



Research Article

Studies on biodiversity, ethnobotanical uses and physicochemical properties of underutilized fruits in Nagaland and Meghalaya

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Abstract

A study was conducted on the bio-diversity and physicochemical properties of underutilized fruit crops in Nagaland and Meghalaya during 2018-19 under the Department of Horticulture, SASRD, Nagaland University. *Artocarpus lakoocha*, *Averrhoa carambola*, *Baccaurea ramiflora*, *Canarium strictum*, *Citrus indica*, *Docynia indica*, *Elaeagnus latifolia*, *Garcinia lanceifolia*, *Haematocarpus validus*, *Myrica nagi*, *Phyllanthus acidus*, *Prunus napaulensis*, *Spondias pinnata* and *Terminalia chebula* were found to be in abundance in the local communities and these fruits play an important role in diet of the local tribes and the local communities have their own vernacular names for the particular fruits which were collected from villages through interaction. The village elders, traditional healers, etc. are well-versed in the medicinal uses of these fruits and their different parts. Most of the fruits are consumed or sold in the local market by collecting them from the forests. The fruits are used as fresh or in various processed products such as RTS, pickles, jam, etc., or utilized in various medicinal purposes like paste and powder to treat wounds, boils, rashes, digestive problems, etc. The physicochemical properties showed a wide spectrum of variation in TSS (6.66-26.46 °Brix), total sugar (4.34-12.01%), reducing sugar (2.19-5.96%), titratable acidity (0.44-4.82%), ascorbic acid (4.40-115.50 mg/100g pulp) and anthocyanin (15.27-117.10 mg/100 g pulp) among the various fruits analyzed.

Keywords ethnobotanical uses, physicochemical composition, underutilized fruits

Introduction

Biodiversity and wild genetic resources of underutilized fruits are found in the foothills of the Eastern Himalayas of India. About 800 different species of minor and underutilized edible crops were identified in India, out of which about 300 species are consumed by the tribal rural population of the North Eastern region. [1]. Nagaland and Meghalaya are two states located in the north-east region of India. These states are reservoirs of biodiversity and have a very large number of wild or minor and underutilized horticultural crops. There is a huge variation among the different fruit crops, which can be used and exploited for further crop improvement programs. Due to heavy rainfall in these states, the soil tends to become acidic and wastelands, ravines and marshy soils have also been found which are unsuitable to cultivate high input demanding agricultural and horticultural crops. These types of lands can be utilized to grow low input demanding potentially underutilized fruits diversify

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the pressure of recent agriculture, which is most vital because of population pressure, fast depleting natural resources, and modifying of human needs. A large proportion of the rural population subsists on locally available fruits to meet their dietary requirements and minor fruits can help in establishing entrepreneurs, creating employment opportunities, and fetching financial support to the rural families. The commercial value of the underutilized fruits of Nagaland and Meghalaya has not been realized yet as research on their nutritional benefits is still very less in literature, thus hampering their promotion for large-scale cultivation, marketing, and consumption. Despite such potential, these genetic resources are yet to be exploited at a commercial level. Judicious exploitation of such potential genetic resources and bringing it to the commercial level are the biggest challenge in the present situation. Domestication, improved cultivation practices, and variety development are the main hindrance to higher production and productivity of minor and underutilized fruits. There is no variety of development programs involving local germplasm, especially the potential indigenous and wild relative crops [2]. These underutilized fruits exist in nature as survival of the fittest possessing several desirable traits such as resistance to biotic and abiotic stresses. For any species' evolution and improvement of germplasm to a commercial level, it is mostly followed by the incorporation of genes from one taxon to another [3]. So, the investigation and survey work was conducted to identify the edible wild and underutilized fruits of Nagaland and Meghalaya as well as to study the plant morphological characters and physico-chemical properties of collected fruits.

Methodology

The survey was carried out in the state of Nagaland and Meghalaya located in the North Eastern Region in India. Nagaland falls under the geographical coordinates of 25° 6' and 27° 4' North latitude and 93° 20' and 95° 15' East longitude covering an area of 16,579 sq km. The state of Meghalaya was regarded as "Abode of Clouds" covering an area of 22,429 sq km. It lies between the geographical coordinates of 25° 47' - 26° 10' North latitude and 89° 45' - 92° 47' East longitude. The common names of the underutilized fruits were collected from various sources such as books and other literature [1, 4-5]. The vernacular names of these underutilized fruits were collected through interaction with the people of different tribes of Nagaland and Meghalaya in which these fruits were available abundantly in and around their locality. Different underutilized fruits were collected from farms, fields, and markets of Nagaland and Meghalaya. The information regarding ethnical uses and mode of use of the fruits were collected through interaction with village elders, local vendors, and traditional healers. The plant type and other information were recorded by visual observation, discussing with village elders, and also referring to some literatures [1, 4-5]. The propagation method, season of flowering, and harvesting time were recorded through interaction with the villagers who used to grow these underutilized fruits in their backyards or farms. The fruit and seed weight were recorded in a weighing machine. The shape of the fruit, colour of the skin, and pulp/flesh of the fruit and seed were recorded through visual observations. The TSS of fruit juice was determined by using Hand Refractometer calibrated at 20 °C [6]. Titratable acidity was estimated by titrating the diluted fruit juice against 0.1 N Sodium hydroxide (NaOH) solution using phenolphthalein as an indicator. The total sugar, reducing sugar, and ascorbic acid (Vit C) were estimated by the titrating method as described in A.O.A.C [6]. To get a suitable interpretation, the obtained primary data was subjected to statistical analysis by one-way Analysis of Variance (ANOVA) at 0.05%.

Results and Discussion

The survey conducted in the states of Nagaland and Meghalaya divulged that some of the underutilized fruits available and commonly used by the indigenous people of the two states are as follows:

Artocarpus lakoocha Roxb.

Monkey Jack belongs to the family Moraceae. It is known by the name *Lakuch/Dhau* in Hindi and *Arimie* in Garo (Table 1). The fruit is generally propagated through seeds [7]. It is either consumed as fresh or as pickles and curries or made into Ready to Serve (RTS) drinks. The bark is macerated and powdered and can be used in the powdered form or in a paste form. Some of the ethnobotanical uses include feeding of fruits



Table 1. General information and vernacular name of different minor and under-utilized fruit crops

Scientific name	Common name	Vernacular name
<i>Artocarpus lakoocha</i> Roxb.	Monkey Jack	Lakuch/Dhau (Hindi), Arimie (Garo)
<i>Averrhoa carambola</i> L.	Carambola/Star fruit	Amalenga (Garo), Karmal (Hindi), Sohkhlor (Pnar), Soh-Pyrshang (Khasi)
<i>Baccaurea ramiflora</i> Lour.	Burmese Grape	Gasampe (Garo), Sohmyndong (Pnar), Sohramdieng (Khasi), Aphek (Kuki), Aolu (Konyak), Aoshojük (Phom)
<i>Canarium strictum</i> Roxb.	Black Dammar/Black Dhup	Nangjalaishi (Ao), Home (Konyak), Phomphet (Phom)
<i>Citrus indica</i> Tanaka	Indian wild orange	Memang Narang (Garo)
<i>Docynia indica</i> (Wall.) Decne	Wild Apple/Crab Apple	Sohpoh Khasi (Khasi), Ciepho (Angami), Malangthi (Lotha)
<i>Elaeagnus latifolia</i> L.	Silver Berry/Wild Olive/Bastard Oleaster	Soh-shang (Khasi), Sokua (Garo), Slangi (Pnar), Heyai (Manipuri), Tsuronthi (Lotha), Metsüsera (Ao), Pechüchüdi (Angami)
<i>Garcinia lanceifolia</i> Roxb.	Garcinia	Hiangsü (Zeliang), Chengkek (Mizo), Thisuru (Garo) and Dieng-soh-jadu (Khasi/Pnar)
<i>Haematocarpus validus</i> (Miers) Bakh. f. ex Forman	Blood Fruit	Te.pattang (Garo), Sohnam (Khasi/Pnar) and Khoonpal (Hindi)
<i>Myrica nagi</i> THUNB. (big size, green colour)	Box Berry/Myrtle	Soh-phie (Khasi/Pnar), Kaephal (Hindi), Yenjük (Phom), Yin (Konyak), Metiung (Ao), Pezia (Angami)
<i>Myrica nagi</i> THUNB. (small size, pink colour)	Box Berry/Myrtle	Soh-phie (Khasi/Pnar), Kaephal (Hindi), Yenjük (Phom), Yin (Konyak), Metiung (Ao), Pezia (Angami)
<i>Phyllanthus acidus</i> (L.) Skeels	Star Gooseberry	Ambare raja (Garo), Khulhu (Angami), Chikithi (Lotha) and Phangjük (Phom), Phang (Konyak)
<i>Prunus nepaulensis</i> L.	Black berry	Soh-iong (Khasi), Arupati (Bengali), Sajong (Assamese) and Mamangthi (Lotha)
<i>Spondias pinnata</i> (L.f) Kurz	Wild Mango/Indian Hog Plum	Paku (Ao), Agimok (Garo)
<i>Terminalia chebula</i> Retz.	Black Myrobalan/ Chebulic Myrobalan	Arotak (Garo), Lüngkhah (Phom), TitaGuti (Nagamese)

to lactating animals to enhance milk production, and products from bark are used to cure any wound and for treating various skin ailments (Table 2). The powdered root is used in treating boils and rashes while the sap and juice of bark are used for treating boils and pimples [8-9]. *Artocarpus lakoocha* is a deciduous tree [9] that flowers in April. The fruits become ready for harvesting in June-August in the Garo Hills of Meghalaya (Table 3). The fruits are irregularly rounded weighing approximately 129.2 g. The seeds (average weight of 0.2 g) are greyish to cream in colour (Table 4). It was noted that the fruit of *Artocarpus lakoocha* contained TSS of 12.77±0.88 °Brix, 2.94±0.13% titratable acidity, 5.26±0.23% total sugar, 2.32±0.07% reducing sugar and ascorbic acid of 103±2.56 mg/100 ml juice (Table 5). A similar study [10] was carried out in Tripura where researchers found wide variations in TSS (12.89 °Brix to 20.20°Brix), titratable acidity (0.87% and 2.66%), and Vitamin-C (168.44 mg to 182.04 mg/100 g pulp) in *Artocarpus lakoocha*.

***Averrhoa carambola* L.**

Carambola or Starfruit under the family Oxalidaceae (Table 1) is locally called as amlenga in Garo, karmal in Hindi, and soh-pyrshang in Khasi. The fruit is generally propagated through seeds and cuttings in this region which conforms with the earlier findings [11]. The fruits are utilized by local people as fresh or processed as RTS, jam, jellies, wine, pickles, etc. The leaves are boiled and prepared as tea for drinking which is found to be helpful to cure some disorders, and lower high blood pressure and blood sugar. Drinking the juice of carambola is used to counteract fever, lower high blood sugar and blood pressure (Table 2). Fresh fruit helps in stimulating the appetite. It is also used when someone is suffering from chronic headaches, boils, cold, cough, fever, gastroenteritis and to have anti-diarrhoeal effects. *Averrhoa carambola* is an evergreen tree [11] which flowers in July to August and again from October to



Table 2. Ethnobotanical uses of different minor and under-utilized fruits based on interrogation of village elders, traditional healers and mode of use

Scientific Name	Ethnobotanical Uses of Fruits	Mode of Use
<i>Artocarpus lakoocha</i> Roxb.	Fruits – fed to lactating animals to produce more milk Bark – cure any wound and for treating skin ailments Root – skin ailments such as boils and rashes Sap and juice of bark – treat boils, pimples	Fruits – fresh, RTS, pickle and curry Bark – macerated, powdered and paste Root – shade dried and powdered
<i>Averrhoa carambola</i> L.	Fruit – stimulates the appetite and has anti-diarrhoeal effects Fruit juice - used to counteract fever, lowers high blood sugar and high blood pressure Leaves – lowers high blood sugar and high blood pressure	Fruit – fresh, RTS, jam, jelly, wine, pickles, dried, etc. Leaves – boiled or prepared as tea
<i>Baccaurea ramiflora</i> Lour.	Fruits – to treat skin diseases, improves immunity, decreases severity of cold and flu and it can help in ensuring a healthy pregnancy	Fruits- Fresh, wine, squash, etc.
<i>Canarium strictum</i> Roxb.	Dried fruit – used to minimize nausea Resin – used extensively to make incense which are used for religious ceremonies, waxes and varnishes are also made by the resin. The resin is even used for the treatment of bronchial diseases and orally given resin powder helps in curing rheumatism	Fruits – fresh, dried Resins – extracted from the bark and made into powder
<i>Citrus indica</i> Tanaka	Fruit – used for treating jaundice, stomach disorders and nausea. Fruits are placed on the dead bodies during the last rites with a belief that it will ward off the ghosts of the departed Fruit juice – good for digestion Powdered extract from the fruit is used as a cure for smallpox	Fruits – fresh, juice, dried (over the fireplace to increase its shelf life), powdered
<i>Docynia indica</i> (Wall.) Decne	Fruits – good appetizer, stimulating digestion and bloating and infectious diseases	Fruits – fresh, pickle, wine, candies and RTS
<i>Elaeagnus latifolia</i> L.	Fruits are good for digestion, cardiac and the fruit is used as an astringent	Fruits - Fresh, jam, jelly, pickles and RTS
<i>Garcinia lanceifolia</i> Roxb.	Fruits and leaves - used to treat stomach disorders such as dysentery and diarrhoea Bark - treat dysentery, dyspepsia and biliousness	Fruits – fresh, pickles, refreshing drink Leaves – cooked as vegetables Bark – chewed, macerated and powdered
<i>Haematocarpus validus</i> (Miers) Bakh. f. ex Forman	Fruits are used for blood purification and Root extracts are used for relieving itching and pain	Fruits - Fresh, RTS and wine Root – dried, powdered/ macerated and paste.
<i>Myrica nagi</i> THUNB. (green)	Fruits – juice extract for gastric problem and helps in digestion problems Bark – used externally for rheumatism and as an anti-septic	Fruits – fresh, juice extract, pickle, jam and jelly. Bark – macerated or powdered
<i>Myrica esculenta</i> Ham. Ex D. Don. (pink)	Fruits – juice extract used to treat gastric problem and helps in digestion problems Bark – used externally for rheumatism and as an anti-septic	Fruits – fresh, juice extract, pickle, jam and jelly. Bark – macerated or powdered
<i>Phyllanthus acidus</i> (L.) Skeels	Fruits – appetite stimulant, blood purifier, digestive disorder, piles, etc. Leaves – treat fever, piles, small pox, itching and infection.	Fruits – fresh, juice, pickles, dried, etc. Leaves – paste, boiled, etc.
<i>Prunus nepaulensis</i> L.	Fruits – appetizer, helps in digestion, etc. Leaf – used as a diuretic	Fruits – fresh, jam, jelly, wine, RTS, etc. Leaf – cooked and made into a paste
<i>Spondias pinnata</i> (L.f) Kurz	Fruit – astringent and used in treatment of bilious dyspepsia Juice of fruit – applied against earache Bark – used for stomach aches, dysentery and also a paste is made and applied topically in the treatment of rheumatism and swollen joints	Fruit – fresh and juice extract Bark – macerated or powdered and made into a paste sometimes even chewed
<i>Terminalia chebula</i> Retz.	Fruit – increases appetite, helps in indigestion, stomach ache, diarrhoea and dysentery Extract of fruit – wound healing, immunity and body resistance against diseases, extensively used in Ayurveda, unani and homeopathy medicine for bleeding piles, sore-throat and nausea	Fruits – Fresh, juice extract, dried

November and fruits become ready for harvest from September to October and December to January in Nagaland (Table 3). The fruits of *Averrhoa carambola* are generally oblong and 5 angled (rarely 4 or 6 angled) with average fruit weight (73g). The seeds of the fruits are brown in colour and the average seed weight was 0.055g (Table 4). The biochemical analysis during the study revealed that the fruit of *Averrhoa carambola* contained TSS of 7.25 ± 0.63 °Brix, titratable acidity $0.44 \pm 0.04\%$, total sugar $6.77 \pm 0.43\%$ and reducing sugar $5.12 \pm 0.10\%$ (Table 5). Similar values [12] was also noticed in TSS content of 7.3 °Brix in half ripe fruits and reached 10.83 °Brix in fully ripe fruits. In the present findings, the ascorbic acid (Vit-C) content was found to be 50.60 ± 1.80 mg/100 ml juice.

***Baccaurea ramiflora* Lour.**

Burmese grape (family Euphorbiaceae) is native to South East Asian countries [13]. It occupies a very important fruit for the people of Meghalaya [4] and known by different vernacular names such as *Gasampe* (Garo), *Sohmyndong* (Pnar), *Sohramdieng* (Khasi), *Aphek* (Kuki), *Aolu* (Konyak), *Aoshojük* (Phom)



(Table 1). The plant is generally propagated by seeds [14] and cuttings in the Tura region. The fruits of *Baccaurea ramiflora* are used to treat skin diseases, improve immunity, decrease the severity of cold and flu and to ensure healthy pregnancy. The ailments of inflammatory and pain injuries, abscesses, rheumatoid arthritis, cellulitis, etc are treated with these fruits of the plant [15]. It is usually consumed as fresh or processed as wine, squash, jam, etc., [16]. *Baccaurea ramiflora* is an evergreen tree [17] that flowers from April to May [13]. It becomes ready to harvest from June to August in the Garo Hills of Meghalaya (Table 3). *Baccaurea ramiflora* fruits are oval to round in shape [18], yellow to yellowish with brown patches when it ripens and flesh colour is usually whitish and occasionally deep pink near seeds; the seeds are arillus, 4 in number per fruit. The average fruit weight is 9.2 g (Table 4). The weight of the seed is 0.5 g and the colour is purple to red. The fruit of *Baccaurea ramiflora* contained 10.77±0.83 °Brix TSS, 1.63±0.09% titratable acidity, 7.54±0.57% total sugar, 5.66±0.13% reducing sugar, and 20.20±0.88 mg/100 g pulp of ascorbic acid (Table 5). The findings were at par with earlier findings [4] where researchers found 8.2-14.1°Brix TSS, acidity of 1.93%, total sugar of 13.69%, and reducing sugar of 5.10%.

***Canarium strictum* Roxb.**

Canarium strictum belongs to the Burseraceae family. It is known as Nangjalaishi in Ao dialect and home in the Konyak dialect (Table 1). This tree is usually propagated by seeds in the Mokokchung district in Nagaland. The dried fruits of *Canarium strictum* are chopped and chewed to cure nausea as well as motion sickness. The fruits are usually consumed as fresh or dried. The bark of *Canarium strictum* were found to exudate a resin known as ‘Sambrani’ or ‘Dammar’ used as medicinal as well as commercial purposes by Augustine and Khrishnan [19] tribal and folk people and explored as ethnobotanical studies. Traditionally, it is used as rural siddha medicine in India. It finds its usage in incense and varnish industries. The incense is usually used for religious ceremonies and orally given powdered resin helps in curing rheumatism. *Canarium strictum* is an evergreen tree [20] that flowers from June to August and becomes ready to harvest (fruits) in December to March in Nagaland (Table 3). The fruits of *Canarium strictum* Roxb. are oval. A single average fruit is weighing about 30.4 g (Table 4). The seeds are light brown in colour with an average weight of 11 g. During the study, it was noticed that the fruit of *Canarium strictum* contained TSS of 16.44±0.91 °Brix, 3.52±0.17% titratable acidity, 5.63±0.19% total sugar, 3.92±0.04% reducing sugar and 13.20±0.79 mg/100 ml juice of ascorbic acid content (Table 5). No bio-chemical analysis was found as this tree is commercially used for its resin and not for its fruit.

Table 3. Plant morphological characters of different minor and under-utilized fruit crops

Scientific name	Type of Plant	Flowering time	Harvesting time
<i>Artocarpus lakoocha</i> Roxb.	Deciduous tree	April	June-Aug
<i>Averrhoa carambola</i> L.	Evergreen tree	July-Aug & Oct-Nov	Sept-Oct & Dec-Jan
<i>Baccaurea ramiflora</i> Lour.	Evergreen tree	April-May	June-Aug
<i>Canarium strictum</i> Roxb.	Evergreen tree	June-Aug	Dec-March
<i>Citrus indica</i> Tanaka	Evergreen shrub	March-April	Nov-Dec
<i>Docynia indica</i> (Wall.) Decne	Deciduous tree	March-April	Aug-Nov
<i>Elaeagnus latifolia</i> L.	Evergreen shrub	Sept-Dec	March-April
<i>Garcinia lanceifolia</i> Roxb.	Evergreen tree	Feb-March	April-June
<i>Haematocarpus validus</i> (Miers) Bakh. f. ex Forman	Evergreen woody climber	Oct-Dec	March-June
<i>Myrica nagi</i> THUNB. (green)	Evergreen tree	Oct-Dec	March-June
<i>Myrica nagi</i> THUNB. (pink)	Evergreen tree	Oct-Dec	March-June
<i>Phyllanthus acidus</i> (L.) Skeels	Deciduous tree	Any time of the year (twice)	Fruits and flower appear simultaneously
<i>Prunus nepaulensis</i> L.	Evergreen tree	Oct-Nov	Aug-Sept
<i>Spondias pinnata</i> (L.f) Kurz	Evergreen to Deciduous tree	April-June	Sept-Nov
<i>Terminalia chebula</i> Retz.	Semi-deciduous tree	May-June	Nov-March



Citrus indica Tanaka

Citrus indica (family Rutaceae) is known as the Indian wild orange and used to believe to be one of the most primitive citrus species. *Citrus indica* is endemic to the Tura range of Garo Hills in Meghalaya and belongs to the buffer zone of Nokrek Biosphere Reserve [21]. The plant is known as *Memang Narang* in the Garo dialect. Indian wild orange is propagated through seeds and cuttings by the locals. The fruits are used for the treatment of jaundice, stomach disorders, and nausea. As ritualism in Meghalaya, fruits are kept on dead bodies during the last set off with a belief that it will ward off the ghosts of the departed soul. The juice of the fruit is used to relief indigestion and the powdered extract of the fruit is used for the treatment of smallpox [21]. The fruits are usually consumed fresh, by preparing juice extract. Fruits are placed over the fireplace for drying which helps in increasing the shelf life and may even be powdered later. *Citrus indica* Tanaka is an evergreen shrub that flowers from March-April and is ready for harvest from November–December (Table 3). The fruits of *Citrus indica* are round to depressed globose in shape weighing an average of 39 g per fruit (Table 4).

Table 4. Fruit and seed morphological characters of different minor and under-utilized fruit crops

Scientific name	Fruits				Seeds	
	Weight (g)	Shape	Skin colour	Pulp/flesh colour	Weight (g)	Seed colour
<i>Artocarpus lakoocha</i> Roxb.	129.20	Irregularly round	Light green to yellow	Yellow	0.20	Greyish to cream colour
<i>Averrhoa carambola</i> L.	73.00	Oblong (5 angled)	Light green to yellow	Green to yellow	0.055	Brown
<i>Baccaurea ramiflora</i> Lour.	9.20	Oval to round	Yellow with brown patches	White-pinkish	0.50	Purple-red
<i>Canarium strictum</i> Roxb.	30.40	Oval	Green to yellowish orange	Light green to yellow	11.00	Light brown
<i>Citrus indica</i> Tanaka	39.00	Round to depressed globose	Deep orange to reddish	Orange	0.10	Greyish white
<i>Docynia indica</i> (Wall.) Decne	63.80	Sub-globose or ellipsoid	Green to yellowish green	Light green	0.043	Dark brown
<i>Elaeagnus latifolia</i> L.	12.00	Oblong	Orange to red	Orange to red	1.10	Brown
<i>Garcinia lanceifolia</i> Roxb.	59.40	Globose (depressed base)	Pinkish to red	white	0.40	Light brown
<i>Haematocarpus validus</i> (Miers) Bakh. f. ex Forman	25.60	Ovoid	Red	Dark red	8.00	Brown
<i>Myrica nagi</i> THUNB. (green)	14.00	Round	Green	Green	2.01	Brown
<i>Myrica nagi</i> THUNB. (pink)	5.20	Oval	Pink	Pink	0.70	Brown
<i>Phyllanthus acidus</i> (L.) Skeels	3.50	Oblate	Light green to yellow	White to light yellow	0.13	Light brown
<i>Prunus nepaulensis</i> L.	6.20	Globose/round	Black to dark purple	Pinkish red	1.76	Light brown
<i>Spondias pinnata</i> (L.f) Kurz	26.60	Ellipsoid to elliptic ovoid	Green to yellow	yellow	11.40	Light brown
<i>Terminalia chebula</i> Retz.	11.40	Unevenly oval	Dark to light green	Light green	4.00	Pale yellow

The seeds are greyish white in colour and the average weight of the seeds is around 0.10 g. The fruits of *Citrus indica* contained a TSS of 10.36 ± 0.79 °Brix, $3.16 \pm 0.19\%$ titratable acidity, $5.71 \pm 0.21\%$ total sugar, $2.96 \pm 0.03\%$ reducing sugar and 50.60 ± 2.01 mg/100 ml juice ascorbic acid (Table 5). Similar results were observed in the case of TSS which varied from 9.40 to 10 °Brix and titratable acidity from 2.05 to 2.11% [22].

Docynia indica (Wall.) Decne

Docynia indica (Rosaceae family) is commonly known as a wild apple. This fruit is known by the name *Ciepho* in *Angamis* and *Sohpoh Khasi* by the *Khasis* (Table 1). *Docynia indica* is propagated through seeds and cuttings in the Khonoma region in Nagaland. The fruits are usually consumed as fresh, wine, pickled,



RTS, and candies. Fruits are consumed as fresh which acts as an appetizer and the juice extract of the fruit helps in stimulating digestion and is used for treatment of bloating and infectious diseases (Table 2). Hypolipidemic, hypoglycemic, infectious diseases and digestive problems are cured as a natural remedy with the fruits of *Docynia indica* [23]. The plant is deciduous which flowers in March to April and the fruits are ready for harvest from August to November (Table 3). *Docynia indica* fruit is sub-globose or ellipsoid in shape [4] weighing 63.8 g on average. The seeds of the fruits are dark brown colour and weigh around 0.043 g per seed. The biochemical analysis during the study showed that the fruit of *Docynia indica* contained 13.37±0.96 °Brix TSS, 2.75±0.11% titratable acidity, 7.54±0.51% total sugar, 3.96±0.08% reducing sugar and 14.30±0.93 mg/100 ml juice ascorbic acid (Table 5).

Elaeagnus latifolia L.

Elaeagnus latifolia (family Elaeagnaceae) is called as Silver berry/Wild olive or Bastard oleaster. The fruit is vernacularly called as *Soh-shang* (Khasi), *Sokua* (Garo), *Slangi* (Pnar), *Heyai* (Manipuri), *Tsuronhi* (Lotha), *Metsüsera* (Ao), and *Pechüchüdi* (Angami) (Table 1). This plant is propagated through seeds and cuttings in this region. The fruits are consumed as fresh and the pulp of the fruit is used for the preparation of jams, jellies, pickles, RTS, and refreshing drinks [24]. This fruit is astringent and it is used for its medicinal values such as stimulating digestion and as a remedy for cardiac patients (Table 2). The large evergreen *Elaeagnus latifolia* is a spreading type of woody shrub that flowers from September to December (Table 3). It is harvested when the fruits turn into light pink colour in March to April [24-25]. The fruit is oblong in shape weighing about 12 g on average (Table 4). The seeds of this fruit are light brown in colour and weigh around 1.1 g in average per seed. During the study it was revealed that the fruit of *Elaeagnus latifolia* contained a TSS of 8.77±0.70°Brix, titratable acidity of 1.88±0.07%, total sugar of 6.89±0.43%, reducing sugar of 4.44±0.11%, ascorbic acid content of 8.20±0.67 mg/100 ml juice and anthocyanin content of 15.27±0.67 mg/100g pulp (Table 5). The findings are in complete agreement with earlier findings [25] where researchers reported

Table 5. Biochemical analysis of different minor and under-utilized fruit crops

Scientific name	TSS (°Brix)	Titratable acidity (%)	Total sugar (%)	Reducing sugar (%)	Ascorbic acid (mg/100g pulp)	Anthocyanin (mg/100g pulp)
<i>Artocarpus lakoocha</i> Roxb.	12.77±0.88	2.94±0.13	5.26±0.23	2.32±0.07	103.00±2.56	-
<i>Averrhoa carambola</i> L.	7.25±0.63	0.44±0.04	6.77±0.43	5.12±0.10	50.60±1.80	-
<i>Baccaurea ramiflora</i> Lour.	10.77±0.83	1.63±0.09	7.54±0.57	5.66±0.13	20.2±0.88	-
<i>Canarium strictum</i> Roxb.	16.44±0.91	3.52±0.17	5.63±0.19	3.92±0.04	13.20±0.79	-
<i>Citrus indica</i> Tanaka	10.36±0.79	3.16±0.19	5.71±0.21	2.96±0.03	50.60±2.01	-
<i>Docynia indica</i> (Wall.) Decne	13.37±0.96	2.75±0.11	7.54±0.51	3.96±0.08	14.30±0.93	-
<i>Elaeagnus latifolia</i> L.	8.77±0.70	1.88±0.07	6.89±0.43	4.44±0.11	8.20±0.67	15.27±0.67
<i>Garcinia lanceifolia</i> Roxb.	8.77±0.67	2.56±0.13	5.55±0.22	2.45±0.05	28.60±1.11	64.66±1.13
<i>Haematocarpus validus</i> (Miers) Bakh. f. ex Forman	12.78±0.93	4.82±0.21	12.01±0.46	5.96±0.13	11.30±0.53	117.10±1.63
<i>Myrica nagi</i> THUNB. (green)	7.74±0.59	4.03±0.19	4.34±0.11	2.19±0.02	18.00±0.78	-
<i>Myrica nagi</i> THUNB. (pink)	8.77±0.63	1.95±0.08	6.06±0.39	4.33±0.06	4.40±0.18	-
<i>Phyllanthus acidus</i> (L.) Skeels	6.66±0.17	1.82±0.10	5.33±0.23	3.77±0.04	24.00±1.20	-
<i>Prunus nepaulensis</i> L.	18.78±1.13	1.15±0.06	8.04±0.49	4.89±0.11	51.30±2.07	-
<i>Spondias pinnata</i> (L.f) Kurz	11.28±0.67	2.81±0.10	4.54±0.10	3.41±0.08	115.50±3.66	-
<i>Terminalia chebula</i> Retz.	26.46±1.03	2.78±0.11	11.11±0.59	9.52±0.17	33.0±1.23	-

TSS range of 8.8 to 11.2°Brix, acid content of 1.96-4.03%, and ascorbic acid content of 4.8 to 7.2 mg/100 ml juice. The findings of total sugar and reducing sugar are also at par with the earlier reports [4] where the total sugar content of 6.1% and reduced sugar of 4.0% were estimated.



***Garcinia lanceifolia* Roxb.**

Garcinia lanceifolia belongs to the family Clusiaceae. The small and evergreen *Garcinia* trees are found in northeast India, especially in Assam and Meghalaya [26]. The fruit is locally known as *Hiangsü (Zeliang)*, *Chengkek (Mizo)*, *Thisuru (Garo)*, and *Dieng-soh-jadu (Khasi/Pnar)* (Table 1). The seeds are usually used for propagation in the Peren region of Nagaland. The consumption habits of these fruits by local people are as fresh or processed as pickles, refreshing drinks etc. The leaves are cooked as vegetables and the bark is chewed, macerated, or powdered and used for different medicinal purposes (Table 2). The fruits and leaves are used to treat stomach disorders such as dysentery and diarrhea [24, 27]. The bark of this plant is also used to treat dysentery, dyspepsia, and biliousness. *Garcinia lanceifolia* is a medium sized evergreen tree that flowers during February to March and becomes ready to harvest in April to June (Table 3). The fruits of *Garcinia lanceifolia* are globose (depressed base) in shape which is similar to a tomato. The average fruit weight is 59.4 g. The seeds are light brown in colour and it weighs around 0.4 g per seed. It was noted that the fruit of *Garcinia lanceifolia* was rich in TSS ($8.77\pm 0.67^\circ\text{Brix}$), titratable acidity ($2.56\pm 0.13\%$), total sugar ($5.55\pm 0.22\%$), reducing sugar ($2.45\pm 0.05\%$), ascorbic acid (28.60 ± 1.11 mg/100 ml juice) and anthocyanin content (64.66 ± 1.13 mg/100 g pulp) (Table 5). The findings reported earlier [24] in the biochemical analysis of *Garcinia lanceifolia* was divided into juice sacs and rind of the fruit. In fruit juice sacs, it analyzed TSS content of 6.8%, the acidity of 2.34%, total sugar of 3.40%, reducing sugar of 1.10%, and vit-c of 42.3 mg/100 ml juice [24]. For the rind, it was noted in TSS content of 5.6%, acidity of 2.37% and ascorbic acid content of 21.15 mg/100 ml rind juice [24]. Few variations in the findings were found however this may be due to the mixing of juice sac and the rind of the fruit in the present study while analyzing the biochemical properties in *Garcinia lanceifolia*.

***Haematocarpus validus* (Miers) Bakh. f. ex Forman**

Haematocarpus validus under Menispermaceae family. It is known as Blood fruit in general. The fruit is known by the name tepattang in Garo, sohsnam in Khasi, and khoonpal in Hindi (Table 1). The wildy grown plant is propagated through seeds or by cuttings in the Tura region of Meghalaya. According to the village elders and local traditional healers, the fruits are believed to have blood purifying properties and cure blood related disorders (Table 2). The root extracts are used for relieving itching and pain [28-29]. The fruit juice is prepared by slicing ripened fruits by soaking in water overnight and used as medicine in next morning. It is also used to prepare wines [29]. The roots are dried and then macerated or powered which are used to treat itching and pain. *Haematocarpus validus* is an evergreen woody climber that flowers in October to December and comes to harvesting stage in March to June (Table 3). The fruit is ovoid in shape, weighing around 25.6 g (Table 4). The seed of the fruit is brown in colour with a weight of around 8g. The study showed that the fruit contained TSS of $12.78\pm 0.93^\circ\text{Brix}$, $4.82\pm 0.21\%$ of titratable acidity, total sugar with $12.01\pm 0.46\%$, reducing sugar of $5.96\pm 0.13\%$, ascorbic acid of 11.30 ± 0.53 mg/100 ml juice and anthocyanin content of 117.10 ± 1.63 mg/100g pulp (Table 5). The findings were in conformity with the earlier [29] in TSS (12.40°B), titratable acidity (5.08%) and reducing sugar (6.90%). The anthocyanin content in the fruit was 203.77 C3GE mg/ 100 g [30].

***Myrica nagi* THUNB. (Big sized, green colour)**

Myrica nagi is known as box myrtle or box berry belonging to the family of Myricaceae. The plant is quietly found in Sibsagar (Dikho valley of Assam), Khasi, and Jaintia hill of Meghalaya. It is usually known as *Soh-phie (Khasi/Pnar)*, *Kaephal (Hindi)*, *Yenjük (Phom)*, *Yin (Konyak)*, *Metiung (Ao)*, *Pezia (Angami)* (Table 1). It is propagated through seeds and cuttings in the Shillong region of Meghalaya. The juice extract is used as for gastric problems and it induces indigestion. The bark of the plant is an external common therapy for rheumatism, anti-septic, and also used as a fish poison by some tribals [31]. The fruits are mostly consumed as fresh, juice extract, pickles, jam, and jelly [32]. *Myrica nagi* is an evergreen tree that flowers in October to December and the harvesting season is from March to June (Table 3). The fruits of *Myrica nagi* are round in shape, with green skin and flesh colour and the average fruit weight was 14 g (Table 4). The seed is brown in colour weighing around 2.01 g. The information on the bio-chemical analysis of fruit revealed that the fruit contained TSS of $7.74\pm 0.59^\circ\text{Brix}$, titratable acidity of $4.03\pm 0.19\%$,



total sugar of $4.34 \pm 0.11\%$, reducing sugar of $2.19 \pm 0.02\%$ and an ascorbic acid content of 18 ± 0.78 mg/100 ml juice. The findings are in agreement with the earlier observation [4] in TSS (5.6-6.5%), acidity (2.5-4.8%), total sugar (3-7.7%), reducing sugar (1.0-3.5%), and Vit. C content of 17.6-28.2 mg/100 ml juice.

***Myrica nagi* THUNB. (Small sized, pink colour)**

Myrica nagi is known as box myrtle or box berry and it belongs to the family Myricaceae (Table 1). The fruits are mostly consumed fresh, juice extract, pickle, and the pulp of the fruit is used for the preparation of jam and jelly [32]. The bark is macerated or powdered and used as medicine. *Myrica nagi* is an evergreen tree that flowers in October to December and the harvesting season is from March to June (Table 3). The oval shape fruits are pink in color with an average weight of 5.2 g (Table 4). The seed is brown in colour weighing around 0.7 g. The information on bio-chemical analysis of fruit revealed that the fruit contained TSS of $8.77 \pm 0.63^\circ$ Brix, titratable acidity of $1.95 \pm 0.08\%$, total sugar of $6.06 \pm 0.39\%$, reducing sugar of $4.33 \pm 0.06\%$ and ascorbic acid content of 4.40 ± 0.18 mg/100 ml juice (Table 5). These findings were in agreement with previous works [32] where they found a good amount of TSS (6.20%), titratable acidity (2.44%), total sugar (7.68%), reducing sugar (3.57%) and ascorbic acid (vit-c) of 4.03 mg/100 ml juice.

***Phyllanthus acidus* (L.) Skeels**

Star gooseberry (family Euphorbiaceae) is known as *Ambare raja* in the Garo dialect (Table 1). It is found in southern parts and also the northeastern parts of India particularly in Mizoram [24]. The plant is generally propagated by seeds, budding, greenwood cuttings, and air layering. The fruits are consumed as fresh, pickles, juice extracts, dried and candies (Table 2). The fruits are used to stimulate the appetite, acts as a blood purifier to help during digestive disorder, and also used in piles problem [33] and folk medicine [34]. The roots and seeds are used for cathartic. Fruit juice is used as a blood purifier, for liver tonic, jaundice, bronchitis, constipation, and piles in the Ayurvedic system of medicine. For ailments of fever, piles, smallpox, blood vomiting, itching, and gum infection, the leaves are very useful. *Phyllanthus acidus* is a deciduous tree. It is a small to medium tree which grows about 2-9 m [24]. According to the interaction with the locals, *Phyllanthus acidus* flowers twice any time of the year and the fruits and flowers appear simultaneously (Table 3). The fruit of star gooseberry is oblate in shape weighing around 3.5 g on an average (Table 4). The seeds of the fruit are light brown in colour weighing around 0.13 g per seed. It was observed that *Phyllanthus acidus* contained TSS of $6.66 \pm 0.17^\circ$ Brix, titratable acidity of $1.82 \pm 0.10\%$, total sugar of $5.33 \pm 0.23\%$, reducing sugar of $3.77 \pm 0.04\%$ and vitamin-C content of 24.00 ± 1.20 mg/100 g pulp (Table 5). TSS content of 4.68%, acidity of 2.27%, and ascorbic acid of 21.15 mg/100 ml juice was also noticed by [24].

***Prunus nepaulensis* L.**

Prunus nepaulensis (family Rosaceae) is known as blackberry. It is an important fruit in Meghalaya which is vernacularly known as *Sohiong* in Khasi dialect (Table 1). This is commonly propagated through seeds in the Shillong region [5]. The fruits are consumed as fresh and/or prepared into jam, jelly, wine, and RTS using the pulp of the fruit. The leaves are also cooked and sometimes made into a paste for its medicinal values (Table 2). The fruit is used as an appetizer and it also helps in digestion as the fruits are astringent in taste. The leaves are believed to be diuretic and used for edema [35]. The fruits of *Prunus nepaulensis* are globose or round in shape weighing 6.2 g on an average per fruit (Table 3). The seeds are light brown in colour and weighing about 1.76 g each seed. The biochemical properties of *Prunus nepaulensis* revealed that the fruit contained TSS of $18.78 \pm 1.13^\circ$ Brix, titratable acidity of $1.15 \pm 0.06\%$, total sugar of $8.04 \pm 0.49\%$, reducing sugar of $4.89 \pm 0.11\%$ and an ascorbic acid content of 51.30 ± 2.07 mg/100 ml juice (Table 5). The present results were almost in conformity with earlier findings [36] where they reported that the fruit was rich in TSS content (19.60-20.15%), titratable acidity (2.56-3.32%), total sugar (7.50-8.75%), reducing sugar (4.26-4.44%) and ascorbic acid (50.04-58.38 mg/100 ml juice).

***Spondias pinnata* (L.f) Kurz**



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