluster of heteromorphous tubers with aromatic flavour, which makes it likeable as a delicacy among the vegetables. It is generally raised as a monsoon crop and the duration is 4-5 months. Even though profuse flowering was observed during September-November season, the crop is completely sterile due to the lack of fertile pollen grains (Vasudevan et al, 1967). Highly irregular meiosis (Ramachandran, 1967) and occurrence of desynapsis (Vasudevan et al, 1967) might have resulted in the complete sterility of the crop. The analysis of data on frequency of different size of tubers also revealed that no significant difference between the accessions. The average weight of medium and big size tubers were on par and the average weight of small and very small tubers were not significantly different on their mean values.



Significant difference was observed in tuber size within the accessions and not between the accessions (Vimala, 1994). Evaluation of 87 accessions of Chinese potato showed that not much variation existed between the accessions in morphological or tuber characters. This may be the consequence of vegetative propagation and sterility of the crop. The promising 11 accessions were tested in the multilocation trials in Kerala and one accession 'CP-58' which recorded 25.0-28.0 t ha<sup>-1</sup> tuber



yield was released as 'Sree Dhara' in 1993, the first one for Chinese potato (Vimala, 1994). The dry matter and starch content of the tuber was 28.5 and 19.5 per cent respectively. In the year 2000 another selection 'Nidhi' was released by the Kerala Agricultural University.

## 2. Yam Bean (*Pachyrrhizus erosus* (L.) Urban)

Yam bean is a leguminous root crop of good nutritional value. The plant is a coarse, hairy herbaceous twiner with alternate trifoliate leaves. The tubers are simple, lobed, turnip-like or elongated in shape and flesh of the tuber is white, crispy, juicy, refreshing and sweetish in taste and can be eaten as raw or cooked. The mature tuber yields starch, which is similar to arrowroot starch (CSIR, 1966). The pods are poisonous due to the presence of toxic substance 'rotenon'. The powdered seeds are used as an insecticide (Purseglove, 1968).



Yam bean is propagated mainly through seeds and it is a self pollinated crop. Sometimes tubers are used for planting when a particular genotype is desired to be maintained. It grows well on light sandy soil. The plants are pruned once or twice after two months of planting in order to restrict vegetative growth and encourage better tuber development. The crop matures in 6-8 months. Non-flowering plant produces best quality tubers. Hence when grown for tubers, the buds or inflorescence are removed to prevent flower development. Yam bean being a legume, fixes nitrogen and hence increased the soil fertility (Poonpipat, 1984). A high yielding selection 'Rajendra Mishrikand' yielding 40 t ha<sup>-1</sup> was released by the Rajendra Agricultural University, Pusa, Bihar (Singh et al. 1981).



The 63 accessions of yam bean were evaluated for tuber yield and biochemical characters. The dry matter ranged from 9.17-21.82%, starch varied from 3.63-15.78%

and sugar content ranged from 3.07-5.43%. (Annual Report, 1992). The yield trial conducted with 16 promising accessions of yam bean for three years revealed that 6 accessions (DL-3, DL-20, DL-21, DL-29, EC 100566 and Rajendra local) produced significantly superior yield of > 25.0 t ha<sup>-1</sup>. Maximum yield of 29.3 t ha<sup>-1</sup> was recorded in the accession EC 100566 (Annual Report 1999-2000).



### 3. Queensland Arrowroot

(*Canna edulis* ker-Gawler)

*Canna edulis* is a perennial herb, growing to a height of 1.0-2.5 m, leaves are arranged spirally with a prominent midrib and numerous lateral veins. It is widely distributed throughout the tropics and sub-tropics. It is grown for its branched and fleshy rhizomes. The plant is hardy and in view of low incidence of pest and diseases as well as the wind resistance of the crop, it is considered easy to grow in the typhoon region (Kurtia, 1967). In Japan it is grown as a fodder crop. It is commercially cultivated in Australia for its starch. In India, it is grown for the edible, tuberous rhizome. There are two types of canna, ornamental and edible. The flowers of ornamental cannas are larger and more beautiful and variable in colour than the edible types. Although both types of canna store starch in the root-stocks, the edible types have more fleshy rhizomes with better flavour, taste, low fibre and less tannin content than the ornamental types (Arbizu, 1994).

The rhizomes are formed in a compact mass. The small terminal portion of the rhizomes are used for planting. Duration of the crop varied from 8-12 months. The tubers are eaten boiled or baked. Starch is obtained from the tubers by a process of rasping, washing and straining. The final product is a shiny, cream coloured powder. Starch is easily digestible and used as food for children and invalids. Based on the leaf and



emerging leaf colour and other morphological characters the five accessions in the germplasm are grouped into three morphotypes namely, dark purple, purple and green accessions. Out of five accessions only two (dark purple and green) are edible. The leaves of edible accessions are bigger than the non edible accessions. Eventhough flowering was observed in all the accessions no seed set was observed in the edible accessions. The yield data revealed that maximum yield of 32.8 t ha<sup>-1</sup> was recorded in the dark purple accessions followed by 24.7 t ha<sup>-1</sup> in the green accession. In the other three accessions the yield varied from 11-20 t ha<sup>-1</sup>.



Tubers of dark purple and one green accession was more fleshy, had better taste and low fibre and phenol content than the other three accessions. The biochemical analysis of tubers indicated that dark purple accession had higher dry matter (35.7%) and starch (27.03%) compared to other accessions.



The studies on physico chemical properties also revealed that canna starch has good potential in food application since it possesses high viscosity, gel strength and high phosphorus content (Moorthy et al, 2002). Hermann (1994) reported that the bakery products prepared from canna starch are much lighter, crispier and tastier than those from wheat.

#### 4. West Indian Arrowroot *Maranta arundinacea* L.

West Indian Arrowroot (*Maranta arundinacea* L.) is a perennial herb, cultivated for its edible rhizomes, throughout the tropical countries of the world. The plant is an erect, perennial herb, 1.0-1.5 m high, shallow-rooted with rhizomes penetrating into the soil. The plant thrives best in light, well drained, loamy or sandy soil and partial shade is beneficial. It is propagated by tips of rhizomes known as 'bits' which contains 2-4 nodes. The small rhizome containing eyes are used for planting. The

land is ploughed and the bits are planted, 5.0-7.5 cm deep and 30 cm apart. Usually planting is done in May. The shoots come up within 15 days. Irrigation is necessary during the growing period and the flowers are nipped off as they appear. The rhizomes are ready for harvest in 10-11 months after planting. Maturity is indicated by yellowing, wilting and drying up of leaves. Harvested rhizomes are 20-45 cm long and 2.5 cm thick.



The tubers are eaten boiled or baked and the bulk of the material is used for the production of starch. Arrowroot starch is a fine, white powder and it is tasteless and odourless when dry, but a faint odour develops when it is wet or cooked. The starch granules are ovoid or ellipsoid in shape. The starch is easily digestible and valued as a food especially for infants, invalids and convalescents. It is used in the preparation of biscuits, cakes, puddings and jellies. It possesses demulcent properties and is given for correcting bowel complaints. It is employed as a suspending agent in the preparation of barium meals and the starch is preferred in tablet making since it disintegrates fast. Arrowroot starch is used as a base for face powders and in the preparation of special glues (CSIR, 1962).



Four accessions of arrowroot collected from Kerala, Bihar, Madhya Pradesh and Shillong are maintained in the germplasm. The tuber yield of four accessions ranged from 22-25 t/ha under open conditions. There was no significant difference between the accessions for tuber yield, morphological and biochemical characters. Tuber contains 30.69-31.25% dry matter and 17.20-18.86% starch.

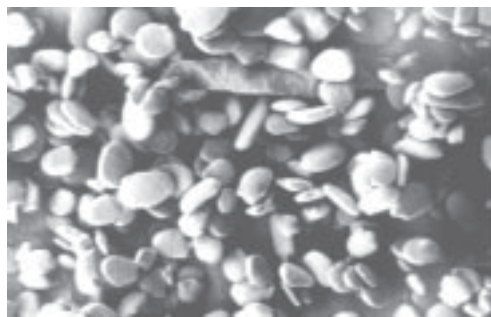
## 5. Curcuma species

Out of 10 Curcuma species, two species *C. amada* and *C. zedoaria* and distributed throughout India in the wild and cultivated forms; four species *C. aeruginosa*,

*C. brog*, *C. caesia* and *C. sylvatica* occur in wild conditions and distributed throughout north eastern part of India. *C. malabarica* and *C. aromatica* occur in south India while *C. raktakanta* and *C. harita* are distributed throughout Kerala (Velayudhan et al, 1999).

The root stocks and sessile tubers vary in colour from pale yellow, yellow, orange yellow, lemon yellow, green and blue (Velayudhan et al, 1999). This is the most valuable character for the identification of the species. Tuber taste and aroma also vary considerably. Most of the species have a camphoraceous odour and some are odourless and tasteless. Out of the 10 species, only *C. amada* and *C. sylvatica* possess mango aroma in the rhizomes.

The tuber yield of different species varied from 1.0-2.0 kg per plant. The biochemical composition of the different curcuma species showed that dry matter ranged from 21.2-31.4%. Maximum starch was recorded in *C. malabarica* (21.4%) followed by *C. caesia* (19.86%) and *C. brog* (18.0%). All the other species possess 10-15% starch.



*C. zedoaria* (500 x)

Scanning electron microscopy studies revealed that the starch granules are round or oval in shape and consisted of both small sized and large sized ones. The granule size ranged from 6-25  $\mu$  for *C. zedoaria*, *C. raktakanta*, *C. caesia*, *C. aerugsoma* and *C. aromatica*. In *C. malabarica*, *C. brog* and *C. sylvatica* it varied from 10-40  $\mu$  m.



*C. malabarica* (500 x)

Considering the plant characteristics of the various species of curcuma, all of them may contain medicinal principles and a thorough biochemical and clinical investigation on all the species would be highly useful.

**a. *Curcuma brog* Val.**

Plants are semi erect with green leaves and light green midrib. Root stocks are oblong, long fusiform tubers, pale yellow flesh with camphoraceous smell and bitter taste.

Plant height: 80-100 cm

Yield : 1.5-2.0 kg/plant

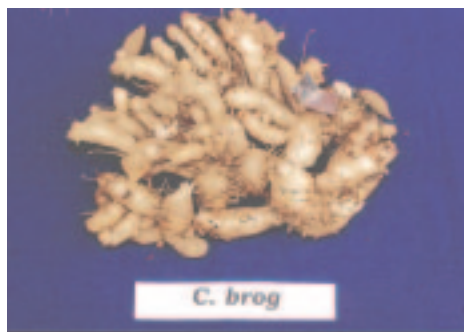
Dry matter : 30.40%

Starch: 18.00%

Sugar: 0.99%

Lipids: 0.79%

Starch Granule Size: 10-40  $\mu$ m



**b. *Curcuma malabarica* Vel.**

Plants are semi erect with green leaf sheath and light purple midrib. Root stocks are slightly oblong, fusiform tubers, pale blue flesh with camphoraceous smell and bitter taste.

Plant height: 100-120 cm

Yield : 1.50-2.00 kg/plant

Dry matter : 31.4%

Starch: 21.4%

Sugar: 0.91%

Lipids: 0.75%

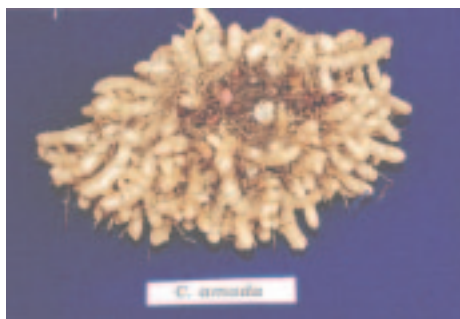
Starch granule size: 10-40  $\mu$ m



**c. *Curcuma amada* Roxb.**

Plants are semi erect with green leaves and leaf sheath. Root stocks are oblong, pale yellow or white in colour with mango aroma and no taste.

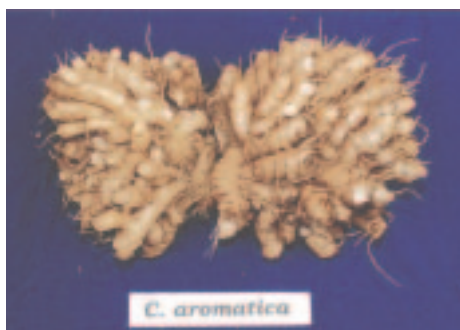
Plant height:85-100 cm  
Yield : 1.25-1.50 kg/plant  
Dry matter :22.40 %  
Starch: 10.22%  
Sugar: 0.72%  
Lipids: 1.01%  
Starch Granule Size: 8.60-21.60  $\mu\text{m}$



#### ***d. Curcuma aromatica* Salisb**

Plants are semi erect, leaves with green leaf sheath and green midrib. Root stocks are oblong with fusiform tubers, camphoraceous smell and bitter taste.

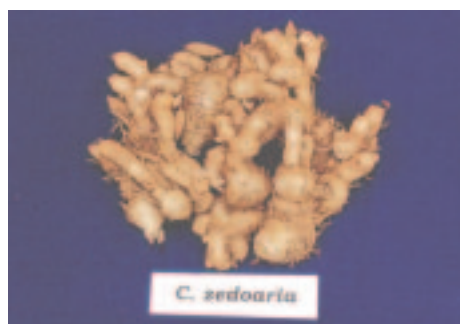
Plant height: 75-90 cm  
Yield : 1.25-1.50 kg/plant  
Dry matter : 28.80%  
Starch: 15.00%  
Sugar: 0.99%  
Lipids: 1.27%  
Starch Granule Size: 10.0-33.30  $\mu\text{m}$



#### ***e. Curcuma zedoaria* Rosc.**

Plants are erect with green leaf sheaths and light purple midrib. Root stocks are oblong with fusiform tubers, dark orange flesh colour, camphoraceous smell and bitter taste.

Plant height 135-150 cm  
Yield : 1.25-1.50 kg/plant  
Dry matter : 25.0%  
Starch: 14.06%  
Sugar: 1.3%  
Lipids: 0.78%  
Starch Granule Size: 6.60-23.00  $\mu\text{m}$



### **f. *Curcuma aeruginosa* Roxb.**

Plant are semi erect with green leaves and dark purple midrib. Root stocks are oblong, fusiform tubers, camphoraceous smell and bitter taste.

Plant height: 85-100 cm

Yield : 1.25-1.50 kg/plant

Dry matter : 29.30%

Starch: 14.10%

Sugar: 1.41%

Lipids: 0.47%

Starch Granule Size: 6.66-33.30  $\mu\text{m}$



### **g. *Curcuma harita* Mangaly & Sabu**

Plants are semi erect with green leaf sheath and midrib. Root stocks are oblong, fusiform tubers, white or cream flesh colour, camphoraceous smell and bitter taste.

Plant height: 75-90 cm

Yield : 1.00-1.25 kg/plant

Dry matter : 24.1%

Starch: 14.32%

Sugar: 1.11%



### **h. *Curcuma caesia* Roxb.**

Plants are erect with purple leaf sheath and midrib. Root stocks are oblong, fusiform tubers, dark bluish flesh colour with camphoraceous smell and bitter taste.

Plant height: 85-95 cm

Yield : 1.00-1.25 kg/plant

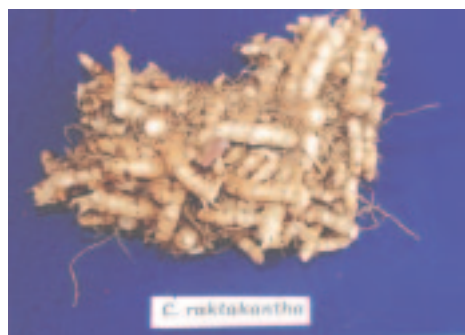


Dry matter : 31.00%  
Starch: 19.86  
Sugar: 0.84%  
Lipids: 0.81%  
Starch Granule Size: 6.66-26.60  $\mu\text{m}$

### i. *Curcuma raktakanta* Mangaly & Sabu

Plants are semi erect with dark purple leaf sheath and brown midrib on the leaves. Root stocks are oblong, fusiform tubers with camphoraceous smell and slightly bitter taste.

Plant height: 100-125 cm  
Yield : 1.50-1.75 kg/plant  
Dry matter : 28.80%  
Starch: 14.20%  
Sugar: 0.62 %  
Lipids: 1.15%  
Starch Granule size: 6.66-26.60  $\mu\text{m}$



### j. *Curcuma sylvatica* Val.

Plants are semi erect with green leaves and midrib. Root stocks are oblong, fusiform tubers, white with pale yellow flesh, mango aroma and bitter taste.

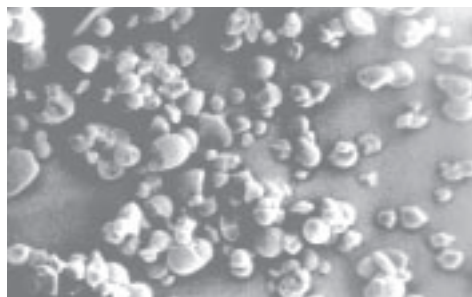
Plant height: 100-125 cm  
Yield : 1.00-1.25 kg/plant  
Dry matter : 21.20%  
Starch: 10.34%  
Sugar: 1.11%  
Lipids: 0.76%  
Starch Granule Size :10.33-36.60  $\mu\text{m}$



## 6. Typhonium species

The genus *Typhonium* includes perennial tuberous herbs distributed throughout India. In CTCRI three species of *Typhonium* are maintained in the germplasm. Out of three species, maximum yield was observed in *T. trilobatum*. There was not much difference between the dry matter and starch content between the species. However maximum dry matter (36.44%) and starch content (23.68%) was observed in *T. flagelliforme*.

Scanning Electron Microscopic studies revealed that starch granules are polygonal, or round in shape and consist of both small and large sized ones. Small sized granules ranged from 3-10  $\mu$ m and the large granules varied from 10-20  $\mu$ m.



### a. *Typhonium trilobatum* Schott.

*Typhonium trilobatum* distributed in the north-eastern region of India. The plants are erect with trilobed leaves grown to a height of 50-75 cm. The globose tubers are acrid and used as a vegetable (CSIR, 1976).

Plant height: 40-50 cm

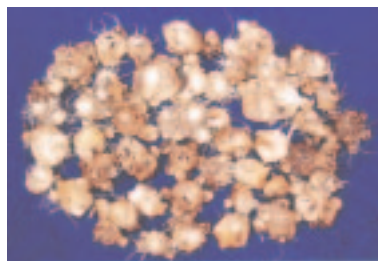
Tuber yield: 150-200 g/plant

Dry matter: 33.00%

Starch: 22.50%

Sugar: 0.71%

Lipid 0.92%



### b. *Typhonium flagelliforme*

*Typhonium flagelliforme*. The tubers are globose and leaves are hastate and sagittately cordate in shape.

Plant height 20-25 cm

Tuber yield: 75-100g/plant

Sugar: 1.06%

Lipids: 0.76%

Dry matter: 36.44%

Starch: 23.68%



### *c. T. divaricatum* Deone

*T. divaricatum* is a perennial herb with sagitate leaves and sub-globose small tubers. The tuber yield varied from 25-50 g/plant

Dry matter: 32.00%

Starch: 23.07%

Sugar: 1.42%

Lipids: 0.85%.



## 7. *Costus speciosus* (Koenig) Sm.

The genus *Costus* includes about 175 species of perennial herbs. *Costus speciosus* is a common plant with tuberous rhizome distributed throughout India up to an altitude of 4000 ft. It is common in Bengal and Konkan areas and often cultivated as an ornamental plant. It attains a height of approximately 1.0-1.5 m and white coloured flowers appear on the top of the plant. The rhizome has purgative and tonic properties. The root is used as tonic and anthelmintic in Uttar Pradesh (CSIR, 1950).



About 200 plants were evaluated for 3 years. Rhizome is edible and is used after cooking. The flesh is white, mucilagenous, feeble astringent but has no aroma. Compared to other tuber crops the fibre content is high.

Tuber yield: 1.30-1.50 kg/plant

Dry matter: 16.40(%)

Starch: 10.48%

Sugar: 1.30%

## 8. *Tacca pinnatifida* Forst & Forst. f.

The genus *Tacca* includes about 30 species of perennial herbs with tuberous or creeping rhizomes. *Tacca pinnatifida* originated in south east Asia and widely distributed in the moist tropics of Asia, Australia and Pacific islands. The plant is a perennial herb and grows to a height of 60-90 cm. The tubers are globose, 15-20 cm in diameter and harvested after the tops have died down. The tubers are used for the treatment of piles. A bitter extract prepared by washing the grated tubers in running water is rubefacient and is given for diarrhoea and dysentery (CSIR, 1976).



The fresh acrid, bitter tubers are peeled, macerated, repeatedly washed in several changes of water and strained through a coarse cloth. The final product when dried yields a nutritive starch having excellent culinary properties. The product is known as 'Fiji' or 'Tahiti' or 'East Indian arrowroot' starch. The starch is used to prepare porridges, cakes and other sweet meals. It is also mixed with wheat flour for making bread. The starch is recommended as a food for invalids and also used as laundry starch (CSIR, 1976). The evaluation of the few plants showed that the tuber yield varied from 150-250 g/plant and the shape of tubers resembles potato. The tubers possess 22.40% dry matter and 10.22% starch and 0.54% sugar content.

## 9. *Vigna Vexillata* (L.) A Rich

**Syn. *Vigna capensis* Walp.**

The genus *Vigna* includes climbing or trailing herbs, distributed mostly in the tropical and sub-tropical regions. In India, nearly 15 species are known, some of

which form an important protein supplement and some are valued as green manure or cover crop (CSIR, 1976). It is a new unexploited edible tuber crop (Chandel et al., 1972). It grows wild in western Ghats, central Peninsular hills, western Himalayas and Meghalaya. The plant is a twining herb with stipulate, alternate trifoliate leaves. Tubers are fusiform and one tuber is borne on each plant. However, 2 tubers or branched tubers are also observed in some plants. Tubers are 5-11 cm long, 1.5-2.0 cm broad. The tubers have an easily peelable skin. The seeds can be used as a nutritious vegetable. These group of plants usually require low inputs and adapted to varying agro climatic conditions and are tolerant to biotic and abiotic stresses.

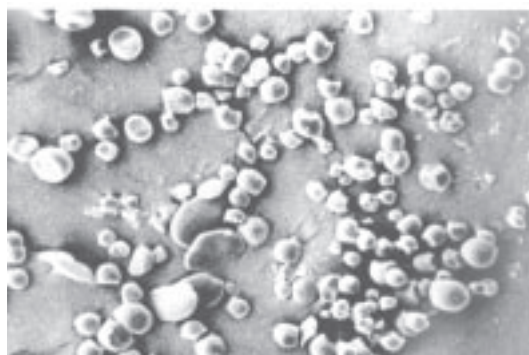
Microscopic examination of starch granule revealed that they are round cupuliform or convex or biconvex in shape. and composed of small and large grains. The size of small grains ranged from 3.8-7.0  $\mu\text{m}$  and large ones from 7.0-20  $\mu\text{m}$ .

Tuber yield: 95-100g/plant

Dry matter: 19.80%

Starch: 9.7%

Sugar: 1.28%



## Conclusion

The evaluation of minor tuber crops showed that some of these crops have high yield potential ( $> 30 \text{ t ha}^{-1}$ ) and can act as a carbohydrate reserve to support the food security of the country. Canna starch resembles yam starch in most of the functional properties. The starch has good potential in food application due to its high viscosity, gel strength and paste stability. Arrowroot starch is commercially used in the preparation of different types of biscuits and other bakery products. All curcuma species are used by the local people for the starch extraction because of its medicinal properties. The tubers of *Costus*, *Typhonium*, *Vigna* and *Tacca* are used as a vegetable. Considering the importance of these crops as food, medicine and for industries these under utilized crops can be exploited at the commercial level. The high nutritional qualities indicate that the cultivation and consumption of these crops may be helpful in overcoming the nutritional deficiencies predominant in many rural areas of the country. In the present context of rapid increase of population and consequent shortage of food grains, collection and utilization of various types of unutilized and underutilized tuber crops are considered very essential. Ample scope exists for the exploitation of these minor tuber crops for correcting the deficiencies arising on the food shortage of the country in the years to come.

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