Value Addition in Underutilized Crops for Enhancing Nutritional Security of Tribals

Sachidananda Swain, G Kavita, Rajiv Sinha, D. Basantia, K. Abirami,
Pooja Kapoor, Sanjay Kumar Pandey, Manoj Kumar, B. Gangaiah and A. Kundu

Under Schedule Tribe Component (STC) programme

Division of Natural Resource Management (NRM)
ICAR-Central Island Agricultural Research Institute (CIARI)
Port Blair, A&N Islands - 744 101

Value Addition in Underutilized Crops for Enhancing Nutritional Security of Tribals

Sachidananda Swain, G Kavita, Rajiv Sinha,
D. Basantia, K. Abirami, Pooja Kapoor,
Sanjay Kumar Pandey, Manoj Kumar,
B. Gangaiah and A. Kundu

Under Schedule Tribe Component (STC)
programme

Division of Natural Resource Management (NRM)
ICAR-Central Island Agricultural Research Institute (CIARI)
Port Blair, A & N Islands - 744 101

Citation

Swain, Sachidananda., Kavita, G., Sinha, Rajiv., Basantia, D., Abirami, K., Kapoor, Pooja., Pandey, Sanjay Kumar., Kumar, Manoj., Gangaiah, B. and Kundu, A. Value Addition in Underutilized Crops for Enhancing Nutritional Security of Tribals. CIARI/STC/NRM/Technical Bulletin/ 01. Pp 1-40. 2018.

Year of publication: 2018

Published by

Director
ICAR-Central Island Agricultural Research Institute (CIARI)
Port Blair, A & N Islands - 744 101

Printed by

Shri Vignesh prints, Ashok Nagar, Chennai
E-mail : vprintschennai1@gmail.com; vprintschennai@gmail.com

INTRODUCTION

The term "underutilized species" refer to those species whose potential to improve people's livelihoods, as well as food security and sovereignty, is not being fully realized because of their limited competitiveness with commodity crops in mainstream agriculture. While their potential may not be fully realized at national level, they are of significant importance locally, being highly adapted to marginal, complex and difficult environments and contributing significantly to diversification and resilience of agro-ecosystems. Underutilized species include not just food plants but also many other species—wild or cultivated—used as sources of oil, fuel, fiber, fodder, beverages, stimulants, narcotics, ornamental, aromatic compounds, and medicine. These crops are cultivated, traded and consumed locally. Most of them are very rich sources of vitamins, minerals, and other nutrients such as carbohydrates, proteins and fats. Since, the underutilized horticultural crops have a long history of consumption, the local people are aware about their nutritional and medicinal properties. Moreover, these are cheap and readily available. In addition to this, there is always demand from consumers for new, delicious, nutritious and attractive food products. To satisfy this demand, there is a constant effort to develop products from diverse sources. The potentiality of processed products from some underutilized crops in the Island is still untapped.

Andaman and Nicobar Islands is one of the richest reservoirs of genetic variability and diversity of different underutilized crops, which exist in plant types, morphological and physiological variations, reactions to diseases and pests, adaptability and distribution owing to congenial climatic conditions. It is a fact that nutritional security of Island population cannot be met by focussing on the staple and major horticultural crops alone with limited cultivated areas. This is an area of attention and should be researched in the near future but the role of underutilized species to that end need to be better recognized. Such a role can be realized in two ways; first, by providing genetic traits for adaptation and second by strengthening the resilience of agro-ecosystems through crop diversification. With regard to the first way, historically, in a climate stable world, crop wild relatives (CWR) as gene donors for plant breeding will be a major contributor to economic development and food security. In second way, crop diversification with special attention to growing of untapped resilient crop resources will be important for a stable agro-ecosystem.

It is worth to mention that huge potential exists for processing of the various unexploited fruits of these Islands into high-value added products. In these Islands, there is a great scope for the processed products not only because of their exotic flavor but also due to their nutraceutical impotence and therapeutic values.

Facts about underutilized crops

- These are not grown in large scale, but exist in the wild or home gardens, hence seasonal and limited availability, so economics of scale cannot be achieved by individual processors or if a single fruit or product is targeted.
- These fruits ate highly perishable and there is a high amount of loss due to improper pre and post harvest handling due to lack of facilities, technology and knowhow with the farmers.
- Selections suitable for processing need to be identified.

- Simple tools and techniques need to be developed for pre and post harvest, handling and processing of these fruits.
- Trainings need to be organized for creating awareness and sensitizing the farmers to pre and post harvest handling, management and hygienic processing of underutilized fruits for their livelihood enhancement.
- The farmers have to be organized into clusters or groups to facilitate profitable processing of this low volume, scattered and seasonal output of minor fruits.
- International and domestic marketing has to be promoted by forward and backward integration of the supply chain.

Underutilized fruits and vegetables are commercially neglected but recognized as rich sources of nutrients and non-nutrient bioactive compounds. These crops are very popular among local communities in many parts of the world and well accepted in their traditional diets and medicines. Some of the bioactive compounds neutralize free radical species generated as a part of biochemical reactions in our body system. Accessibility and availability of these bioactive com- pounds from dietary sources contribute significantly in traditional health system of tribals in the Islands. With the limited medical facility, higher average life span of tribals is the testimony of this fact. The importance of these lesser known fruits is increasing day by day because people realized the importance of new useful terms such as caloric sweetness, insecticide compounds, and medicinal value. Therefore, these are gaining significance in research and development programmes of many organizations. India is successful in evolving appropriate processing technologies for the profitable utilization and value addition in these crops.

Tribals in Nicobar Island

The population of Nicobarese represents about 85 per cent of the total tribal population of Andaman & Nicobar Islands. The Nicobar group is divided into three zones, *viz.*, the Northern zone, consisting of Car Nicobar Island; the Central zone (also known as Nancowry group of Islands) and the southern zone consisting of Great and Little Nicobar Islands. The Nancowry group is comprised of nine Islands *viz.*, Chowra, Teressa, Nancowry, Kamorta, Katchal, Bompooka, Trinket, Isle of Man and Tillangchong, of which only the first five are inhabited. The Nicobarese belong to the mongoloid race. They are coast-dwellers and enjoy the vicinity of exuberant and verdant tropical forests. Nicobarese of Nancowry group of Islands, particularly those inhabiting Chowra and Teressa Islands, still maintain their traditional way of life though the lifestyle of those living in Nancowry, Kamorta and Katchal Islands are in a state of rapid transition due to frequent exposure to modern amenities. The tribal inhabitants of these Islands continue to lead a life closely linked to the nature and are mostly isolated from modern influences. Documentation of ethnomedical practices of the tribes of these islands is scarse and the wealth of the their traditional knowledge remains unexplored. We carried out an extensive ethnobotanical survey with the aim of documenting the use of medicinal plants and the allied traditional knowledge of the Nicobarese tribe living in the presently inhabited Islands of Nancowry group. Some of glimpses of tribals are shown in figure 1 below.

Fig. 1. Glimpses of tribals in Nicobar group of Islands

Underutilized crops of Andaman

Andaman and Nicobar Islands are having a vast variety and diversity in underutilized wild tropical fruits, many of which are of evolutionary climate in specific niche. Most of these fruit trees have remained semi-domesticated while many species have become rare and endangered due to large scale urbanization. These underutilized fruits although having nutritional and commercial medicinal value are yet to be exploited to full potential. These underutilized fruits though contain all the essential ingredients of their diet, yet they are not recognized as important source of minerals and vitamins. These islands being rich in biodiversity have a very large number of underutilized fruits but the information on the nutritive value is not available for all of them. However, the traditional use of these crops does well for remedies of variety of diseases as well as to their livelihood security. Most important underutilized crops of Islands is enlisted in Table1.

Table 1. Some underutilized crops in the Islands

S. No.	Local Name	Botanical Name	Family
1	Bael	*Aegle marmelos*	Rutaceae
2	Jamun	*Syzygium cumini* (L.)	Myrtaceae
3	Amla	*Phyllanthus emblica*	Phyllanthaceae
4	Alligator apple	*Annona glabra* (L.)	Annonaceae
5	Khoon phal	*Haematocarpus validus*	Menispermaceae
6	West Indian Cherry	*Malpighia glabra*	Malpighiaceae
7	Noni	*Morinda citrifolia*	Rubiaceae
8	Carambola	*Averrhoa carambola*	Oxalidaceae

9	Malay Rose apple	*Syzygium malaccense*	Myrtaceae
10	Custard apple	*Annona squamosa*	Annonaceae
11	Bilimbi	*Avverhoa bilimbi*	Oxalidaceae
12	Soursop	*Annona muricata*	Annonaceae
13	Chalta	*Dillenia indica*	Dilleniaceae
14	Fig	*Ficus racemosa* (L.)	Moraceae
15	Tapioca	*Manihot esculenta*	Euphorbiaceae
16	Bread fruit	*Artocarpus ultilis*	Moraceae
17	Jack fruit	*Artocarpus heterophyllus*	Moraceae
18	Pandanus	*Pandanus leram*	Pandanaceae
19	Elephant foot yam	*Amorphophallus paeoniifolius*	Araceae
20	Pomelo	*Citrus maxima*	Rutaceae
21	Ber	*Zizyphus marutiana*	Rhamnaceae
22	Tamarind	*Tamarindus indica*	Leguminosae

Scope of underutilized horticultural crops

In these Islands, there are hilly upland and coastal zones are unfit for supporting cultivation of high input demanding crops. Such lands can easily be put to use for growing low input crops in order to diversify the present day agriculture, which is so inevitable in view of the increasing population pressure and fast depletion of natural resources as well as the growing and changing human needs in the region.

- As paddy-cum-vegetables farming is proving un-remunerative in the undulating topography of hilly tracts, which is deprived of irrigation facilities, their vast potential remains unexploited. It becomes possible to exploit the untapped potential of the region through location specific underutilized plant species cultivation.
- Apart from nutritive value, underutilized crops are particularly more important for medicinal properties and famous for the retentive value in Ayurvedic medicine. Mostly people are familiar with the medicinal properties of locally grown horticultural crops.

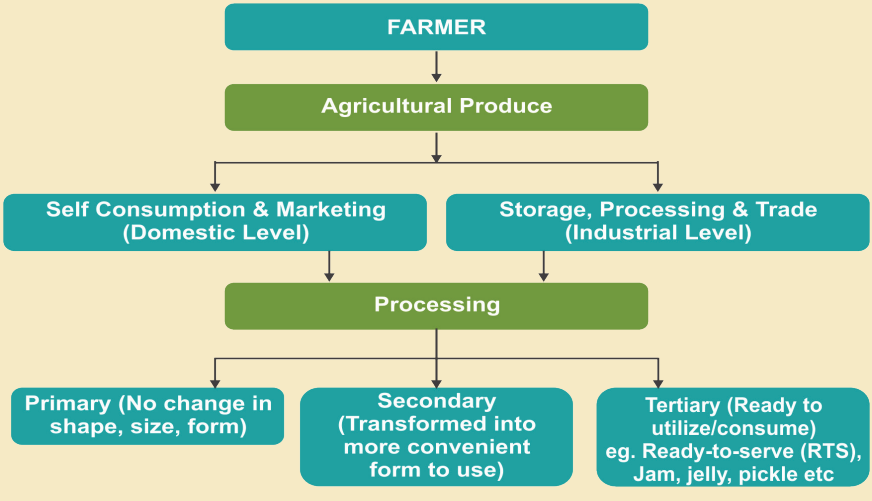
Tropical fruits, which are at present underutilized, have an important role to play in satisfying the demand for nutritious, delicately flavoured and attractive natural foods of high therapeutic value. A huge quantum fresh fruits are being shrivelled and staled, lowering their market value and consumer acceptability. Today, consumers are becoming increasingly conscious of the health and nutritional aspects of their food basket. Hence, proper post harvest management handling and processing is very much essential for required in these crops. Processing not only serves as a purpose of its preservation but also several other purposes such as diversification of the economy, stimulating agricultural production by obtaining marketable products, generate employment, reduce fruit & vegetable losses, develop new value added products from underutilized crops which are also available during off-seasons. The composition of some tropical fruits is presented below (Table 2)

Table 2. Composition of some tropical fruits (per 100 g of edible portion)

Fruits	Edible portion (%)	Mois-ture (%)	Protein (g)	Fat (g)	Min-erals (g)	Fiber (g)	Carbo-hydrates (g)	Carotene (g)	Vitamin (mg)
Aonla	89	81.8	0.5	0.1	0.5	3.4	13.7	9	600
Bael	64	61.5	1.8	0.3	1.7	2.9	31.8	55	8
Custard apple	45	70.5	1.6	0.4	0.9	3.1	23.5	-	37
Jackfruit	30	76.2	1.9	0.1	0.9	1.1	19.8	175	7
Guava	100	81.7	0.9	0.3	0.7	5.2	11.2	0	212
Jamun	75	83.7	0.7	0.3	0.4	0.9	14.0	48	18
Mango	74	81.0	0.6	0.4	0.4	0.7	16.9	2743	16
Sapota	83	73.7	0.7	1.1	0.5	2.6	21.4	97	6
	-	20.9	3.1	0.1	2.9	5.6	67.4	60	3
Wood apple	53	64.2	7.1	3.7	1.9	5.0	18.1	61	3

Value Addition

Process of changing or transforming a product from its original state to a more valuable state is called value addition. All the harvested economic produce are converted into ready to use form through processing at primary, secondary and tertiary levels (Flow chart 1). Processing improves palatability, nutritional value, convenience and shelf life of the product. Primary processing includes cleaning, grading.



Flow chart 1. A generic flow diagram indicating the movement of agricultural produces and products from farmer to consumers

Advantages of processing

- Helps in converting perishable fruits in to durable form
- Fruits, which are very difficult to eat out of hand can be processed in to a range of highly acceptable fruit product.
- Helps in reducing wastage.
- Value addition.

Methods of processing of fruits into products includes one or more of the following

- Preservation by heat treatment.
- Asceptic packaging.
- Preservation of by removal of heat.
- Quick freezing.
- Preservation by removal of moisture.
- Preservation by addition of chemicals.
- Minimal processing.

Drying processes of Different fruits

The process in general, used in drying of fruits and vegetables are shown below, whereas the process used for drying of individual fruit and vegetable is describes separately

Selection
↓
Washing
↓
Sorting Preparation (peeling/slicing/coring/pitting)
↓
Blanching (only in vegetables except onion and garlic)
↓
Spreading on flat surface
↓
Sulphuring
↓
Drying/dehydration
↓
Sweating
↓
Packaging
↓
Storage (at ambient temperatures)

Different types of value added products

Ready to Serve (RTS) products

This is a type of fruit beverage which contains at least 10 per cent fruit juice and 10 percent total soluble besides about 0.3 per cent acid. It is not diluted before serving, hence it is known as ready – to –serve (RTS) can be prepared from different fruits.

Fruit (pulp/juice)
↓
Mixing with strained syrup solution (sugar + water + acid, heated just to dissolve)
↓
Homogenization
↓
Bottling
↓
Crown corking
↓
Cooling
↓
Storage

Squash

This is a type of fruit beverage containing at least 25 per cent fruit juice or pulp 40 to 50 percent total soluble solids, commercially. It also contains about 1.0 per cent acid and 350 ppm sulphur dioxide or 600 ppm sodium benzoate. It can also be prepared from lemon, lime, bael, guava, litchi, pear, aprocit, muskmelon, papaya etc., using potassium metabisulphite (KMS) as preservative, or from jamun, passion fruit, passion fruit, peach, phalsa, etc with sodium benzoate as preservative. The flow chart for preparation of squash is given below.

Fruits
↓
Washing
↓
Trimming
↓
Cutting or grafting
↓
Juice extraction
↓
Straining
↓
Juice measuring
↓

Preparation of syrup (sugar + water + acid, heating just to dissolve)

↓

Straining

↓

Mixing with juice

↓

Addition of preservative (0.6g KMS or 1.0g sodium benzoate / litre squash)

↓

Bottling, Capping and Storage

Jam : Jam is a product made by boiling fruit pulp with sufficient sugar to reasonable thick consistency from enough to hold the fruit tissues in position. Apple, pear, sapota, apricot, loquat, peach, papaya, karonda, carrot, plum, strawberry, raspberry, mango, tomato, grapes and muskmelon are used for preparation of jam. It can be prepared from pieces of fruit, fruit scraping and pulp adhering to cores of fruits which are available in plenty in canning factories. Jam contains 0.5-0.6 per cent acid and invert sugar should not be more than 40 per cent. This is type fruit product containing at least 45 percent fruit juice or pulp and 68 per cent total soluble solids, commercially.

Ripe firm fruits

↓

Washing

↓

Peeling

↓

Pulping (remove seed and core)

↓

Addition of sugar (add water if necessary)

↓

Boiling (with continuous stirring)

↓

Addition of citric acid

↓

Judging of end point by heating up to 105^0 C or 68-70 % by sheet test

↓

Filling hot in to sterilized bottles

↓

Cooling

↓

Waxing

↓

Capping and Storage

Jelly : Jelly is a semi solid product prepared by boiling a clear, strained solution of pectin containing fruits extract, free from pulp, after the addition of sugar and acid. A perfect jelly should be transparent, well set, but not too stiff, and should have the original flavor of the fruit. It should be of attractive color and keep its shape when removed from the mould. It should be firm enough to retain a sharp edge but tender enough to quiver when pressed. It should not be gummy, sticky or syrupy or have crystallized sugar. Guava, sour apple, plum, karonda, wood apple, loquat, papaya and gooseberry are generally used for preparation of jelly, Apricot, pineapple, strawberry, raspberry, etc., can be used only after addition of pectin powder, because these fruits have low pectin content. Jelly is a type of fruit product containing at least 45 per cent fruit juice and 65 per cent total soluble solids. Commercially, Its acid content should be 0.5 -0.75 %.

The process for making jelly is depicted in flow chart below

Fruits (firm, not over ripe)
↓
Washing
↓
Cutting in to think slices
↓
Boiling with water (1.5 times the weight of fruit for about 20-30 mintutes)
↓
Addition of citric acid during boiling (2 g per kg of fruits)
↓
Straining of extract
↓
Pectin test (for addition of sugar)
↓
Boiling
↓
Judging of end point (Sheet/ Drop/ Temperature test)
↓
Removal of scum or foam (one teaspoonful edible oil added for 45 kg sugar)
↓
Color and remaining citric acid added
↓
Filling hot into clean sterilized bottles
↓
Waxing (paraffin wax)
↓
Capping
↓
Storage at ambient temperature

Marmalade

This is a fruit jelly in which slices of the fruit or its peel are suspended. The term is generally used for products made from citrus fruits like oranges and lemons in which shredded peel is used as the suspended material. Citrus marmalades are classified in to (i) Jelly marmalade (ii) jam marmalade. The procedure for preparation of jelly marmalade is mentioned below; however the procedure for making the jam marmalade is same as that for jelly marmalade. In this case the pectin extract of fruit is not clarified and the whole pulp is used, Sugar is added according to the weight of fruit, generally in the proportion of 1:1 the pulp –sugar mixture is cooked till the TSS content reaches 65 %. Marmalade is a type of fruit product containing at least 45 % and 65 % total soluble solids, commercially.

Jelly marmalade

Ripe fruits

↓

Washing

↓

Peeling outer yellow portion thinly

↓

Cutting yellow portion in to fine shreds (1.9-2.5 cm long and 0.8-0.12 cm thick)

↓

Cutting of 0.3 -0.45 cm thick slices of peeled fruit or crushing in to pulp in a grater

↓

Boiling (in 2-3 times its weight of water for 40-60 minutes)

↓

Straining the extract

↓

Testing for pectin content (Alcohol test)

↓

Addition of sugar (as required)

↓

Cooking to 103-105^{0}C (continuous string)

↓

Addition of prepared shreds (shredded peel boiled for 10-15 minutes in several changes of water for softening and removing bitterness and added @ about 62 g of extract)

↓

Boiling till jellying point (continuous stiring)

↓

Testing of end point (sheet/drop/temperature test)

↓

Cooling (to 82-88 ^{0}C with continuous string)

↓

Flavouring (orange oil)

↓

Filling in sterilized bottles

↓

Sealing

↓

Storage at ambient temperatures

Preserve and candy

A mature fruit or vegetable or its pieces impregnated with heavy sugar syrup till it becomes tender and transparent is known as a preserve. Aonla, bael, apple, pear, mango, cherry, karonda, strawberry, pineapple, papaya etc can also be used for making preserves. Preserve is a type of fruit product containing at least 55% fruit portion and 68 % total soluble solids commercially.

A fruit/vegetable impregnated with cane sugar or glucose syrup and subsequently drained free of syrup and dried is known as candied fruit or vegetable. The most suitable fruits for candying are aonla, karonda, pineapple, cherry, papaya, apple, peach and peels of orange, lemon, grapefruit, ginger etc. Pineapple cores which are a waste product in the canning of pineapples, can be candied without any preliminary treatment.

Candy is a type of fruit product containing sugar not less than 70 per cent and reducing sugar as per centage of total sugar not less than 25 %.

Canning of fruits

Fruit are canned in the season when the raw material is available in plenty. The canned products are sold in the offseason and give better returns to the grower. Caning is a process of sealing food stuffs hermetically in containers and sterilizing them by heat for long storage is known as canning. Thus, destruction of spoilage organism within the sealed container by means of heat is the principle of canning which is given below.

Flow chart for canning process Selection of fruit

↓

Grading

↓

Washing

↓

Peeling

↓

Cutting

↓

Blanching

↓

Cooling
↓
Filling and syruping
↓
Brining
↓
Exhausting
↓
Sealing
↓
Processing
↓
Cooling
↓
Storage

Preservation by salt

Pickle is the main product prepared by using salt or brine solution. Pickling involves curing of raw vegetables/fruits with dry salt or brine followed by preserving in spices and condiments or in vinegar. Main ingredients of pickles are 15 to 20% salt, 2 to 10% vinegar, 8 to 10% lactic acid, 10 ppm SO_2, mustard oil or juices. Chilli, cauliflower, carrot, onion and mixed vegetables are common for processing by salt. The flow chart for pickling is given below.

Selection of vegetables/fruits
↓
Washing
↓
Grading
↓
Cutting
↓
Brining (10-12 % salt+ 1% glacial acetic acid+ 100 ppm KMS)
↓
Desalting/freshening
↓
Pickling (salt/vinegar/oil/combinations)
↓
Add preservative (suphur dioxide 100 ppm)
↓
Packing
↓
Storage at ambient temperature

Value added products from different underutilized fruits

Aonla

Fig. 2. Aonla fruit

Aonla fruits are used in traditional Indian systems of medicines, like ayurvedic and unani for treating ailments like common cold, gastric troubles, c hronic diarrhoea and dysentery, headache, constipation, enlarged liver, diabetes, bronchitis, jaundice and fever, etc. Aonla fruit is sour and astringent in taste; hence it is not popular as table fruit. The fruit however has excellent nutritive and therapeutic value; thus has great potentiality for processing into value added products. It is a rich source of ascorbic acid and contains about 20 times more vitamin C than citrus fruit.

Aonla fruits are highly perishable in nature and hence its storage in atmospheric conditions after harvesting is very limited, which is accompanied by browning of the skin, loss of glossiness and vitamin C content. Aonla fruits are processed into a number of food products like preserve, jam, jelly, candy, toffee, pickle, sauce, squash, juice, RTS beverage, cider, shreds, dried powder, etc. Process flow chart for production of various aonla products is given below

Flow chart for Aonla preserve

Aonla fruit
↓
Washing
↓
Pricking
↓
Dip in salt solution (2%)
↓
Washing
↓
Dipping and heating in sugar solution (50% sugar solution upto 70^{O}brix for complete osmosis of sugar solution in Aonla)
↓
End point (70^{O}Brix)
↓
Aonla preserve
↓
Store at room temperature

Flow chart for production of Aonla candy

Aonla fruit

↓

Washing

↓

Blanching

↓

Segmentation

↓

Dipping and heating in sugar solution (50^{O}Brix to 75^{O}Brix)

↓

Remove sugar syrup

↓

Sun drying of aonla segment

↓

Aonla segment

↓

Store at room temperature

Flow Chart for Production of Aonla jam

Aonla fruit

↓

Washing

↓

Heating

↓

Segment

↓

Pulp

↓

Addition of sugar (1:1)

↓

Heating

↓

Aonla jam (end point 68.5^{O} Brix)

Flow chart for production of Aonla juice

Aonla fruit

↓

Washing

↓

Shredding

↓

Extraction of juice

↓

Filteration

Bael fruit (*Aegle marmelos*)

Bael fruits are abundantly found as underutilized crops where a meagre amount are consumed by the local people during festival season. Lot of fruits are getting wasted in the yard causing environmental threat after its decomposition. This calls for effective utilization at domestic level to resolve the above issue.The bael fruit (Fig. 3) is known for its medicinal properties.

Fig 3. Bael fruit

The bael is one of the most nutritious fruits. It contains 61.5 g of water, 1.8 g of protein, 1.7 g of minerals, 31.8 g of carbohydrates and 1.19 mg of riboflavin/100 g edible portion. It may be noted that no other fruits has such a high content of riboflavin.

Processing and value addition of bael

Bael fruit can be stored for 10-15 days at normal temperature, whereas fruit harvested at ripe stage can be stored for a week. From extracted bael pulp, various fruit products *viz.*, preserve, candy, jam, RTS, nectar squash/leather/slab, powder etc., are prepared which can be commercially exploited.

Preserve and Candy

Preserve and candy are prepared from mature (tender green fruit), hole or large pieces of fruit in which sugar is impregnated till its becomes tender and transparent. The minimum fruit portion and total soluble solids in preserves (Fig.4) should be 55 and 70%. Fruits in general contain more than 75% water and get spoiled quickly if not stored properly. Removal of water from fruits is known to help in longer period of storage. The osmotic dehydration techniques not only enables the storage of fruits for a longer period but also preserve the flavor, colour and texture of the product to a great extent and prevents its microbial spoilage.

Fig. 4. Bael preserve

"A fruit of its pieces impregnated with sugar or glucose syrup, subsequently drained free of syrup and dried is known as candied fruit". The total sugar content of the impregnated fruit is kept at about 75% to prevent fermentation. In case of bael candy, the fruit slices are drained subsequently free of syrup and dried at 55-60oC for 8-10 hrs in oven. The method of preparation of bael candy are given in flow chart below.

Flow chart for preserve and candy

Mature fruit
↓
Washing
↓
Preparation of sugar treatment
↓
Keeping fruit and sugar in alternate layer(1 kg fruit : 1kg sugar) or steeping fruit in syrup of 40%TSS for a day
↓
Removal of fruit
↓
Increasing consistency of syrup to 60%TSS by folding
↓
Steeping of fruit (for a day)
↓
Repairing the process and raising strength of syrup by 50% TSS to 70% TSS (preserve) or 75% TSS (candy) on alternate day Steeping in 70% TSS for a week

Preserve
↓
Draining
↓
Filling in jar or container
↓
Covering fruit with fleshy prepared sugar syrup
↓
Sealing
↓
Storage

Steeping in 75% TSS for a week
↓
Draining
↓
Shade drying (prior to drying, fruits dipped in boiling water to remove adhering syrup
↓
Packing
↓
storage

Bael Fruit Squash

An ideal composition of bael fruit squash (Fig. 5) is 50 % extracted pulp, 50 ^{0}Brix and 1% acidity. The squash was chemically preserved by addition of 300 ppm SO_2. Fruit beverages commercially contains at least 25 % fruit pulp or juice and 40-50 % TSS, besides 1 % acid. The squash from bael fruit

Fig. 5. Bael preserve

pulp is prepared by adjusting the TSS and by adding the preservatives like sodium metabisulphite @ 350 ppm SO_2, sodium benzoate @ 1g/litre. The squash was then filled in sterilized bottles, crowned and pasteurized at 80 °C for 30 minutes fallowed by cooling and wax sealing to insure air tightness.

Bael fruit pulp

The ripe fruits are to be washed with tap water and broken by striking against hard object. The fruit pulp along with seeds and fibres is scooped with the help of stainless steel spoon. Amount of water equal to the weight of pulp is added. Then, the mixture of pulp and water is heated to 80°C for 1 minute and cooled. Pulp free from seeds and fibres is then obtained by passing through 20 mesh stainless steel sieve. The extracted bael pulp (Fig. 6) may be improved by adjusting the TSS by addition of sugar and acidity by the addition of citric acid.

Fig. 6. Bael pulp

Dehydrated Bael powder

Select mature green fruits, wash and cut 1-1.5 cm thick slices of fruit pulp after removing its hard shell. Fumigate these slices with sulphur dioxide fumes for an hour in sulphur box and dehydrated in oven up to a constant weight. Pack dried slices in polyethylene bags or glass jar for future use. Before this, fruits are cracked and treated with (i) hot water at 70 °C for 1 hour, (ii) hot sand for 2 hours, (iii) oven for 2 hours at 70 °C, after that, rind of bael fruit is broken and removed the bael pulp, and dried in direct sun light.

Bael Ready-to-serve (Bael RTS)

For preparing bael ready-to-serve (RTS) drink, TSS (%) and acidity (%) in the extracted bael fruit pulp is to be analyzed. On the basis of analysis, requisite amounts of sugar and citric acid dissolved in required amount of water were added to measure quantity of bael pulp for adjustment of TSS (%) and acidity (%) in RTS drink (Fig. 7) as per treatment. The prepared RTS drink is thoroughly homogenized and filled in clean, sterilized 200 ml capacity glass bottles leaving 2-3 cm head space. The beverage filled bottles are sealed with sterilized crown corks, pasteurized in boiling water for 5-6 minute, cooled in air and stored in cool and dry place.

Fig. 7. RTS Bael

Bael Jam

Fig. 8. Bael Jam

Jam is a concentrated fruit product posessing a fairly heavy body, rich in natural fruit flavour. Pectin in fruit gives it a good set and high concentration of sugar facilitates its preservation. It is prepared by boiling the fruit pulp and juice with sufficient quantity of sugar to a reasonably thick consistency to hold the fruit tissues in position. A fruit jam should contain minimum 45% of fruit portion and minimum 68% of total soluble solids (Fig. 8). The process flow chart is given below.

Flow chart for Bael Jam

Ripe firm fruits

↓

Washing

↓

Peeling

↓

Pulping (remove seed and core)

↓

Addition of sugar (add water if necessary)

↓

Boiling (with continuous stirring)

↓

Addition of citric acid

↓

Judging of end-point by further cooking up to 105^{O}C OR 68-70%TSS or by sheet test

↓

Filling hot into sterilized bottles

↓

Cooling

↓

Waxing

↓

Capping

↓

Storage (at ambient temperature)

Bael Slab

Fig. 9. Bael Slab

It is also known as leather or paper. Ripe fruits are used in its preparation. Wash ripe fruits and collect fruit pulp by breaking fruits and removing its hard shell. Add 200-300 ml of water per kg of fruit pulp, mix well and heat it up to 80^0C. Collect fruit pulp free of seeds and fibers by straining heated mass through stainless steel sieve. Sugar, citric acid and potassium meta-bisulphite (KMS) to this pulp is added so that treated pulp contains 35% total soluble solids, 0.5% total acidity and 0.07% KMS. Then, boil the treated pulp and spread on aluminum trays smeared with butter followed by drying at 55-60^0C for 15-16 hours to a moisture content of 14.5%. Cut slaves of dried pulp in aluminum trays, wrap in butter paper and pack in polyethylene bags (Flow chart below). Addition of up to 10 % sugar to the extracted pulp is found to be ideal before drying the pulp to a moisture content of 14.5 % (Fig. 9).

Flow chart for bael slab

Fruits (mature, ripe)
↓
Washing
↓
Remove the hard shell
↓
Seed removal and separation into segments
↓
Extraction of fruit pulp
↓
Mixed 200-300ml water/kg fruit pulp
↓
Heated up to 80^{O}C
↓
Strained the fruit pulp with stainless steel sieve
↓
Addition of sugar, citric acid and KMS
↓
Boiling of pulp
↓
Spread on aluminium trays smeared with butter
↓

Dry at 55-60^{O}C for 15-16 hrs to a moisture content of 14.5%

↓

Wrap dried pulp in butter paper and pack in polyethylene bags

↓

Storage

Flavoured bael products

Sometimes, the flavour of bael pulp is not acceptable to some people. In this case, by blending the pulp with spices (cardamom and zinger) may makes it palatable and acceptable. In addition to this, blending of pulp may enhance the nutritional qualities compared to the pure product. Nutritive value of candy prepared by incorporation of different flavours showed that the energy, protein, fat, carbohydrate, fiber, calcium, iron, and phosphrous increases by incorporation of ginger and cardamom whereas the nutritive value did not change with the incorporation of rose extract. The nutritive value of the blended products with the incorporation of 2% each of ginger, cardamom and rose extract are shown in Table 3-5.

Table 3. Nutritive value of bael candy with different flavours (100 g)

	Energy (Kcal)	Protein (g)	Fat (g)	Carbohydrate (g)	Fiber (g)	Calcium (mg)	Iron (mg)	Phosphous (mg)
Ginger	309	0.67	0.10	76.41	0.98	36.23	0.27	17.62
Cardamom	310	0.73	0.11	76.60	1.09	36.95	0.28	18.28
Rose extract	308	0.62	0.10	76.33	0.96	36.09	0.25	17.22

Table 4. Nutritive value of bael jam with different flavours (100 g)

	Energy (Kcal)	Protein (g)	Fat (g)	Carbohydrate (g)	Fiber (g)	Calcium (mg)	Iron (mg)	Phosphous (mg)
Ginger	265	0.96	0.15	65.03	1.46	48.22	0.41	25.84
Cardamom	267	1.04	0.17	65.32	1.63	49.31	0.42	26.83
Rose extract	265	0.94	0.15	64.91	1.44	48.02	0.37	25.25

Table 5. Nutritive value of bael chutney with different flavours (100 g)

	Energy (Kcal)	Protein (g)	Fat (g)	Carbohydrate (g)	Fiber (g)	Calcium (mg)	Iron (mg)	Phosphous (mg)
Ginger	231	1.28	5.39	44.29	1.79	53.59	0.66	36.82
Cardamom	233	1.38	5.42	44.61	1.98	54.74	0.67	37.86
Rose extract	230	1.27	5.39	44.17	1.77	53.38	0.63	36.20

Jamun *(Syzygium cumini)*

Fig. 10. Jamun fruit

Jamun (Fig. 10) falls in underutilizing fruit species which is neither cultivated in an organized farming system nor processed by established commercial processing methods particularly in the Islands. The fruits are widely used by traditional practitioners over many centuries for the treatment of a number of diseases due to presence of following pharmacological actions *viz.*, free radical scavenging, antioxidant, hepatoprotective, anti-diarrhoeal, hypoglycaemic, antidiabetic effects, antibacterial, antifungal, antiviral, anti-allergic, anticancer etc. The jamun fruit contains 83.7-85.8 g moisture, 0.7- 0.129 g protein, 0.15-0.3 g fat, 0.3-0.9 g crude fiber, 14 g carbohydrate, 0.32-0.4 g ash with traces of micronutrients. Different value added product prepared from Jamun are described briefly.

RTS Jamun

The process flow chart is similar to bael. Fresh ripe fruits are washed properly and the spoiled fruits are discarded. Pulping is to be done by pulper machine. Straining with the help of muslin clothes are needed to collect the dark purple colour juice. Then, the TSS and TA are measured and on the basis of analysis, requisite amounts of sugar and citric acid dissolved in required amount of water are added to measure quantity of jamun pulp (Fig. 11) for adjustment of TSS (%) and acidity (%) in RTS drink as per treatment. The prepared RTS drink (Fig. 12) was thoroughly homogenized and filled in clean, sterilized 200 ml capacity glass bottles leaving 2-3 cm head space. The beverage filled bottles were sealed with sterilized crown corks, pasteurized at 80ºC for 5-6 minutes followed by hot packaging in sterile bottles. After cooling, the products are stored in a refrigerator. It is observed that the maximum yield of jamun juice with a high level of the anthocyanin and other soluble constituents is obtained by grating the fruit, heating up to 70ºC and passing the heated mass through a basket press. The attractive colour due to anthocyanin pigments is a major quality attributes in jamun beverages. The anthocyanin pigments are destroyed at high storage temperature. Refrigerated storage has stabilizing effect on the anthocyanins of the fruit juices upto one year.

Fig. 11. Jamun pulp

Fig. 12. RTS Jamun

Jamun enriched Shrikhand

The jamun pulp powder are prepared from pilot scale spray dryer. Before the samples fed in to spray dryer, pulp is to be well mixed with appropriate proportion of water and maltodextrin. The standardized level of inletair temperature and concentration of maltodextrin were 185°C and 10 % respectively. The flow diagram for enriched shrikhand is shown below

Flow diagram for the manufacture of jamun enriched shrikhand

Milk
↓
Filtration
↓
Standardization (4.5% fat and 8.5% SNF)
↓
Heating (85°C for 30 minutes)
↓
Cooling (20-25°C)
↓
Inoculation (2-3%)
↓
Incubation
↓
Breaking of set curd
↓
Filtration whey
↓
Sugar (30.66%)
↓
Obtained solid mass (chakka)
↓
Jamun pulp powder (12.78%)
↓
Mixing and kneading
↓
Shrikhand

Jun seed powder

After pulping, the seeds (Fig. 13) are thoroughly cleaned using tap water. The cleaned seeds are dried under sun or at cabinet dryer at 45-50^{0}C for 24-28 hours for attaining safe moisture content of 5-6%. Then the dried seeds are powdered using mixture grinder followed by packaging in moisture proof barrier (polyethylene bags or glass jar). The product will be safe for use upto six months (Fig. 14).

Fig. 13. Jamun seed

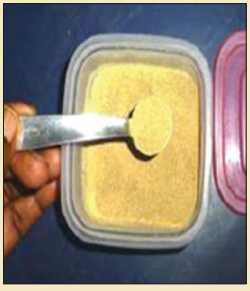


Fig. 14. Jamun seed powder

Jamun squash (Fig. 15) and jam (Fig. 16) are made as per same procedure of bael squash/jam.

Fig. 15. Jamun jam

Fig. 16. Jamun squash

Jackfruit (*Artocarpus heterophyllus L.*)

Fig. 17. Jack fruit

The jackfruit (Fig. 17) tree is a widely cultivated and popular food item throughout the tropical regions of the world. It is indigenous to India, giving the heaviest single fruit (40 kg.) and high yielder producing more than many of the fruit trees. The perianth portion of the fruit are fleshy, fibrous, and rich in sugars, minerals, carboxylic acids, dietary fibre, and vitamins such as ascorbic acid and thiamine. Jackfruit contains water (73.1 %), protein (0.6 %), fat (0.6 %), carbohydrate (23.4 %), fibre (1.8 %) and ash (0.5 %).

Procedure extraction of pulp

Fig. 18. Jack fruit bulb and seed

Fresh ripe fruits are cut into in four sections from vertical to horizontal section. Separate the cubes and remove the seeds (Fig. 18) and collect the fresh flesh. Pulping by pulper machine and collect the pulp. Filled in sterilized bottles with adding of preservative, capping and sealing. Pasteurized at 80ºC for 20 minutes. Stored

at refrigeration or room temperature. In room temperature, pulp can be stored up to 10 month but in refrigeration can be stored up to 2 years.

RTS Jackfruit

After pulping, the TSS and TA of pulp are recorded. Sugar syrup is prepared and citric acid is added to the boiled syrup for clarification. Strain the syrup and cool it. The required amount of pulp are added keeping in view the RTS requirement as per FPO standard. Syrup is added little by little to pulp and mixed by stirring to get final RTS. The product is pasteurized at 80-85 ºC for 10-12 minute followed by hot packaging in sterile bottles. After cooling, the bottle are kept in refrigerator and it is found that 14°Brix TSS, 0.22% TA and 16% pulp is the optimal condition for RTS having better organoleptic quality. Sometimes, potassium metabisulphite @0.2 g/l of final product may added instead of citric acid.

Jack fruit jam

Fig. 19. Jack fruit Jam

It is a promising products for the tribals due to its sweet and fruity taste as well as the texture which can be enjoyed with any bakery stuff. To popularize the jack fruit, its jam are developed at CIARI. The developed product was found to be highly acceptable with distinct jackfruit color and flavor. The fruit content for the jam preparation is 45% and pH of jam (Fig. 19) is set to 3.2 since pectin stability is highest at pH 3-4 as the glycosidic linkages hydrolyze in a stronger acidic medium. During storage at ambient temperature ascorbic acid along with total carotenoids get decreased. The samples shows an overall acceptance up to six months of storage at ambient (23-31^{0}C) temperature. The procedure for jam preparation is similar to other products as described before.

Jack fruit leather

Fig. 20. Jack fruit leather

Fruit leather or bar (Fig. 20) is an intermediate moisture product, which is stabilized by reducing the water activity (aw) in order to prevent microbial spoilage. The aw of the developed leather is reduced to below 0. 7 to increase the shelf life of the product. The moisture content in the final product is kept at 22.5%. In the controlled laboratory conditions drying is accomplished in 12 hours at 60^{0}C. Drying was fast at the initial stages of drying where 55% of the moisture was removed during the initial 5 hours of drying. At the end of 10 hours of drying the leather was turned upside down for the drying of the inside layer. The finished product is found to be very tasty and highly acceptable. Product stability was found to be satisfactory with optimal sensory attributes endorsed with sufficient chewiness.

Dehydrated crisps

Dehydrated crisps from jackfruit bulbs could provide convenience to the consumers. The average moisture content of fresh jackfruit bulb slices is around 76±0.02% (wb) which has to be reduced to 5-7% by drying. Rehydration ratio of crisp is found to be 1.61. Browning resulting from the enzymatic and non-enzymatic reactions in dried fruits plays a major role in acceptability of these products. In the jackfruit crisp sample, non- enzymatic browning may be observed during storage as the enzyme activity is restricted during blanching of jackfruit slices prior to drying. Up to six months of storage very low microbial count was detected in the samples. The crisps is found to be acceptable upto more than six months of storage at ambient (23-31^{0}C) temperature. Dehydrated crisps could be used as either food product as such or as ingredient in formulations of various food products during industrial operations.

Custard apple (*Annona* sp)

Sugar apple fruit (Annona) is a tropical fruit (Fig. 21) very prized for its pleasant, aromatic and distinctive flavor. Annonas are generally consumed as fresh fruits, but are also widely used in semi-processed and processed products. Annona is ideal for processing due to the high recovery of pulp and also because of its properties, especially the exotic taste and smell.

Fig. 21. Custard apple

The fruit is an excellent source of energy as it is high in carbohydrate. The fruit contains vitamin C, minerals such as calcium, phosphorus and potassium. A large number of chemical compounds, including flavonoids, alkaloids and acetogenins, have been extracted from annona seeds and many other parts of the plant. The fruits of sugar apple, atemoya and soursop (the species of *Annona*) are oval or heart-shaped with tender soft pliable spines which breakup easily when the fruit is ripe. There is no commercial jam of sugar apple till now. Fruits in its both raw and processed form have long been important items of human diet. Through processing, the shelf life of such products can be increased. The value addition process not only enhances the life of perishable products but also creates a good market relative to that in raw form. It helps to withdraw the surplus produce from the market in the post harvest season, stabilizes the prices and assists in maintaining a stock of fruits to meet the demand in off-seasons.

Pre-processing of Annona

Firstly, the annona fruits are cut into two halves, the pulp and the seeds are removed manually. Then, the fresh pulp is placed in the containers. Alternatively, the pulp is blended with potassium metabisulphite (0.4 g/kg) in a frozen storage or by adding potassium metabisulphite (0.8 g/kg) at room temperature. Then it is placed in jars and stored for about 5 months.

Annona Juice

Annona juice is highly perishable when fresh, often spoiling within a day after being extracted. The pulp can be used for the juice extraction. The juice

can be extracted with screw press, basket press or simple hand pressing; juice is strained through muslin cloth which is clarified by adding 1.4 g of PVP (Poly Vinyl Pyrrolidone) per liter of juice. Juice is boiled with sugar and cooled. 10 g sodium benzoate is added as a preservative. The mixture should be poured into well sterilized bottles, cork air tight with crown cork and store in a cool dry place.

Annona fruit pulp concentrate

Fruit should be selected, rinsed, and hand peeled, and the seeds removed. Then pulps is heated to 80°C for 1 minute then cool and determine soluble solids content. Add 1 g of sodium benzoate per kg of pulp, blend for 10 minutes, then sieve. Again it is allowed to concentrate at 100°C for a 3-4 minutes followed by storing in a container. Fruit should be hand-peeled and cored, as fruits have fragile skin, irregular shape and soft pulp, all of which limit machine processing. Fruit pulp processed below 93°C and frozen into polythene bags offers a high quality product with no loss of taste or smell.

Oxidation is a very common problem with processed annona pulp. To avoid oxidation, the pulp can be heated at 70°C for 20 minutes, and 0.5% of ascorbic acid can then be added.

This preparation can be stored in polythene bags for one month at 5°C in a refrigerator.Frozen pulp should be kept at -18°C.

Annona syrup

Extraction of juice and removal of astringency are done in the same way as in the pre-treatment of juice. Sugar is added at the rate of 0.37 kg for every litre of juice and 1g citric acid per litre. Then mix the pulp with water, sugar and citric acid and boil for 3 mins at70°C.The clear syrup is cooled and filled in bottles. The bottles are sealed using crown caps and sterilized for 15 minutes at 95°C.

Annona jam

Annona is thoroughly cleaned by washing with water. The skin is peeled and the seeds are removed manually. Then the pulp are crushed and mixed with sugar in the ratio of 1:1.then the mixture is boiled. A pinch of citric acid is added to improve the taste. The pulp is mixed with potassium metabisulphite (0.1 g/kg in water). Finally it is stored well in sterilized jam bottles.

Noni (*Morinda citrifolia*)

Fig. 22. Noni fruit

Noni (Fig. 22) is commonly referred to the species *M. citirfolia* and is also called as Indian Mulberry. It is an evergreen tree found growing in open coastal regions at sea level (*Fig. 1*) and in forest areas up to about 1300 feet above sea level which is very conducive to these Islands. The mature Noni fruit has a foul taste and odour. The fruit juice is in high demand in alternative medicine for different kinds of illnesses such as arthritis, diabetes, high blood pressure, muscle aches and pains, heart disease, AIDS, cancers, gastric ulcer, sprains, mental depression and

arteriosclerosis etc. The shelf life of noni after harvesting is only 2-3 days and so, proper processing intervention should be made for its utilization enabling different value added products.

Noni jam

Due to high tannin content of fruit, it is acidic and very bitter in taste. Just in few moments, peeled fruit tend to be darker in colour due to high level of enzymatic oxidation. So, care must be taken to avoid such thing by adding turmeric powder. To make noni fruit into edible, other fruit pulps are added as below.

Mixed Noni Jam Fruit (Fig. 23)

Noni extract	: 170 g
Fruit pulp	: 1.25 kg
Sugar	: 1.25 kg
Citric acid	: 7.5 g
Essence	: 3 ml
Pulp:noni ratio	: 7.35

Fig. 23. Mixed Noni Jam

For noni pickle (Fig. 24), following ingredients are to be used for better organoleptic taste.

Noni fruit	: 1 kg (850 g extract)
Salt	: 200 g
Fenugreek powder	: 25g
Chilli powder	: 15 g
Turmeric powder	: 10 g
Mustard powder	: 25 g
Hing	: 2.5 g
Mustard oil	: 400 ml

Fig. 24. Noni Pickle

RTS noni blended beverage : For the preparation of RTS noni (Fig. 25) , 12% pulp, 8% TSS and 0.98% TA was found to be satisfactory. The physico-chemical properties of pure noni juice is given in table 6. However, to enhance the palatability of the product, fruit pulp from apple, guava, cherry, pomegranate and grapes may be added to provide acceptable flavour (Fig. 26).

Table 6. Physicochemical properties of noni juice

Characteristics	Values
TSS (^{o}brix)	8.23
pH	4.19
Brix:Acid ratio	8.39
Acidity	0.98
Reducing sugar (%)	1.35
Total phenol (%)	0.81
Ascorbic acid (mg/100 g)	33.54
Carbohydrate (%)	3.94
Protein (%)	0.42
Energy (KCal)	168

Fig. 25. Pure noni

Fig. 26. blended noni juice

Carambola (*Averrhoa carambola*)

Fig. 27. Carambola fruit

Carambola (Fig. 27) is also known as Star fruit. It is a good source of potassium, copper, as well as folate and pantothenic acid. In spite of its high availability, it is an underutilized fruit in the Indian market. The plant is proved to possess medicinal properties such as anti-inflammatory, analgesic, hypoglycemic, antimicrobial, hepatoprotective and anti-ulcer activity and therefore the plant and its fruit can be used as a potent medicine. The ascorbic acid level of the star fruit is believed to be responsible for its sweet or sour taste. It is often consumed fresh and also processed into jam, jelly, sweets, fresh juice and cordial concentrate. Star fruit is rich in nutritive value – 100 g of star fruit pulp contain 0.38 g protein, 9.38 g carbohydrates, 35.7 calories, 0.08 g fat, 89-91 g moisture, 0.80-0.90 g fiber, 0.26-0.40 g ash, 26-53.1 mg Ascorbic Acid, 4.4-6 mg Calcium, 0.32-1.65 mg Iron, 15.5-21 mg Phosphorus, 0.003-0.552 mg Carotene, 0.03-0.038 mg Thiamine, 0.019-0.03 mg Riboflavin and 0.294-0.38 mg Niacin.

Extraction of Carambola fruit Juice

The fully ripe, healthy and fresh fruit need to be washed thoroughly with potable water. The seeds are removed and then the fruit is blended by a blending machine. The juice thus obtained is preserved by freezing at -20°C.

Jam

Selections of fresh mature fruit are weighted and washed them thoroughly with cold water. Then the washed fruits are cut with a stainless steel knife into small pieces. Pulp was extracted from fruit and adjusted the pH by addition of citric acid or sodium hydroxide. Then the pulp are filtered, strained and mixed. For 1 kg of jam, 450 g fruit pulp, 550 g sugar, 5 g citric acid are used in addition to 5 g of pectin (High Methoxy pectin >50). Pectin are mixed with equal amount of sugar in a stainless steel pot. The remaining sugar should be mixed with fruit pulp and heated until the TSS become nearer to 55° Brix. Then sugar mixed pectin are added and continued the heating until TSS becomes nearer to 58° Brix. The citric acid is added and continue the heating. When TSS of the jelly becomes 68° Brix, then the KMS are added and then poured in a sterilized glass bottle and parafinning the cap.

Squash

Sugar, citric acid, juice and KMS are to be weighted as required separately (Table 7). Water also measured according to calculation. Then, sugar and acid are mixed in water (a small quantity of water to be taken out from the measured quantity to dissolve KMS later on). After that, heated the mixture to boil and strained through filter. Then, cool the syrup. The above syrup are mixed with the juice. Then KMS is dissolved in calculated quantity of water and added to the squash. Finally, poured into pasteurized bottles and sealed.

Table 7. Formulation of Carambola fruit Squash

Ingredients	Amount
Juice	250 ml
Sugar	372 g
Citric acid	11.5 g
KMS	0.52 g
Water	365.54 ml

Tamarind (*Tamarindus indica*)

Fig. 28. Tamarind pod

The fruit of tamarind (Fig. 28) is 5 to 15 cm long pod with 3 to 10 seeds surrounded with edible pulp which is principal souring agent for sauces, chutney, in beverages and in general cooking. Pulp is carminative, laxative, given as infusion in biliousness and febrile conditions. It is also used in dyring and tanning and for polishing and cleaning metal ware. The tartaric acid is extracted from unripe fruits. The polysaccharide (jellose) is extracted from seeds, which is used as a sizing material in the cotton and jute industries. Besides, polyose obtained from the seed is good substitute for fruit pectin in the preparation of jam, jelly or marmalade. The bark and leaves are used for tanning. Tamarind balls are prepared after taking out seeds from the fruit. Tamarind paste and tamarind juice concentrate are the other commercial products.

Ber (*Zizyphus mauritiana*)

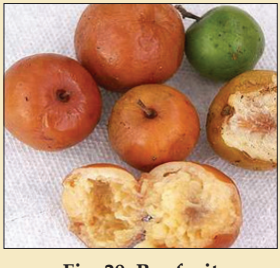


Fig. 29. Ber fruit

Ber fruit (Fig. 29) are consumed as such or can be processed into different fruit products. Juicy varieties are better suited for pulp and juice extraction. The fully ripe, well-developed fruits are washed de-stoned and juicer extracts juice. Ber juice can be used for the preparation of ready to serve beverage. Carbonated beverage of ber is highly acceptable and has excellent keeping quality. Dehydrated powder is prepared by treating ber fruits with sulphur dioxide at 3.5-10 g/kg

for 3 hours followed by sun drying, or carbinet drying below 15% moisture. Ber can be utilized for candy and ber pulp can be processed into wine. The steps include diluting the pulp, adding pectinase enzymes adjusting proper Brix with sugar, addition of yeast, fermentation, stabilization and clarification.

Processing and value addition of ber

Delicious preserve, osmo air-dried products, chauhara and RTS can be made from mature ber fruits. Only fully mature fruits at the hard stage are used for making preserve and osmodehydrated products. Ripe fruits do not make a good product. The fruits are pricked and softened so that sugar impregnation is uniform and effective. Pricking of the fruits can be done manually with a fork or a pricking board. The fruits are dipped in boiling water for 1 to 2 minutes depending on the cultivar and then rinsed in cold water. The prepared fruits are kept submerged overnight in sugar syrup of 25^0 to 30^0 brix. However, it is better to use the lower starting strength of 30^0 brix to avoid shrinking of fruits. Addition of citric acid at 0.1 % to the syrup imparts a bright colour and slightly acidic taste to the product. The concentration of citric acid required depends upon the acid content in the fruit of a particular cultivar. The strength of the sugar syrup is then slowly increased by repeatedly adding sugar for several days raised by 5^0 brix each day until it reaches 6^0 brix and then on alternate days until it is 75^0 brix.

Value addition in tubers

Fig. 30. Tapioca

Roots and tubers are the third important food for human after cereals grain and legumes. These crops constitute either staple or subsidiary food for about one fifth of the word population and are known to supply a cheap source of energy especially for the weaker sections of the population. In A &N Islands, tribals depend on tubers as source healthy foods. The importance and dietary fibre in tubers is well recognized. Dietary fibre reduces the serum cholesterol, prevents colon cancer and maintains good intestinal health as well as provides prophylactic action for cardio-vascular diseases, diabetes and obesity. Tropical tuber crops are tapioca (cassava), sweet potato, aroids (elephant footyam, taro, tannia and gaint taro), yams (greater yam and lesser yam) and other minor tubers namely arrow root and yam bean etc.

Tapioca and among the aroids, elephant footyam (*Amorphophallus paeoniifolius*) and taro (*Colocasia esculenta*), Nicobari Aloo *(Dioscorea alata)* are an important tropical minor tuber crops extensively grown in Nicobar Islands. As a primary staple, they form the major energy source for a vast segment of tribal population. As a secondary staple or vegetable, these crops find wider acceptability and nutritionally, these tubers are rich in carbohydrate, vitamins and minerals.

Processing of tapioca

After harvest, the tapioca are to be washed and peeled. In the Islands, sun drying of tapioca (Fig. 31) by cutting into small chips is very common. But the quality is not upto the mark as this process harbor many micro-organism to grow

due to adverse tropical climate vis-s-vis long drying days. So, pretreatment (blanching) followed by drying in mechanical dryer is essential for its proper utilization.

Fig. 31. Sun drying of tapioca chips

Processing of selected tubers into flour

After the pre-treatment, the tubers were washed in tap water and cut into (1-2 mm) cubes. The cubes were blanched for 5 minutes, blanching helps to kill the harmful microorganisms, soften the cell walls, speed up the drying process and increase the shelf life and to prevent fresh odour in the processed tuber flour. After blanching, the tuber cubes were spread on the trays and were dried in the dehydrator. The cabinet drier was pre-heated at 80° C and the trays were loaded with tuber cubes which were kept in the cabinet dryer. The temperature was maintained at 80° C for 4 hours. The dried cubes were subjected to milling process by using pulverizer, to obtain the fine flow that was sieved by using the sieve. The details of preparation of flour from the selected tubers are given below.

Processing of tuber in the form of flour

Selection of tubers
↓
Washing
↓
Peeling
↓
Cutting (large cubes)
↓
Soaking
↓
(1 % citric acid, 1 hour for elephant foot yam and taro)
↓
Washing (2 times)
↓
Cutting (small cubes in 2 mm)
↓
Blanching (5 minutes)
↓
Drying (80°C, 4 minutes)
↓
Milling
↓
Flour

↓

Roasting (80°C, 5 hour)

↓

Packing

Standardization of value added products from the selected tubers

Puffed snack

Preparation of puffed snack was standardized by incorporating (elephant foot yam, *karunai kizhangu* and Taro) flour at different level of 10, 20 and 30 per cent. The details of processing of puffed snack are given below.

Processing of puffed snack

Maize flour + tuber flour

↓

Mixing (10% moisture)

↓

Tempering for one hour

↓

Mixing

↓

Extruder after pre heating twin screw extruder to 100°C

↓

Puffed snack

↓

Cooling

↓

Packing (polyethylene and metalized polypropylene)

↓

Storing

Value added products from cashew nut

Fig. 32 Cashew Apple

Cashew apple (*Anacardium occidentale* L.) is not a true fruit, but swollen peduncle to which the nut is attached and widely grown in tropical areas. The cashew apple also contains sugars and considerable amounts of tannins and minerals, mainly calcium, iron and phosphorous. Cashew apple (Fig. 32), though very juicy and sweet, is not normally consumed because of its astringent and acrid anacardol and anacardic acid. The phenolic compounds present in apple are mostly responsible for astringency of the juice. The nutritive Value of cashew apple is given in Table 8. Cashew processing is a very competitive and a potentially lucrative activity that has to be exploited by more small-scale processors in Islands. The main objective of processing is to remove

the valuable cashew kernel from the shell with as little damage as possible. Whole kernels command a higher price than broken and pieces. Cashew kernels are a high value luxury commodity with sales growing steadily at an annual rate of 7%.

Table. 8 Nutritive value of fresh cashew apple

Constituent	Per 100 g of fresh cashew apple
Moisture	84.4 – 88.7 g
Protein	0.101-0.162 g
Fat	0.05-0.50 g
Carbohydrates	9.08-9.75 g
Fiber	0.4-1.0 g
Ash	0.19-0.34 g
Calcium	0.9 - 5.4 mg
Phosphorus	6.1-21.4 mg
Iron	0.19 - 0.71 mg
Carotene	0.03 - 0.742 mg
Thiamine	0.023-0.03 mg
Riboflavin	0.13-0.4 mg
Niacin	0.13-0.539 mg
Ascorbic Acid	146.6-372.0 mg

Processing of cashew apple

Cashew juice

The juice contains a fair amount of tannin which has detrimental role in physiological functions in human body. The cashew juice processing is given in flow chart below. The juice can be extracted with screw press, basket press or simple hand pressing; juice is strained through muslin cloth which is clarified by adding 1.4 g of PVP (Poly Vinyl Pyrrolidone) per liter of juice. The mixture should be poured into well sterilized bottles, cork air tight with crown cork and store in a cool dry place. The astringent properties of the cashew apple are removed by clarification and the clarification agents are cassava starch, rice gruel, gelatin powder, gelatin, PVP. For preparation of "Ready-To-Serve"(RTS) beverage, 12% total soluble solid (TSS) and 0.26 % titrable acidity (TA) and preservative (mainly citric acid) is found satisfactory.

Harvesting
↓
Nut detachment
↓
Washing
↓
Pressing
↓
Storage (4^0C)

↓

Clarification

↓

Analysis of TSS (%) and acidity (%) in fruit pulp

↓

Addition of sugar and preservative

↓

Pasteurization at 80-85^{0}C for 3-4 minutes

↓

Pasteurization at 80-85^{0}C for 3-4 minuntes

↓

Bottling (crown corking)

↓

Labelling

↓

Storage

Flow chart for RTS cashew juice

Cashew fenny

Fig. 33 Preparation of Cashew fenny

Fenny is flavoured liquor made from the juice of the cashew apple. Traditionally the cashew apples are manually crushed by a rock and juice is collected in a huge earthen pot (Fig. 33) which is buried in the ground. The juice is then distilled in earthen or big copper pots. When the cashew apples are crushed, the pulp is arranged in the shape of a cake in the coimbi and tied with a string. A huge boulder is then placed on top of it. The final quota of juice which trickles out in a clean form is called *Neero*, it helps bowel movement and provides relief from constipation. The juice is then boiled and the concentrated liquid collects in the smaller pot, the pressure in the receiver is kept in check by pouring cold water on it frequently with a wooden ladle. The first stage of processing may be done with higher temperature but the later stage of distillation has to be done with lower temperature to keep the pressure and heat under control. The process of distilling fenny takes about 8 hours. The liquor produced from cashew is of three grades Urrac, Cazulo and Fenny. The Urrac is the light product of first distillation. Its strength ranges between 14 and 16 grao. The Cazulo is moderately strong product of second distillation. The product, which we get after the process of third distillation, is called Fenny. Its strength ranges between 20 and 24 grao. It has a long shelf life. Juice is extracted from cashew apples and toddy and it is fermented till formation of a film floating over the juice. Time required for fermentation is 65-

70 hours. Around 70 liters of arrack is distilled from 100 liters of fermented juice. Arrack and fermented juice are distilled in the ratio of 1:2 to obtain fenny. In fenny, alcohol content ranges from 40-45%.

Cashew wine

It is a light yellow alcoholic drink with alcohol content of 6-12 %. Cashew apples are cut into slices and are crushed in the juice press. The fruit juice is sterilized in stainless steel pans at a temperature of 85°C in order to eliminate wild yeast. The juice is filtered and treated with either sodium or potassium metabisulphite, to destroy or inhibit the growth of undesirable micro-organisms like acetic acid bacteria, wild yeast and mould. The inoculum is added for fermentation.

Dried cashew fruit

Cashew fruit is not readily consumed in the raw state because of its high content of astringent compounds. Boiling with salt for 5 minutes removes astringent compounds and it can be converted into a useful dried product. The fruit must therefore be extensively processed prior to drying.

Cashew syrup

Extraction of juice and removal of astringency are done in the same way as in the pretreatment of juice. Sugar is added at the rate of 1 to 1.25 kg for every litre of juice, 20-25 g citric acid per litre and 0.08% as sodium benzoate is added to the juice and thoroughly mixed for 4-5 hour and clear syrup is cooled and filled in bottles.

Cashew apple jam

Cashew apple is thoroughly cleaned by washing with water. The apple is immersed in 3% salt solution for three days to reduce the tannin content after which the fruits are steamed for 15 to 20 minutes at 0.7 to 1.05 kg steam pressure. Then the apples are crushed and mixed with sugar and boiled. A pinch of citric acid is added towards the end of the cooling process to improve the taste. Finally it is stored well in sterilized jam bottles.

Cashew nut processing

Fig. 34 Dried cashew nuts

After removal from fruit, cashew nuts are dried in the sun for a period of two days and are then stored in the gunny bags for processing throught the year. The process of sun drying helps in removal of excess moisture thus resulting in longer storage. The outer shell of the cashew is very hard and it contains a corrosive oil which is harmful for human consumption. The process of steam roasting helps in removal of this hard shell with minimal effort. The raw cashew nuts are put in a drum connected to a mini boiler. The steam from this mini boiler is passed over the cashew nuts placed in the drum for a period of 10 -15 minutes. These cashew nuts are left in the drum for 20 minutes for proper roasting. The roasted cashew nuts are then taken out of the drum and placed in the open air for a period of around 12 hours to let them cool down and help in removal of the cashew shells.

After roasting, shell cutting is required to get maximum unbroken kernel output (Fig. 34). This process required each cashew nut to be individually placed between blades of the machine operated manually to remove the outer shell. This process results in production of cashew kernel with soft inner shell. These nuts are then placed in a oven which is constantly maintained at a temperature of about 60^0C for a period of 24 hours to make the inner shell brittle. Peeling removes inner kernel shell to produce white nuts. Each nut is individually peeled to get white nuts.

Post harvest research of underutilized food crops at CIARI

Fortifications of the products with numerous nutrients, vitamins etc and value added products in the form of nutraceuticals by blending the underutilized fruits with suitable medicinal herbs and spices for health benefit has been developed by Food Process Engineering Laboratory (FPTC) with free "hands on" training and demonstration programme to the Progressive farmers/small scale entrepreneurs/ Self help groups/NGO's. This would create employment opportunities to the rural educated poor youth to the Islands as the chance of going to mainland for getting additional family support is inadequate keeping the isolation of these vast island in its strategic location. Once, the products are marketed with good response from consumer, then A&N islands will be a attracting place for the industry or FDI sector to explore the diversity of indigenous plant species as a result the contribution of fruit juice processing to the total food processing would increase manifold and the demand of Indian healthy beverage fruit juice will increase internationally.

Standardized minor food products at Food Process Engineering Laboratory (FPEL)

- RTS Jamun, Jamun squash, Jamun jam
- RTS Noni, Noni Jam, Noni pickle
- RTS dragon fruit
- RTS Pomello
- RTS Rose apple
- RTS Carambola, Crambola Jam, Crambola squash
- RTS Jack fruit, dried bulb slice

Underutilized crops have the following constraints in their wider exploitation

- Lack of awareness among the farming community about the nutritional and medicinal value.
- Lack of desirable seeds and planting material.
- Limited application of advance on-farm agrotechniques.

- Lack of application of innovative and novel technologies such as biotechnology, plasticulture for enhancement of productivity.
- Lack of effective post harvest management practices.
- Limited and inadequate marketing supports & infrastructure facilities for transportation, storage and processing.
- Poor recognition of these crops in horticulture promotion programmes.
- Improper institutional arrangements and limited role played by financial institutions in setting up of agro industrial and horticulture based industrial units.

Strategies for the development of underutilized crops

- As 86% of the area is under forest, joint forest management programmes should facilitate spread of ITK available with local communities on sustainable collection and use of various species.
- Domestication of potential wild species through homestead cultivation should be encouraged for avoiding over-exploitation from natural sources.
- Under-utilized crops are nutritionally rich and adapted to low input agriculture. More R & D efforts in these will add substantially to food security and nutrition vis-à-vis human welfare.
- Limited number of species needs to be targeted for detailed research and development in under-utilized horticultural crops by national programmes focusing on their conservation and use. Research needs to be geared up both on species/crops important for subsistence farming and those exhibiting potential to become commodity crops.
- Increased focus to document indigenous knowledge is required such as through ethNobotanical studies. Such emphasis will help tap value additions as much of native diversity is put to multipurpose uses.
- Rapid expansion of infrastructure facilities with priority on market development, transport and communication needs to be done.
- The yield and quality of these crops are poor which hamper the productivity. Hence, some criteria need to be developed for commercial exploitation of these crops. The criteria may be high productivity, market demand, freedom from serious insect-pest and diseases, easier post harvest management, high

nutritive value and availability of production technology. Hence, special efforts are needed on the part of the research scientists to develop the suitable location specific package of practices of different underutilized crops including the development of superior varieties, and conservation of genetics resources.

- For proper exploitation and better economic returns from underutilized horticultural crops emphasis should be given on developing processing units in this area. It would also provide employment opportunities to the rural folk.

Conclusions

There is a vast production of underutilized and underexploited minor horticultural crops in the Islands which could be used as the "future crops" to supplement our nutritional needs. The wise and proper utilization of these crops can prove to be a promising solution after realizing their health and employment potential. Increase in the consumption of processed products will prevent the incidence of malnutrition disorders and generate more income to the tribals communities at large. Diversification for the production of value added products is one of the methods to retain the minor crops in the existing cropping systems in the fragile Islands. This will directly or indirectly lead to the generation of employment opportunities. So, there is need to promote and support the implementation of initiatives that make the most use of locally available biodiversity based an ecosystem approach to address food and nutrition security issues. The emerging health benefits and documentation of indigenous underutilized foods to the need for strategic community based interventions would help to improve food security, nutrition and health of populations. There is also need to demonstrate and quantify the benefits of the diversity of underutilized foods for livelihoods and to ensure that such information gathered is put to use widely to increase their well being. The more effective use of such diversity can also serve to be a more sustainable and environmentally friendly solution to the problems of food production. Taking cognizance of these unique strengths of indigenous foods there is need to incorporate agricultural biodiversity in the implementation of existing policy tools, such as food-based dietary guidelines of the Islands (if possible) as well as global nutrition strategies and interventions to improve diets and health on a sustainable basis. Up scaling and validation are needed for the developed technologies before recommendation and transfer to the entrepreneurs for commercial production and marketing. It can be concluded that exploitation of underutilized horticultural crops can provide a way to nutrient and economic security of tribals. Also, tribals can earn their livelihood through use of underutilized fruit crops. They can fetch self-employment opportunities through marketing of untapped potential of underutilized crop resources.