Review Article
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Genetic diversity of underutilized fruits in india for environmental sustainability

Abstract

India, the centre of origin for many tropical fruit tree species, most of which are not commercially cultivated but provides significant source of livelihood support for many rural communities. The tribal inhabitants of Western Ghats, Maharashtra and North Eastern States of India were traditionally reliant on non-timber forest products and favoured local fruit species like tamarind (*Tamarindus indica*), jackfruit (*Artocarpus heterophyllus*), Indian gooseberry (*Emblica officinalis*), ber (*Zizyphus mauritiana*), etc., instead of arable food crops apart from mango and cashew, for establishing agri-horti-forestry for their livelihoods. Innumerable wild species of *Citrus, Musa, Pyrus* and *Malus* were also prevalent in the North Eastern regions. Conversely, most of these species are in a state of neglect, while a trivial number of them are under cultivation in their native tracts by local communities for specific household uses only. These species were rendered "Underutilized" by the fact that even though they are locally abundant, they are restricted to their geographical location with dearth of scientific knowledge about them, and their current use is linked to their economic potential. These species were immensely constructive by surviving harsh agro-climatic conditions, and can be established on degraded lands, which are presently being underutilized either due to poor soil fertility or moisture scarcity. Due to unsustainable market pressures and rapid urbanization, majority of these species have come to near extinction. A holistic approach is hence proposed which includes both in-situ and ex-situ conservation strategies, as well as re-governance of the market chain. Reinforcement of their domestication through standardization of cultivation practices, facilitation for supply of planting material and increasing the demands for the produce by exploring their uses, creation of awareness among consumers and establishing a good distribution network are also crucial for attaining sustainability.

Keywords: fruits, minor, subtropical, sustainable, temperate, tropical, underutilised

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Introduction

India, the home of the world's most useful plants thriving in diverse agro-ecological zones from the monsoon tropics of the south to temperate and alpine north-western Himalayas, from the extremely arid and semi-arid north-western plains to the humid tropics of the east.[1] Located between 8°N-38°N latitude and 68°E-93.5°E longitude and showing altitudinal variations ranging from below sea level to more than 3500m above mean sea level, it exhibits extreme diversity of edaphic and climatic conditions and is one of the most significant and unique countries in the world in view of fruit genetic resources and diversity. Over 300 species of fruits, including temperate, subtropical and tropical, are growing in the country. The important fruit crops grown commercially in India are mango, banana, *Citrus*, guava, grape, pineapple, papaya, sapota, litchi and apple which comprise more than 75 percent of total area under fruit cultivation.[1] Among the pome fruits, in addition to cultivated fruits like apple and pear, a wide range of wild, temperate pome fruits occur in the Indian Himalayas. These include several species of *Malus, Pyrus, Sorbus, Cydonia, Cotoneaster, Crataegus, Pyracantha, Diospyrus and Docynial.*[2]

A few percentages of these fruits are commercially grown, while most of the others are given less importance nor traded widely and rendered them as underutilized fruit crops. The several less-known fruit species which have the potential for commercial exploitation are yet to be utilized to their potential.[3] Most of the indigenous fruits are underutilized. They are rich in vitamin, minerals, nutrients and has medicinal potential. These fruits have lack of genetic material, loss of germplasm collection and traditional knowledge, lack of knowledge on uses, have constraints and opportunities, limited income generation, market, commercialization and demand limitations, lack of research and development activities and weak national capacities and lack of links across conservation and production. Underutilized crops could also have an important role to play as new promising crops due to their consistent use in lesser common farming situations and subsistence agriculture as practiced by poor farming households. Their adoption on a commercial scale, with crop improvement, standardization of cultural practices and popularization in diverse farming systems are warranted to achieve stability in farm production and food security.[4]

Genetic diversity and their significance

The tribal inhabitants of Western Ghats, Maharashtra and North Eastern States of India were traditionally reliant on non-timber forest products and favoured local fruit species like tamarind (*Tamarindus indica*), jackfruit (*Artocarpus heterophyllus*), Indian gooseberry (*Emblica officinalis*), ber (*Zizyphus mauritiana*),etc. instead of arable food crops apart from mango and cashew, for establishing agri-horti-forestry for their livelihoods. The various underutilized fruits enriching the areas of India are described hereunder.

Tropical and sub-tropical fruits

Aonla/Amalaki/Amla (*Emblica officinalis*): Aonla is a deciduous fruiting plant grown in many states of India. The tree is hardy,

prolific bearer and a suitable choice for arid regions of the country.[5] Likewise,[6] also reported on the presence and significance of this fruit in hilly regions of India. Amla is the most concentrated form of vitamin C (500-600mg/100g) found in the plant kingdom, and when the whole fruit is used rather than an active ingredient, the vitamin C is easily assimilated by the human body and has been found to have great antioxidant properties. It also contains proteins and minerals like calcium, phosphorus and iron. The high vitamin C content of fruit makes its wide use in Ayurvedic medicine. The tree has been regarded as sacred in India, worshipped as the Mother Earth and is believed to nurture humankind by its nourishing taste and also believed to stimulate purity.

Medicinal significance: The nutritional values of aonla are numerous and is recommended to be included as part of the daily diet. The fruit is the richest source of vitamin C and is a diuretic, aperient and laxative. It cures insomnia, scurvy, constipation, used as a cooling agent to reduce the effects of sun strokes. It is also useful for haemorrhage, leucorrhoea and discharge of blood from uterus.[7] As an anti-oxidant, it prevents premature ageing. Aonla stimulate the isolated group of cells that secrete the hormone insulin. Thus it reduces blood sugar in diabetic patient.[8]

Aonla is also used in many hair tonics. It enriches the growth and hair pigmentation. It prevents premature graying and falling of hair. It strengthens roots of hair, maintains colour and luster. It is the main ingredient used in the shampoo and hair dye. Eating fresh fruit or applying its paste on hair roots improves hair growth and colour. Aonla powder and oil are traditionally used in Ayurvedic applications for the treatment of scalp and improves complexion, removes wrinkles and sun burns.

Bael/stone apple/bengal quince/bel/siriphal (*Aegle marmelos*): It is native to India and Pakistan and spread throughout South-East Asia. Being one of the oldest cultivated fruits in India, it has a mythological significance viz. leaves are used for worshiping Lord Shiva. This fruit is also commonly found in the hilly regions of India.[6] Bael fruits consist of moisture (61.5%), protein (1.8%), fat (0.3%), minerals (1.7%), fibre (2.9%) and carbohydrates (31.8%) per 100g of edible portion. Its vitamin and mineral contents include calcium, phosphorus, iron, carotene, thiamine, riboflavin, niacin and vitamin C.[7]

Medicinal significance: The bael tree is one of the most useful medicinal plants. The fruit is used as ayurvedic remedy against diarrhea, dryness of the eye and common cold.[9] The fruit's medicinal value is very high when it just begins to ripen. The fruit is aromatic, cooling and laxative. It arrests secretion or bleeding. It is also useful in preventing scurvy and strengthens the stomach and promotes its actions.[10] The unripe fruit is good for digestion and is perhaps the most effective remedy for chronic diarrhoea and dysentery where there is no fever.[11] Best results are obtained by the use of dried bael or its powder. Beverages prepared from bael have great healing properties on account of its mucilage content. This form a coating on the stomach mucosa thereby helps ulcers to heal.[12]

Pomegranate/Anar (*Punica granatum L.*): It is a native of Middle East and in ancient Greek mythology, it is known as the "fruit of the dead". A ripe pomegranate fruit contributes about 105 calories and 25g of sugar. It contains potassium, carbohydrates, protein, fat, fibre and other vitamins and minerals.

Medicinal significance: Pomegranate juice is remarkably rich in antioxidants viz. poly phenols, tannins and anthocyanins, thereby acting as scavengers and prevents DNA damage. Studies have also shown that pomegranate can be used for the treatment of cancers of the lung, prostrate and breast.[13] Pomegranate hull and/or root extract are used both orally and intra-vaginally in preventing fertility,[14,15] abortion and to ameliorate assorted gynaecological problems.[16] Due to its astringent properties it is also beneficial for diarrhoea and dysentery.[17]

Jackfruit (*Artocarpus heterophyllus*): India is considered to be the native to jack. This is an important fruit crop of humid tropical and near-tropical climatic regions. An evergreen tree which bears the largest edible fruit in the world, whose seeds are also relished when boiled or roasted and eaten or cooked in dishes. Apart from being used as a table fruit, jack is a popular fruit for making pickles, sweets and thin round papad, canned jackfruit pieces, syrup, jam, jelly and candy. The fruit contains carbohydrate, protein, fibre, fat, calcium, phosphorus, iron, carotene, thiamine, riboflavin, niacin and vitamin C in various concentrations.[6]

Medicinal significance: Almost all parts of the plant viz., bark, roots, leaves and fruit has medicinal properties. The ash of jackfruit leaves, burned with corn and coconut shells, is used alone or mixed with coconut oil to heal ulcers. The latex stimulates healing of abscesses, snakebite and glandular swellings. The root is used for curing skin diseases and asthma and root extract is used for treating fever and diarrhoea. The wood has a sedative property. Heated leaves are placed on wounds. It also helps one get over the influence of alcohol. The starch from the seeds is used to relieve biliousness. The roasted seeds are said to be an aphrodisiac. It is also a good source of vitamin B1 and B2. The jackfruit's phyto nutrients help eliminating the cancer causing free radicals, increase the white blood cell count and help prevent hypertension. Jackfruit also provides a good amount of potassium to lower the high blood pressure and promote a healthy cardiovascular system.

Wood apple/Kath Bel (*Feronia limonia*): It is originated in India and belongs to the family Rutaceae. It is a hardy upright tree, producing nutritive acidic fruit and the pulp is eaten raw with or without sugar. The pulp contains 18.1% carbohydrate, 7.1% protein, 3.7% fat, 5.0% fibre and 1.9% mineral matter.[6] The pulp is a rich source of calcium, phosphorus, iron and vitamins like carotene, riboflavin, niacin, thiamine and vitamin C. It is also used for making chutneys, jam, jelly and squash. The fruit is used as a liver and cardiac tonic, and when unripe, for easing diarrhoea and dysentery.

Jamun (*Syzygium cumini*): It is an important indigenous fruit of commercial value in the country. It belongs to the family Myrtaceae. The tree is ideally suited for windbreak and roadside plantations. Fruits contains carbohydrate, protein, iron, calcium, phosphorus, fat and fibre. It is taken as a dessert fruit and is also used in making beverages, squash, jam, jelly and wine. It is used in blood purification, diabetes, diarrhoea, eczema and as an antidote for strychnine poisoning. It is stomachic, carminative and diuretic and lowers the blood pressure. The jamun seed powder reduces the sugar content in urine.

Ber/Indian Jujube (*Zyziphus mauritiana*): It belongs to the family Rhamnaceae. It is an ideal fruit tree for arid and semi-arid regions in tropical and subtropical climate where most of the fruit crops cannot be grown either due to lack of irrigation facilities or adverse climatic and soil conditions. Fruits are greenish yellow to reddish brown. It has a high amount of vitamin C (85-95mg per 100g). More vitamin C was found in the fruit flesh near the seed rather than near the skin

of the fruit.[18] It is also a rich source of vitamin A and B-complex. The fruits can also be used for making several products like chutney, dried ber, murabba, jelly, etc. Wines can also be prepared from the fruits. The decoction from root and bark is good for dysentery and diarrhoea and leaf decoction is useful as gargle in sore throat and in bleeding gums. The seed kernels are aphrodisiac. The powder of ber roots has medicinal properties for curing ulcer, fever and wounds.

Fig (*Ficus carica*): Fig was an important food crop in ancient civilization. It is a highly nutritious fruit consisting of 84% pulp and 16% skin. Besides, the fruit also contains protein, calcium, iron, vitamin A and thiamine at varying concentrations.[19] Figs are consumed as fresh or dried, preserved, candied or canned. Fresh figs are nutritious and used as dessert or for making jam, jelly, pudding, cakes, etc. The fruit is valued for its laxative property. It is applied for boils and other skin infections.[20,21] The latex is used to coagulate milk[22] and leaves are used medicinally as diuretic, demulcent, emollient and anthelmintic properties.

Karonda (*Carissa carandas*): It is a hardy, evergreen, spiny and indigenous shrub which thrives well as rainfed crop. The fruit belongs to the family Apocynaceae. Fruits, sour and astringent in taste, are a very rich in iron contains a good amount of vitamin C. They also contains protein, carbohydrates, fat, fibre and calcium. The ripened fruits may be eaten as dessert or used for the preparation of jelly, sauce, carissa cream or jellied salad. Unripe fruits are used for making pickles, sauces and chutney. The dried fruits may act as a substitute for raisins.[23] The wine prepared from ripe fruits contains about 14.5 to 15% alcohol and is very much liked by wine fanciers.[24] Fruits can also be used in dyeing and tanning industries. Karonda fruit is considered to be antiscorbutic and is also very useful in curing anaemia, stomach ache and is anthelmintic. Root extracts are used in lumbago, chest complains and venereal diseases.[25]

Pummelo/Jambura (*Citrus grandis*): It is the largest citrus fruit and belongs to the family Rutaceae. It is also known as "Shaddock" and locally called "Jambura". It is a mono embryonic species which is native to Malaysia and Polynesia. Fruits are sweet and moderately juicy. Two types, viz. white fleshed and red or pink fleshed are available in India and cultivars are named accordingly. The fruits are eaten fresh or processed into juice. Pummelo fruit is also an excellent source of vitamin A, B and C.

Tamarind (*Tamarindus indica*): It is native to Tropical Africa and belongs to the family Fabaceae. It is the 'Indian date' and is one of the most important fruits of India. In Tripura, it is locally called "tentul".[6] It is a large sized, long-lived evergreen tall tree with a spreading crown. It is an excellent tree for social forestry and agro forestry. This crop is highly suitable for wastelands due to its multi ferrous uses and capacity to withstand adverse agro-climatic conditions. It also acts as a good wind break. Almost every part of the tree finds some uses but fruit is the most useful which contains the sweet acidic pulp. The pulp has low water content and high levels of proteins, carbohydrates and minerals. The pulp is also the principal souring agent for squashes, chutney, beverages, etc. The fruit is used in the Indian medicine as a refrigerant, carminative, antiscorbutic and laxative and is also prescribed for bilious disorders.[26] The active constituents present are furunone, phenyl acetaldehyde and tartaric acid. The products of the seeds are used mostly for manufacture of sizing powders.[27] Tamarind kernel powder is extensively used for starching of cotton yarns, jute fabrics and woollen materials. The leaf sap possesses diuretic, antibacterial properties and nematode toxicity. Bark extracts reduce mosaic virus infection.[28] Seed husk can be used to kill predatory fish in nursery ponds.[29]

Passion fruit (Passiflora edulis): It is native to tropical America. It produces fruits with unique flavour and aroma for fresh eating and processing as well. Passion fruits are fair to good source of provitamin A, ascorbic acid, riboflavin and niacin and have a high mineral content. The pulp obtained after scooping from the fruits when cut in halves are added to fruit salads, ice-cream or fruit juice. Other processed products include juices, jelly, jam, squash, etc.[30] Various other underutilized fruit species are also prevalent in the country which are depicted in Table 1.

Table 1 Underutilised fruits in North-Eastern parts of India

Common name	Scientific name
Amla	*Emblica officinalis* Gaertn.
Wood-Apple/Kath bel	*Feronia limonia*
Jackfruit	*Artocarpus heterophyllus*
Jamun	*Syzygium cumini*
Bael	*Aegle marmelos*
Carambola	*Averrhoa carambola*
Elephant Apple/Chulta	*Dillenia indica*
Star Aonla	*Phyllanthus acidus*
Jalpai/Indian Olive	*Elaeocarpus floribundus*
Ber or Indian Jujube	*Zyziphus mauritiana*
Amra	*Spondias Pinnata*
Custard Apple	*Annona squamosa*
Passion Fruit	*Passiflora edulis*
Fig	*Ficus carica*
Latka/Burmese Grape	*Baccaurea sapida*
Karonda	*Carissa carandas*
Pomelo/Jambura	*Citrus grandis*
Jumrool/Jamrul/Amrool	*Syzygium samarangense* (syns. *Eugenia javanica*)
Sat Kara/Kaffir Lime	*Citrus hystrix*
Tal/Palmyrah	*Borassus flabellifer*
Tamarind	*Tamarindus indica*

Minor temperate fruits

A wide range of wild, temperate fruits occurs in the Indian Himalayas. The agro-ecological niches and variation in altitude in North-Western Himalaya are suitable for adaptation of minor temperate fruits like *Rubus, Ribes, Viburnum, Pyrus and Prunus*.[31–33] Species of pome fruits, in addition to cultivated fruits like apple and pear, *viz. Malus, Pyrus, Sorbus, Cydonia, Cotoneaster, Crataegus, Pyracantha, Diospyrus and Docynia* are also prevalent.[2] Several other species that are indigenous to India are also described in Table 2. These minor crops can assure yield, tolerance to biotic and abiotic stress and low input. Very little attention has been paid by the researchers in case of minor temperate fruit crops for its exploitation at commercial scale. Moreover, the size of the fruit, less pulp-to-seed ratio, undesirable sugar-to-acid ratio, perishable nature of the fruit,

less productivity, presence of protective structures (spines, prickles), long juvenile period and lack of awareness about their potentiality are the major limiting factor for its popularization.[34] There is also a need to investigate value additions useful for product and processing, medicinal, ornamental and other potential applications.

Table 2 Temperate minor fruits prevalent in India

Genus	Species	Source
Malus	*M. baccata* (L.) Borkh., *M. baccata* var. *himalaica*(Maxim.) Schneid., *M. baccata* var. *dirangensis*, *M. sikkimensis*(Wenz.) Koehne ex Schneider	34–35
Pyrus	*P. griffithi*Decne.,*P. jacquemontiana* Decne., *P. khasiana* Decne., *P. pashia* Buch. & Ham. ex. D. Don, *Pyrus kumaonii*(Decne.) Stapf., *P. polycarpa* Hook. f.,*P. pyrifolia* (Burm. f.) Nakai var. *culta* (Makino) Nakai, *P. serotina* Rehd.,*P. thomsoni* King	
Sorbus	*S. aucuparia*L.,*S. cuspidata*(Spach.) Hedlund., *S. foliolosa* (Wallich.) Spach.,*S.granulosa*(Bertol.) Rehd.,*S. insignis* (Hook. f.) Hedlund, *S. lanata*(D. Don) Schner., *S. microphylla*Wenzi g, *S. Rhamnoides* (Decne.) Rehder	
Cotoneaster	*C. acuminata* Lindl.,*C. acuminatus*Lindl.,*C. affinis* Lindl.,*C. bacillaris*Wallich ex Lindley,*C. buxifolia* Wall., *C. falconeri* Klotz.,*C. frigida*Wall.,*C. microphylla*Wall. ex Lindl.,*C. multiflora* Bunge.,*C. nummularia*Fish. & Mey.,*C. roseus* Edgew., *C. rotundifolia*Moench.,*C. vulgaris* Lindl.	
Docynia	*D. hookeriana* Decne.,*D. indica* Decne.	
Cydonia	*C. oblonga*Mill.	
Pyracantha	*P. crenulata* Roem.	
Prunus	*P. cerasoides, P. armeniaca, P. persica, P. cornuta, P. salicina, P. nepalensis, P. wallichi, P. jacquemontii, P. mira.*	
Ribes	*R. alpestre, R. glaciate, R. griffithii, R. nigrum, R. rubrum.*	
Rubus	*R. ellipticus, R. foliosus, R. fruiticosus, R. lasiocarpus, R. nepalensis, R. niveus, R. paniculatus, R. purpureus, R. hexagynus, R. ferox, R. calycinus, R. pungens, R. rosaefolius, R. saxatilis, R. macilentus, R. acuminatus.*	
Vitis	*V. himalayana,V. lanata,V. latifolia.*	
Fragaria	*F. nubicola, F. indica.*	
Duchesnea	*D. indica.*	
Myrica	*M. nagi.*	34
Crataegus	*C. songarica, C. oxyacantha.*	
Pinus	*P. gerardiana.*	
Diospyros	*D. kaki, D. lotus.*	
Corals	*C. colurna, C. ferox.*	
Viburnum	*V. corylifolium,V. cotinifolium,V. grandiflorum,V. jacquemontii, V. mullaha.*	
Carissa	*C. congesta, C. grandiflora, C. spinarum.*	
Castanea	*C. sativa.*	
Citrus	*C. limon, C. pseudolimon, C. karna*	
Hippophae	*H. rhamnoides, H. salicifolia, H. tibetana.*	

Promotion of underutilized fruits

A great deal is known about the virtues of the underutilized fruits of India, but unfortunately very few of these fruit crops have ended up in farmer's orchards. They can contribute to food security, health or energy needs of people. Promotion of their cultivation and conservation is hence essential. Most of the indigenous fruits have only a few specified varieties. Therefore, their improvement and development of ideal propagation methods and agro-techniques should also be adopted. Being local crops and harvested from the wild or found in the home gardens, they are easily available and thereby provides food security to the people. The crops are not or little processed. Promotion for setting up of processing industries (jams, jellies, fermented products, etc) and industries for manufacturing of resins, gums, etc., lifestyle (e.g., cosmetics), etc. should also be encouraged.

Underutilized fruit crops can be used for sustainable land use since they do not require external inputs, such as irrigation or fertilization. Undomesticated landraces have adapted to a variety of ecosystems and can sometimes survive conditions which high-bred cultivars cannot. The low external input requirements have also given rise to suggestions that underutilized crops production can go hand in hand with organic certification, thus opening niche market options to the producers.[35] In addition, underutilized crops are components of mixed cropping systems, whether on terraces, agro forestry systems or home gardens. Besides, underutilized crops are integrated into the farming system and are better suited to harsh conditions than domesticated commercial crops. Since an uncertainty of climate is prevalent, a certain level of resilience can be built through increased agro-biodiversity. If one crop, or one variety, fails due to unforeseen events, others might be available to provide food or income instead.

Conclusion

Though minor fruits are popularly known as 'less known fruits' these fruits have great values both in nutritional and medicinal properties. However, in spite of rich germplasm existing in India, development of standard varieties were limited. Having a wide degree of adaptability with high degree of tolerance, they can thrive well under adverse climatic and edaphic conditions. These fruits also serve a potentiality in sustainable agriculture. Hence, research and development work, farmers awareness and feasibility for cultivation of these less known fruits are to be given due consideration.

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Conflict of interest

The author declares no conflict of interest.

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