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NOTES ON NEGLECTED AND UNDERUTILIZED CROPS

Analysis study on potential underutilized edible fruit genetic resources of the foothills track of Eastern Himalayas, India

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Abstract Several wild indigenous fruit crops which are rare in other part of the world grow favourably and naturally in the foothills track of Eastern Himalayas due to suitable geo-climatic conditions. These wild fruits are *Padus napaulensis* (Ser. ex DC.) Schneider, *Elaeagnus latifolia* L., *Myrica esculenta* Buch.-Ham. ex D. Don, *Baccaurea ramiflora* Lour., *Pyrus pashia* Hamilton ex D. Don, *Calamus meghalayensis* (Becc.) A.J. Hend., *Gynocardia odorata* R. Br., *Prunus undulata* Buch.-Ham., *Docynia indica* (Wall.) Decne., *Rhus chinensis* Mill. and *Viburnum foetidum* Wallich. These naturally occurring fruit plants which are harvested and marketed locally, not only nutritionally and medicinally rich but also thrive well under adverse climatic conditions and can be the source of several desirable gene(s) or traits particularly for resistance to biotic and abiotic stresses. In spite of their potential, these fruit plants are unattended both at scientific and farmers level. There is a need to attain sustainable growth, food and nutritional security for the most susceptible tribal population in the near future. Therefore, during the course of survey, collection and evaluation of eleven naturally occurring potential wild edible fruit plants have been discussed including their habitat, distribution, morphological description, quality parameters, utilization potential, constraints and possible strategies like how to increase their population size, productivity, conservation and utilization.

Keywords Eastern Himalayas · Fruits · Plant genetic resources · Utilization · Wild species

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Introduction

The track is predominantly mountainous and among the highest rainfall regions in the world. The economy of the region is basically rural based, with agriculture playing a predominant role, among which underutilized fruit crops contribute significantly in the livelihood security. The diverse agro-climatic conditions, varied soil type, abundant rainfall and undulating topography of the region offer immense scope for evolution and development of different wild species especially the underutilized fruit trees. Wild fruit species have potential for economic, nutritional and other desirable traits. These wild indigenous edible fruit species distributed in the foot hill tracts of the Eastern Himalayas, India inclusive eight states, viz., Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim (North East India) were screened and discussed based on survey, collection and physic-chemical properties of the fruits. Geographically, the region stretches between 21°50′ and 29°34′N latitude and 85°34′ and 97°50′E

longitude, and altitude varies from near sea-level to over 7000 m a.s.l. This region represents an important part of Indo Myanmar bio-diversity hotspot, one of the 25 global biodiversity hotspots (Myers et al. 2000). Therefore, the region is considered to be a store house and reservoir of wild genetic resources, particularly of underutilized fruit crops occurring wildly in the forest and in almost every backyard. There are about 800 different species of underutilized edible crops in India, out of which about 300 species are used mostly by the tribal and rural population of the North Eastern region alone (Nath et al. 2013). About 60 % of the world's population and 80 % of the population in developing countries depends on traditional medicines (Hazarika et al. 2012).

A vast area of the whole range surveyed is of marginal terrains, rocky, undulating land and wastelands which mostly are not feasible for commercial adoption of high input fruit crop. Similarly, food grain cultivation may prove un-remunerative due to absent of irrigation facilities and poor water holding capacity of the rocky soil. Under such adverse climatic conditions these wild fruit tree species are found to adapt well even without any care. Due to their easy availability, these genetic resources are the major sources of various vitamins and minerals for the indigenous population of the region. They also have medicinal properties and are used frequently by the local people for curing of several ailments (Agrahar-Murugkar and Subbulakshmi 2005). In addition, some of the fruits possess high pigment contents which can be of high value as an alternative to synthetic dye. With the rapid rise of demand for natural dye and flavor in the Processing Industry, and laws prohibiting in many countries for the use of synthetic colorants, the dyes extracted from these fruits may be exploited for health benefits. Furthermore, these fruits also supplement the subsistence and income generation of the rural populace.

Despite of such potential these genetic resources are yet to be exploited to a commercial level. Till date very little work has been initiated on domestication, improvement and cultivar development for these species, which is a hindrance to higher production and productivity. There is no variety developed involving local germplasm especially the potential indigenous and wild relative crops (Sharma and Rana 2005). These underutilized fruit crops exist in the nature through survival of the fittest, thus may possesses several desirable traits such as resistance to biotic and abiotic stresses. For any species evolution and improvement to a commercially cultivated one is mostly attributed to introgression of genes from one taxon to another (Rana et al. 2007). Thus adoption of scientific breeding programme and production techniques on these hardy and low input demand fruit crops will further enhance the economic conditions of the growers; meet the demand of the ever increasing population for food and nutrition; increase the population size of these valuable plant genetic resources which otherwise may become extinct. Therefore, analysis studies on these underutilized and wild fruit genetic resources are the needs of the hour, so that interested researchers may accurately assess and improve their adaptability, nutritional value, physiological state, determine their relationships to human health and diseases and develop them further as fruit crops of the future.

Materials and methods

A preliminary survey and collection was made to enumerate the important potential wild edible fruits of North East India situated in the foot hills track of Eastern Himalayas (Fig. 1). During the field visit, information on utilization of these potential underutilized fruit crops were collected by filling questionnaire and personal interviews with the village elders and traditional healers residing in various areas (Jain and Goel 1995). To gather more information, weekly markets of the tribes were also visited and interviewed. Periodical interviews were conducted to 26 individuals from 10 villages among different age groups (45–75 years), which were identified with the help of village administrators and community leaders. The species were identified with the help of the collected plant parts viz., leaf, flowers and fruits and authentic literatures and monographs including regional flora to validate all information (Kanjlal et al. 1934–1940; Hooker 1897; Jain 1987; Choudhary 1989; Sharma et al. 1993; Saklani and Jain 1994). Botanical description such as tree, flower, leaf and fruit characteristics of these crops was studied during field trips and also in the laboratory with the help of literatures. Morphological and biochemical characteristics of fruits were carried out in the laboratory following standard procedures and literatures. Thirty

Fig. 1 The *dots* represent the foothills track of Eastern Himalayas, India where the survey was undertaken

fruits were collected at ripened stage for physical and chemical analysis of each identified species. Samples for analysis were collected from all the ten villages wherever these fruits are available. The fruits were washed and determined for total soluble sugar, titratable acidity and vitamin C according to Rangana (2002), reducing sugars, total sugars, β-carotene, anthocyanin, antioxidants, moisture content, fibre and ash (AOAC 2002). After proper identification, seeds and vegetative parts of these potential plants were collected, planted and conserved in the field gene bank of the Horticulture Division, ICAR Research Complex for NEH Region, Umiam 793 103, Meghalaya.

Result and discussion

Survey divulged that the most common and potential underutilized edible fruit genetic resources occurring naturally in the region are. *Padus napaulensis* (Ser. ex DC.) Schneider, *Elaeagnus latifolia* L., *Myrica esculenta* Buch.-Ham. ex D. Don, *Baccaurea ramiflora* Lour., *Pyrus pashia* Hamilton ex D. Don, *Calamus meghalayensis* (Becc.) A.J. Hend., *Gynocardia odorata* R. Br., *Prunus undulata* Buch.-Ham., *Docynia indica* (Wall.) Decne., *Rhus chinensis* Mill. and *Viburnum foetidum* Wallich. These fruit crops are intensively used by the tribal populace for food and medicine (Pandey 2002; Mishra et al. 2003; Kayang 2007). Our finding on distribution, botanical description, physico-chemical characters and utilization of each promising and common fruit species are given below;

Padus napaulensis (Ser. ex DC.) Schneider (syn. *Prunus nepalensis* Hook., *Prunus nepaulensis* (Ser. ex DC.) Steud.)

Khasi cherry (*Padus napaulensis* is a member of Rosaceae family which is popularly known by its vernacular name Sohiong.

Habitat and distribution

It is a wild growing fruit found in temperate Himalayan regions at altitudes between 800 and 3000 m a.s.l. It starts occurring from Kumaon hills of Indian up to Bhutan and North East India. It is quite common in the Khasi and Jaintia hills of the Indian state of Meghalaya and Assam where it is cultivated.

Morphological and quality parameters

Trees are large with grey bark, open, upright branches and oblong-lanceolate leaves. The plant is of low chilling types resembling very much to the common

Fig. 2 Fruits of *Padus napaulensis* (Ser. ex DC.) Schneider

cherry (Singh et al. 1975). Flowering appearing in October–November and fruits mature during August–September. Mature fruits are bigger in size and purplish or blackish brown (Fig. 2) (Rai et al. 2005). Variability was observed within the species both for fruit size and quality. There are two types of Sohiong fruits based on size, viz, big and small fruit size were observed during the survey. Physical fruit traits analysis revealed wide variations, ranging from smaller to bigger fruit type as indicated in Table 1. Similar variations were also observed in the chemical contents of both the fruit types, bigger fruit type recorded higher content of acidity (3.32 %), ascorbic acid (58.38 mg/100 g), reducing sugar (4.44 %), total sugar (8.75 %), pectin (2.00 %), moisture (in fruit, 61.84 % and seed, 33.33 %) as compared to smaller fruit types. However, higher content of TSS (20.15 %), β-carotene (2.76 mg/100 g), anthocyanin (358.86 mg/100 g) and fibre (2.5 %) was obtained in smaller fruit of Sohiong (Rymbai et al. 2014a).

Utilization

Fruits are eaten raw and used for wine making due to its imparting purple colour to the wine. Sohiong showed graft compatible with *P. cornuta* initially with good growth but subsequent scion's growth was slow. This species is resistant to collar rot and powdery mildew (Pareek et al. 1998; Singh and Gupta 1972). However, according to Baiswar et al. (2009) powdery mildew is one of the most severe diseases of Sohiong and almost 40 % of the plants were found infected during July throughout the surveyed track.

Elaeagnus latifolia L. (syn. *Elaeagnus javanica* Blume)

It belongs to family Elaeagnaceae, genus *Elaeagnus* commonly known as Bastard oleaster and the vernacular name is Sohshang in Khasi Hills, *Slangi* in Jaintia Hills and Muslerhi in Sikkim.

Habitat and distribution

The species is found to grow well in forest openings, swamps, to elevations between 1500 and 2600 m a.s.l in the Himalayas (Gamble 1972; Gupta 1945; Manandhar 2002). Grows well at light sandy, medium loamy and heavy clay soils and prefers well-drained soil. It can grow in nutritionally poor soil and can also tolerate varied conditions like acidic to alkaline soil, dry to moist soil and drought conditions. The species is distributed in Myanmar, China, subtropical and temperate Himalaya. It is also cultivated in warmer parts of southern Europe, North America and Vietnam (Hanelt and IPK 2001). It is a very common shrub in the foothills track of Eastern Himalayas, particularly in the hills of Khasi and Jaintia, Meghalaya, India and is mostly grown in semi-wild condition in the back yard for its ornamental values and edible fruits.

Morphological and quality parameters

Plant is large, grows up to 2.7–3.7 m, evergreen liana (woody climber), spreading type, woody shrub with rusty-shiny scales that are often thorny. Flowers are hermaphrodite and pollinated by bees, occurring during September–December. Fruit is oblong in shape with dark pink colour at the time of ripening (Fig. 3). It is harvested at light pink coloured stage during March–April in 3–4 picking. They are very perishable with shelf-life of only 3–5 days at room temperature (23 °C). It contains a single seed, which is large and has very less viability. Physical analysis of fruits is shown in Table 1. Chemical analysis recorded TSS (11.9 %), acidity (2.8 %), vit. C (16–19.2 mg/100 g pulp), reducing sugar (4.0 %), total sugar (6.1 %), β-carotene (1.1 µg/100 g pulp), anthocyanin (16.2 mg/100 g pulp) and antioxidants (10.1 µg moltrolox/g). Fruit is fairly rich in minerals and essential fatty acids, which is unusual for a fruit (Patel et al. 2008a).

Table 1 Physical characteristics of potential edible underutilized fruit crops of the foothills track of Eastern Himalayas, India

Crops	Fruit						Seed		
	Weight (g)	Length (cm)	Diameter (cm)	Volume (ml)	Pulp (%)	Juice content (%)	Weight (g)	Length (mm)	Breadth (mm)
Padus napaulensis	3.98–7.91	1.82–2.18	1.71–2.18	4.05–8.33	69.11–74.71	20.02–26.15	1.00–2.44	13.48–15.94	11.48–15.08
Elaeagnus latifolia	13.0–16.4	3.51–4.46	2.27–2.53	12.58–16.72	56.24–57.01	25.11–28.72	2.71–3.35	33.43–34.27	12.15–14.06
Myrica esculenta	7.0–14.13	2.2–3.2	2.0–2.8	7.48–15.22	23.01–30.65	30–40	1.0–2.0	16.98–20.95	11.02–15.70
Baccaurea sapida	11.02–12.60	2.63–2.76	2.64–3.16	11.31–13.15	45.50–49.79	27.37–36.30	1.40–2.33	10.72–12.05	9.42–10.62
Pyrus pashia	6.57–44.25	1.85–4.50	2.21–5.13	7.02–46.26	49.78–57.84	24–30	0.34–0.81	6.48–10.22	4.16–5.93
Calamus meghalayensis	11.46–17.25	2.5–4.0	2.0–3.0	12.26–18.44	69.28–75.59	32.33–37.33	3.52–4.21	2.02–3.00	1.47–2.13
Gynocardia odorata	–	3.00–7.50	4.20–8.00	–	–	–	–	1.42–3.12	1.17–2.20
Prunus undulata	2.86–5.62	1.6–2.2	1.3–1.5	2.94–6.02	42.65–47.68	16.33–20.16	1.64–2.98	12.18–16.80	10.56–17.36
Docynia indica	25.27–42.26	3.89–4.71	3.35–4.28	30.0–41.0	22.34–25.96	23.66–37.65	0.067–0.089	9.31–10.56	4.94–5.46
Rhus semialata	–	0.4–0.6	0.4–0.5	–	–	–	–	–	–
Viburnum foetidum	0.25–0.33	0.4–0.6	0.3–0.6	0.22–0.34	–	–	0.11–0.13	0.21–0.28	0.14–0.27

Value is presented in range as fruits for each species were collected from various locations, an indication of a wide spread of value within the species

Utilization

All parts of the fruits are edible including seed, and at all stages of fruit growth. They are consumed raw with salt or used in pickle preparation by the indigenous tribes. Pulp is used for making jam, jelly and refreshing drink. The extracted juice possess attractive reddish or pinkish colour. Apart from the above usage the fruit is probably capable of reducing the incidence of cancer, also as a means of halting or reversing the growth of cancers (Matthews 1994).

Myrica esculenta Buch.-Ham. ex D. Don (syn. *Myrica farquhariana* Wall.)

This fruit crop belongs to family Myricaceae, commonly known as box myrtle and locally known as Soh-phie-nam in Khasi and Saphai in Jaintia Hills.

Habitat and distribution

The species is distributed in the temperate and sub-tropical regions (India and China) of both hemispheres except Australia. In India, it is confined in sub-tropical Himalayas from Ravi eastwards to Assam and quite common in the Hills of Khasi, Jaintia, Naga and Lushai where it is cultivated (Kumar 2002). The plants are thriving well at an altitude of about 1300 m up to 2000 m a.s.l. in nitrogen depleted soils and mostly associates in *Pinus* sp. and *Quercus leucotrichophora* mixed forests and marginal lands (Bhatt et al. 2000).

Morphological and quality parameters

The tree is a moderate sized and ever green. The leaves are lanceolate and ovate nearly entire or serrate. Inflorescence is a catkin, compound raceme and axillary bearing. Pistillate flowers are very small, sessile, solitary and bracteates. Edible part of the fruit is the pulp which constitutes about 75 % of the fruit and is available during April–July. Fruits are about 2.5 cm ellipsoidal or ovoid reddish or cheese colour at ripening (Fig. 4). Physical fruit characteristics of *M. esculenta* are given in Table 1. Chemical characteristics of fruit have also been estimated with TSS (5.7–6.5 %), acidity (2.5–4.8 %), vit. C (17.6–28.2 mg/100 mL pulp), reducing sugar (1.0–3.5 %) and total sugar (3–7.7 %).

Utilization

Fruits are eaten fresh at all stages of its growth, and are one of the tastiest and preferred wild fruits of the region. It has several commercial important in the region. Fruits are used for making refreshing drink and pickle. The bark has medicinal properties and is used as aromatic, stimulant for rheumatism, astringent, carminative, asthma, toothache, diarrhoea, lung infection, fever, cough, bronchitis, dysentery, antiseptic indigenous medicine and in the preparation of yellow dye (Kirtikar and Basu 1984; Rai et al. 2005). Furthermore, authors also noticed that the extracted juice has a very attractive sparkling red colour.

Fig. 3 Fruits of *Elaeagnus latifolia* L.

Baccaurea ramiflora Lour. (syn. *Baccaurea sapida* Muell. Arg.)

Burmese grape (*B. ramiflora* Lour.) is a species of flowering plant belonging to the Phyllanthaceae family. The vernacular name is Sohramdieng in Khasi and Sohmyndong in Pnar. It is a very important and popular fruit to people of all ages in Khasi and Jaintia Hills (Meghalaya). The genus comprises about 80 species, distributed from Indo-Malesia to the West Pacific.

Fig. 5 Fruits of *Baccaurea ramiflora* Lour.

Fig. 4 Fruits of *Malus esculenta* Buch.-Ham. ex D. Don

Habitat and distribution

The species is native to the South East Asian region. The tree is found wild or semi- cultivated in the sub-Himalayan tract in eastern India from Bihar to Arunachal Pradesh and in the lower hills and valleys of Meghalaya, Assam, Nagaland, Manipur, Mizoram, Tripura and Orissa, ascending to an altitude of 900 m, and in Andaman and Nicobar Islands, chiefly in the moist tropical forests. It is also cultivated in China, Myanmar, Thailand, Vietnam and Malaysia (Hanelt and IPK 2001).

Morphological and quality parameters

Tree is evergreen up to 5 m height, with long branches from near the ground, particularly when the stem is laden with fruits (Brandis 1991; Sundriyal and Sundriyal 2003). The wood is pinkish-white, soft and even-grained (Abdullah et al. 2005). Flower is tomentose on short pedicels in simple bracteates spiciform densely fascicled racemes borne below the old wood. Fruit is yellow, velvety, 2–3 cm diameter, with leathery pericarp (Fig. 5). Sometime, the yellowish ripe fruits turn into ivory to pinkish-buff or bright red. Pulp is aril with whitish and occasionally deep pink near seeds. Taste varies from acid to sweet in taste. Seeds are arillus, 3 in number per fruit, embedded in pale rose-coloured delicious pulp. Physical analysis of fruit parameters are indicated in Table 1. Chemical analysis of fruits revealed that TSS was 8.2–14.1 %, acidity 1.93 %, reducing sugar 5.10 % and total sugar 13.69 % besides, fruits are also rich in protein and iron.

Utilization

Arils of ripened fruits are eaten and very delicious with high market preferences among the tribal population. Fruits are mainly used for preparation of squash, RTS, wine and jam (Patel et al. 2008b). Fruits and leaf also yielded dye of chocolate colour (Deka and Rymbai 2014) which can be used as colorants for any processing products. The rinds of the fruits are occasionally used for making pickle (Sundriyal and Sundriyal 2003). Traditionally, fruit juice is either stewed or used to prepare wine (Goyal et al. 2013), and are also used for treatment of arthritis, abscesses and injuries (Lin et al. 2003).

Pyrus pashia Hamilton ex D. Don (syn. *Malus pashia* Wenzig)

Pyrus pashia Hamilton ex D. Don, the wild Himalayan pear belongs to the Rosaceae family, is known as Sohjhur in Khasi and Sohait-syiar in Pnar (Meghalaya).

Habitat and distribution

The species prefers moist soil and can tolerate drought and atmospheric pollution Huxley et al. (1992). It is distributed across the Himalayas, from East Afghanistan, North Pakistan through Himalaya to Vietnam and from southern province of China to the North Eastern Region of India up to 2700 m a.s.l (Arya et al. 2011; Hanelt and IPK 2001). In Khasi and Jaintia Hills, the cultivation of this crop has been undertaken in the back yard for the gritty texture of fruit pulp.

Morphological and quality parameters

It is a medium size deciduous tree. Flowers occur during February–March and are white in colour, 0.75–1 cm diameter when fully opened. Fruits are 1.5–4 cm diameter, globose, depressed at the top, somewhat rough with raised white specks and dark brown when ripe (Fig. 6). Endocarp contains grit cells. The fruit varies in taste from strong stringency type to sweet and gritty type. Analysis of physical parameters of fruit is indicated in Table 1. Estimation of chemical

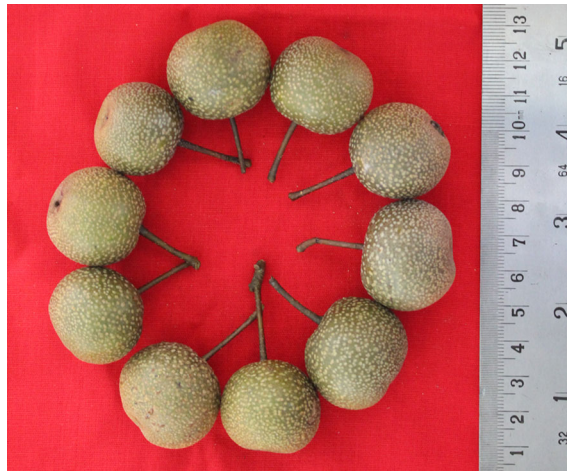

Fig. 6 Fruits of *Pyrus pashia* Hamilton ex D. Don

content revealed that fruits has moisture 62 %, TSS 31 %, acidity 0.97 %, total sugars 6.85 %, reducing sugars 6.79 %, tannins 0.42 %, vit. C 1.22 mg/g pulp, pectin 0.4 %, ash 0.99 %, protein 3.68 %, phosphorous 0.026 %, magnesium 0.027 %, potassium 0.475 %, calcium 0.061 % and iron 0.006 % (Parmar and Kaushal 1982; Huxley et al. 1992; Rymbai et al. 2014b). Although, the plants are cultivated in backyard gardens, however, no commercial cultivation has been taken up which might be due to non-availability of standard cultivars and poor shelf-life of the fruits.

Utilization

This fruit of this species is very popular and preferred by tribal population for its sweetness and grittiness. Sohjhur offers a good source of income and nutrition for the population residing in the Himalayan hill tracts due to its richness in nutrients and sweet aroma for consumption as dessert fruit. Apart from these uses, the plant also has medicinal properties viz., fruit juice is used for curing eye disorder (Hazarika et al. 2012); leaf extract is used as a tonic for hair loss, treatment of digestion related ailments and possess antimicrobial activity (Gulia 2005). In addition, warm leaf extract is also consumed as beverages. Seedlings can be used as rootstock for pear and quince grafts (Rai et al. 2005).

Calamus meghalayensis (Becc.) A.J. Hend. (syn. *Calamus floribundus* var. *depauperatus* Becc.)

The fruit is locally known as Soththri in Khasi and Pnar, Sohmil in Garo. It belongs to the Arecaceae family and native of Khasi Hills of the northeastern India (Henderson and Henderson 2007).

Habitat and distribution

It grows wildly as well cultivated in warmer parts of the Khasi, Jaintia, Garo Hills and other areas of the region. This species prefers low land forest on river plains or flat areas up to 1000 m a.s.l.

Morphological and quality parameters

Tree grows up to 2 m height and 0.5–0.6 m diameter with leaf sheaths. Leaf sheaths are green with brown tomentum, sparsely covered with brown, flattened, horizontally spreading spines. Inflorescence is up to 1 m long, flagellate, and partial inflorescences inserted above the mouth of the partial inflorescence bracts. The tree bear fruits in bunches during February–April. Fruits are globose, varies from 1.5 to 3.0 cm in length and 1.0–2.0 cm width (Table 1). The peel of the fruit is light yellow and the pulp is white in colour (Fig. 7).

Utilization

Fruit pulp inside the outer woody skin is aril and are edible, very juice, little acidic but very delicious and relished by the indigenous population. Apart from the fruits the canes are also used for domestic crafts, while leaves are used for roof thatch making.

Gynocardia odorata R. Br. (syn. *Gynocardia prainii* Desprez.)

It is locally known as Sohliang in Khasi and Pnar, belongs to family of Flacourtiaceae.

Habitat and distribution

The plant is native to the moist forests of Khasi and Jaintia Hills and Sikkim of the Eastern Himalayan Hills (Roxburg 1820). It is also found to grow in temperate and tropical region of Asia such as the Indian subcontinent, China and Myanmar (GRIN 2014). It is cultivated in some parts of Jaintia Hills, Meghalaya.

Fig. 7 Fruits of *Calamus meghalayensis* (Becc.) A.J. Hend.

Morphological and quality parameters

The plant is a beautiful, crooked, and evergreen tree grows up to 30 m and has an untidy branching habit. Flowers are pale yellow, sweet scented, and arise directly from the bark. Fruits arise straight from the corky stems and are round, ash-coloured. Fruit is available from January to March; with fruit length varies from 3.0 cm to 7.5 cm, fruit diameter (4.2–8.0 cm), seed length (1.42–3.12 cm) and seed diameter (1.17–2.20 cm; Table 1).

Utilization

Fruit is poisonous, however seeds are edible. The seed before eating must be boiled and drained the boiled solution for three to fourth time. The boiled seeds are then sliced into thin pieces (Fig. 8). A crude oil has been extracted from the fruit under pressure, which is used in cooking and lighting purposes (Roxburg 1820). Oil obtained from seed is used in treatment of psoriasis, eczema, scrofula, gout, leprosy and rheumatic. In addition to oil, triterpenoid ketolactone and odo-lactone has been isolated from the plant (Khare 2007).

Prunus undulata Buch.-Ham. (syn. *Prunus acuminata* (Wall.) D. Dietr.)

It is locally known as Diengtyrkhung and belongs to Rosaceae family. This species comes under section *Laurocerasus* of subgenus *Laurocerasus* (Ghora and Panigrahi 1995).

Habitat and distribution

The species is rare, growing wild in Khasi and Jaintia Hills (Meghalaya, India) occurring in mountainous or hilly forests or river valleys (Rana et al. 2007). It is well distributed from Asia-temperate to tropical including Indian Subcontinent such as Bangladesh, Bhutan, Nepal, India—Arunachal Pradesh, Assam, Manipur, Meghalaya, Nagaland, Sikkim, Uttar Pradesh and West Bengal (Pandey et al. 2008) at elevations of 500–3600 m a.s.l. It is cultivated in a semi-commercial manner in the adjacent forest areas of the region.

Morphological and quality parameters

The plant is a small deciduous tree, upright and moderately branched. Leaves are simple, broad, smooth, ovate-lanceolate or broad-eliptic, unlobed and toothed along the margin. Flowers are raceme, axillary, small, white, fragrant, appears in September–November. Fruit is a drupe, ovoid, pointed and are ripened in December–May (Ghora and Panigrahi 1995; Fig. 9; Table 1).

Utilization

The fruit are edible. Its decoction stimulates respiration and improves digestion (Hazarika et al. 2012). Fruit extract gives dark grey to green dye (Grae 1974). This species show resistance to powdery mildew, and

Fig. 8 Processed and sliced seed of *Gynocardia odorata* R. Br.

Fig. 9 Fruits of *Prunus undulata* Buch.-Ham.

is incompatible as rootstock on grafting with peach and plum (Kishore and Randhawa 1993).

Docynia indica (Wall.) Decne. (syn. *Docynia hookeriana* Decne.; *Malus docynioides* Schneid.)

Assam apple (*D. indica* (Wall.) Decne.) belongs to the Rosaceae family and locally known as Sohphoh in Khasi and Sohptet in Pnar.

Habitat and distribution

The species prefers moist soil and open places up to elevations of 700–3000 m a.s.l. It is a native of the Eastern Himalayas. The species is distributed from East Asia to China, Nepal, Bhutan and North Eastern India including Khasi and Jaintia Hills of Meghalaya, where it is cultivated in the back yard and naturally occurring in forest areas.

Morphological and quality parameters

Tree is deciduous with medium to tall in height. Leaves are ovate to oblong, lanceolate, acuminate, serrate and glabrous. Flowers appears during March to April and are either solitary or arranged in fascicales of 2–3. Fruits mature during August to November depending on the altitude where the plants are growing. Fruits are acidic, sub-globose or ellipsoid, slightly pubescent when young, sepals persistent and erect, and greenish or yellowish colour with red tinged (Fig. 10). Physical analysis of fruit is given in Table 1.

Fig. 10 Fruits of *Docynia indica* (Wall.) Decne.

Studies on chemical content of fruits showed that *pH* 3.25, moisture 80.31–85.14 %, vit. C 14.8–17.5 mg/100 g pulp, antioxidant activity IC_{50} 1657–1731 µg/ml, protein 1.81–2.76 mg/100 g pulp, total sugar content 21.92 mg/100 g pulp, reducing sugar 1.05–4.31 mg/100 g pulp, potassium 140 mg/100 g, magnesium 20.60 mg/100 g and micro elements such as iron, copper, cobalt, manganese and zinc (Khomdram and Devi 2010). The taste of the fruit in the foot hill tracts ranged from medium sweetness to acidic and astringent varies with genotypes.

Utilization

The fully ripe fruit is eating as fresh, while the half ripe are consumed as fresh with salt or boiled with sugar, sundried and consumed. Fruits are also used for preparation of pickles and jelly. Traditionally, fruits are used for treatment of infectious diseases and also has anti-obesity compound (Van Chi 1997). It was reported that the natural products extracted from the fruit consist of polyphenol compounds, especially flavonoids and alkaloids which are found to reduce the blood glucose concentration, and in turn have anti-obese effect in mice (Loan et al. 2011). It is also used as rootstock for imparting semi-dwarf in apple (Rai et al. 2005).

Rhus chinensis Mill. (syn. *R. semialata* Murr.; *R. javanica* L.; *Brucea javanica* (L.) Merill.)

Rhus chinensis Mill. belongs to Anacardiaceae family and is locally known as Sohmluh in Khasi Hills and Sohsama in Jaintia Hills of the foothills track of Eastern Himalayas.

Habitat and distribution

The plant is a member of the monophyletic group, most likely migrated from North America into Asia via the Bering land bridge during the late Eocene (Yi et al. 2004). It is also reported that *R. chinensis* is under cultivation in China, Korea, Japan, Java, Europe and USA (Hanelt and IPK 2001). It is wildly distributed in Temperate and subtropical Asia. In India, it is mainly found in Khasi, Jaintia Hills of Meghalaya, and other part of the eastern Himalayas range including Bhutan at altitude ranged 600–2400 m a.s.l. It is growing as secondary forest in the region.

Fig. 11 Fruit bunch of *Rhus chinensis* Mill.

Morphological and quality parameters

The plant is dioecious, deciduous with imparipinnately compound leaves (Hillebrand 1888). Flower appears during July–September, whitish or pale green having many sterile flower and long hairy pedicle (Chaudhuri 1993). Fruit is a red fleshy drupe, occurring in cluster of galls with red glandular hairs on the fruit wall (Fig. 11; Table 1). Fruits are rich sources of several antioxidants such as tannin, gallic acid and minerals like potassium acid salts, traceable amount of aluminium, calcium, magnesium and iron, acid salts of malic, tartaric and citric acids (Krisnamurthi 2003; Khare 2007).

Utilization

Fruits are salty with sharp acidic taste and whole fruit is eaten when ripe. Traditionally, fruits are used for treatment of diarrhoea, dysentery, ingestion, cough, rectal prolapse, spontaneous sweating, night sweating, epistasis, functional bleeding; topically for wound bleeding, ulcerous dermatitis and toxic skin swelling (Rai and Rai 1994; Dharmananda 2003). This has been further confirmed by Bose et al. (2008) who found that fruit extract possesses anti-diarrhoea activity in rat. New compounds named Semialatic acid, Semialactone, Isofouquierone peroxide and Fouquierone, a triterpenes has also been isolated from this fruit (Parveen et al. 1991).

Fig. 12 Fruits of *Viburnum foetidum* Wall.

Viburnum foetidum Wall.

It is known as Sohlangksew in Khasi and Salang in Pnar and belongs to the Caprifoliaceae family.

Habitat and distribution

Sohlangksew is native of northeast India, Bhutan and northern Myanmar (International Dendrology Society 2014). It is a shrub found mainly in subtropical broad-leaved forests at the higher elevations of 900–1800 m a.s.l. The species occurring wildly throughout Meghalaya, however, more prominent along the southern slope of Khasi and Jaintia Hills where the rainfall is very high about 2000–5000 mm with a severe winter during November–March (Marak 2007). So far, no cultivation of this crop in the region has been observed in a commercial scale. However, it is found to grow in the backyard as well as in the surrounding areas of tribal resident living in the vicinity of the forest.

Morphological and quality parameters

It is a semi-evergreen shrub up to 3–4 m height. Leaves are either broadly ovate with rounded base or more or less trilobed towards the apex of about 3–7 cm length and 2–3.5 cm width. Flowering takes place in the months of June–July. Flowers are borne singly stalk less, in rounded branched clusters about 5–9 cm width. Fruits are closely packed, broadly oval to orbicular shape and scarlet-crimson colour. Fruit ripens during September–November which is very small about 4–6 mm length and width of about 5 mm (Fig. 12; Table 1).

Utilization

Fruits are eaten raw and also utilized as food for fish baits and medicine for skin diseases (Jaisal 2010). The extracted fruit juice is used in remedies of menorrhagia and as a sedative in uterine disorders, and in postpartum haemorrhage (Khare 2007). Leaf extracts is astringent, emmenetic and used in haemorrhage (Kishore and Randhawa 1993).

Constraints for commercial cultivation of these crops

More than hundreds species of underutilized and wild relative fruit crops occurring naturally in the region, however, it has not been demonstrated as an economic enterprise and research interest on these species (Sundriyal and Sundriyal 2005;Jeeva 2009). This is because there are many factors which hindered the popularization and cultivation of these crops in an extensive ways. The major constraints are; exploration of these wild edible plant species is very difficult due to inaccessible mountainous nature, poor transportation and communication of the region; lack of awareness about the economic and nutritional value of these species; non-availability of improved varieties; non-availability of quality planting materials; lack of technology to reduce the gestation period and canopy size; lack of technology for processing and value addition; poor recognition of these species in horticultural promotion and conservation programs.

Strategies for effective utilization these indigenous fruit genetic resources

The population density of these wild species is progressively decreasing and their natural regeneration is often poor in natural habitats due to intense biotic and abiotic pressure. The pressure is further aggravated, as they are collected freely in large quantity from the backyard/forest for selling in the markets and used as fuel wood. Such uncontrolled exploitation of these naturally occurring wild genetic resources has led them to become rare to very rare and many may become extinct in near future. Furthermore, this may lead to narrowing the genetic diversity and variability of these wild species. With the ever increasing population, there is a great need to popularize and conserve these genetic resources in order to meet the future demand for human food, nutrition, medicine, and gene(s) sources for adapting to climate change. Therefore, certain management strategies must be adopted for effective utilization of these genetic resources;

(1) *Improvement programme* These fruit plants can be utilized in the improvement programme in the line of exotic fruit species e.g. *Prunus* species, *Pyrus s*pecies etc. Their long gestation period can be shortened by adopting techniques like grafting and genetic improvement. There is also a need to develop high yielding variety for more economic benefits.

(2) *Research activities* Studies on these wild species and their wild relatives are essential in order to realise their potential in several production aspects. For instance, *P. napaulensis* was found graft compatibility with *P. cornuta* (Singh and Gupta 1972).

(3) *Quality planting materials* Standardization of propagation may be taken up to ensure easy availability of quality planting material for area expansion under cultivation of these species.

(4) *Production technology* Specific low cost production technology and improvement plant health through nutrients, integrated insect-pests and diseases management; efficient use of water and other inputs; mechanisation practices, production of quality fruits, post harvest handling and value addition must be initiated to realise the potential yield and profit of the species.

(5) *Value addition* Some of these fruit are of short shelf life, leading to low market price. Therefore value addition may be introduced in the form of pickle, chutney, jam, jelly, etc. to enhance income generations of the tribal communities. For instance, *P. napaulensis* have been used for making wine due to it imparting purple colour to the wine. This indicates a clear need of diversification the product base for ensuring good price for these commodities.

(6) *Awareness* Awareness among the local peoples on various issues related to conservation, food and nutritive value needed to be addressed. Special campaigns on their plantations along roadside, waste and degraded lands, vacant

community lands, field boundaries and also propagating through mass seeding in the unutilized land may be encouraged.

(7) *Establishment of proper network* Proper network among all the institutes working on minor and wild fruit crops particularly regarding characterization, evaluation and conservation in the field gene banks is necessary. Since it is difficult for a single institute to conserve and evaluate all the fruit plants due to paucity of land, resources and expertise.

Conclusion

Wild edible fruit genetic resources possess valuable nutrients, medicinal and importance sources of desirable gene(s), especially in the context of stress relating to climate change. There is a possibility of adopting these underutilized fruit crops over a wide range of agro-climatic conditions due to their hardy in nature. Similarly, fruit availability can be extended almost throughout the year for nutritional security among the tribal populace. These fruits are rich in bioactive compounds such high anthocyanin in *P. napaulensis*, antioxidants in *E. latifolia,* various vitamin and mineral in *P. pashia.* These crop also posses potential for natural colour such as purple colour from *P. napaulensis*, reddish or pinkish from *E. latifolia* and *M. esculenta* and chocolate colour from *B. ramiflora.* Furthermore, these underutilized crops have been traditionally used for curing several ailments. For example, *E. latifolia* has potential for halting or reversing the growth of cancer. In addition, these crops also have potential for diversification such as value added product to increase the livelihood of the farmers. Thus there is a need to standardize a scientific crop production, protection, development of improved varieties and marketing channel. Similarly, proper strategies must be drawn out for their conservation and utilization in any crop improvement program. It is high time that the communities, researchers and the entrepreneurs all work together to make these minor fruit crops a commercially viable fruit crop of future. The co-existence of these wild fruit plants along with the commercial exotic crops will definitely help in achieving food security and eco-sustainability in the future.

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Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interest in whatsoever.

Research involving human participants and/or animals None.

Informed consent Since the research is not involving human/animal participants. Therefore, authors conducted the survey and study at our level in the institute.

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