Underutilized edible plants of the Sikkim Himalaya: Need for domestication

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The Himalayan region is comprised of a large variety of wild-growing plants that are used for food and other subsistence needs by the local communities. The Sikkim Himalaya harbours as many as 190 food plants that grow in wild habitats. The six most prominently used fruit species (i.e. Baccaurea sapida, Diploknema butyracea, Eriolobus indica, Spondias axillaris, Machilus edulis and Elaeagnus latifolia) that bear maximum pressure in natural habitats due to their higher demands by the locals, were investigated in detail. Densities of all the species were low in the forest stands and fruit-collection procedure was highly erratic, threatening their survival in near future. The fruits were nutritionally rich and could be utilized for making by-products. The fruit yield per tree could easily compete with commercial fruit-yielding species. Therefore, such fruit trees deserve priority action for conservation in natural forest stands and domestication in farmers' fields.

SIKKIM is a small state of India that falls in the eastern Himalaya (27°3′47″ to 28°7′34″N lat and 88°3′40″ to 88°57′19″E long). The total area of the state is 7096 km^2, which forms just 0.02% of the total geographical area of the country. Sikkim is rich in cultural and biological diversity. Lepchas, Bhutias, Limbus and Nepalese are the main ethnic groups of Sikkim, and they differ from each other in their food habits and lifestyle. In the valleys people practice double-cropping system, which is replaced by single-cropping system at higher elevations. A large number of plant species are being used to meet fuel, timber and other needs. The state is undergoing an economic transition phase, and due to population growth and increase in demands of various products, the natural resource exploitation has reached an unprecedented level. Besides growing a few crops, people frequently collect wild edible plants for food and other plants from natural habitats to meet their subsistence needs[1,2]. Use of wild edible plants as a supplementary food resource holds promise. This aspect needs thorough investigation, so that economically important species are promoted for domestication.

The methods employed in this study were designed with the purpose of providing baseline information on the use of plant species in local system through surveys and field visits to various areas in the Sikkim Himalaya[1]. A detailed survey was made of various parts of Sikkim covering different communities to understand the utilization and consumption pattern of various wild edible plants. The species potential was investigated by surveying the three most popular markets (Gangtok, Namchi and Singtam) for one year. Information on extent of availability and quantity sold was collected. Among various edible plants, selected species were prioritized for detailed study. The selection was undertaken on the basis of (a) multipurpose utility, (b) occurrence in natural habitats, (c) preferred species of the local people, (d) market value, (e) scanty information available on nutrient content and growth performance of the species, and finally (f) extent of anthropogenic pressure on species. A total of six species satisfied these criteria[1], i.e. *Machilus edulis* King., *Spondias axillaris* Roxb., *Elaeagnus latifolia* Linn., *Diploknema butyracea* (Roxb.) Lam., *Baccaurea sapida* (Roxb.) Muell.-Arg. and *Eriolobus indica* Schn. Further investigations were carried out on botany, distribution pattern, forest density and regeneration, nutrient status, germination and seedling growth of selected species[1]. A total of eight forest stands, ranging between 400 and 2600 m above sea level and comprising six selected species were investigated for analysing characteristics, associated species, and detailed vegetation structure and regeneration in their stands. The sampled stands fall under different legal forest categories, i.e. Reserve Forests (stands I, II, VIII), Khasmahal (stand VII), Community Forests (stands IV, V, VI), and Private Forest (stands III). The Reserve Forests generally do not bear any anthropogenic pressure, particularly for fuel and timber collection. Khasmahals are designated forest stands to fulfil villagers' need for fuel, fodder and timber, and thus bear maximum pressure. Though the Community and Private Forests, have mixed composition, a few preferred species are also maintained for their economic values. The Reserve Forests located at Mamkhola (stand I, elevation 400–700 m a msl), Raileykhola (stand II, elevation 450–

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900 m a msl), both in Darjeeling district, and Tendong (stand VIII, 1700–2600 m a msl) in South Sikkim maintain high diversity of species with high density and basal cover, which is expected in view of low biotic pressure in these forests. The Khasmahal Forest located at Pangthang (stand VII, elevation 1500–1900 m a msl) showed low density and basal cover due to high biotic pressure. The Community Forests at Samdung (stand IV, elevation 800–1400 m a msl), Central Pandem (stand V, 1200–1500 m a msl), both in East Sikkim, and Yuksam (stand VI, 1200–1600 m a msl) in West Sikkim were also in fairly good condition. The Private Forest (stand III, 860–1025 m a msl) at Chhota-Singtam in South Sikkim was highly exploited due to individual family demands. Sundriyal[1] presents further details on the tree structure of each of the stands. The vegetation was sampled with the help of 10 m × 10 m size quadrats, number varying from 30 to 40, depending upon the area of each of the forests. Stands I, II and VIII that fall under Reserve Forest category were analysed by laying 40 random quadrats, Khasmahal (stand VII) and Community Forests (stands IV, V, VI) with 35 quadrats each, and Private Forests (stands III) with 30 quadrats. All the tree species falling in each quadrat were listed and their cbh (circumference at breast height) was noted. Plants with > 32.4 cm cbh were counted as trees. The frequency, density, abundance and basal cover (ground area covered by each species) were calculated for different species[3]. The average density values for all forest stands are presented in Table 1.

Fruit-yield measurements were done on per tree basis through harvesting method. For all the species, individuals of different girth classes and heights were marked at different locations well before fruit-bearing. Tree girth and height (with the help of bamboo stick) were measured for all selected individuals. Efforts were made to harvest almost all the fruits of small trees. For big trees, it was not possible to harvest all the fruits. Therefore, the uncollected fruits were counted visually and converted to biomass value based on the harvested fruits. This method accounts for nearly 70–80% of total fruit yield[4]. Fruits of six wild edible species have been analysed for their nutrient content in the laboratory, i.e. for protein, fat, carbohydrates, total sugar, N, P, K, Ca and Fe using standard methods[5,6].

A total of 190 wild edible species that are collected from wild habitats and consumed by the communities in the Sikkim Himalaya have been screened. Majority of these plants are available in the low and mid hills. Nearly 75% of the total life forms consumed are perennial species. A total of 43 wild edible species are sold in three studied markets. Gangtok had maximum number of 36 wild edible species followed by Namchi with 24 species and Singtam with 17 species. About 40 types of wild edible plants are available during each month[1]. The six selected wild edible species showed a varied range of distribution. Densities of all species were low in natural forest stands (Table 1). Fruit production increases with age for all species, and a mature tree produces fairly good quantity of yield. All the species bear edible fruits that reach local markets, and are sold in large quantities. Further details on each of the species are provided as under.

Description and related information

Species descriptions are arranged in the order of the botanical name, synonyms (if any), local name and family.

(i) *Spondias axillaris* Roxb. syn. *S. acuminata* Gamble *Choerospondias axillaris* (Roxb.) Burtt. & Hill (Lupsi) ANACARDIACEAE

The species is distributed throughout India from the Indus eastwards and southwards to Malaya and Ceylon ascending between 300 and 1500 m in the Himalaya. It is locally called Lumsee by Bhutias, Silet-kung by Lepachas, but most popularly as *Lupsi* by Nepalese, and is well known as a source of pickle (Figure 1). The processed product has a considerably long shelf-life (up to 5 years). The ripened fruits (pulp) are eaten raw. Fruits are sold at the rate of Rs 10–12 per kg. On an annual basis, the quantity of fruits sold in Gangtok, Singtam and Namchi markets was 5000, 2976 and 1760 kg, respectively. Pickle and processed candies of this fruit are popular among the natives of Sikkim and Nepal. The common associated species in the forest stand are *Bambusa nutans*, *Engelhardtia spicata*, *Ficus roxburghii*, *Ficus bengalensis*, *Ficus cunia*, *Schima wallichii* and *Bambusa* sp.

Table 1. Average density and fruit yield of six selected wild edible species

Species	Local name	Family	Density (trees/ha)	Fruit yield/ plant (kg/tree)
S. axillaris	Lupsi	Anacardiaceae	23.0	6–187
E. latifolia	Muslerhi, Malindo	Eleagnaceae	15.0	9–155
M. edulis	Pumsi, Lapche kawlo	Lauraceae	15.0	5–75
D. butyracea	Chiuri	Sapotaceae	13.7	5–155
B. sapida	Kusum	Euphorbiaceae	22.4	21–156
E. indica	Mehel	Rosaceae	22.5	4–58

Fruit yield for *S. axillaris* varied from 6 to 187 kg (tree cbh 90–250 cm). Among the 43 wild edible species that are sold in the three markets, *S. axillaris* was sold the maximum. This species also yields high income on a yearly basis and is comparable to any other commercial fruit in the country.

(ii) *Elaeagnus latifolia* Linn. syn. *Elaeagnus conferta* Roxb. (Muslerhi, Malindo) ELAEAGNACEAE

The species is found in subtropical and temperate Himalaya from Kumaon through Sikkim, Darjeeling, Bhutan and Khasi hills in Meghalaya. It is a large evergreen liana (woody climber) with rusty–shiny scales that are often thorny (Figure 2). The climber covers the neighbouring trees, and it is difficult to estimate the length of the stems. Flowers appear during August–November, while fruits ripen during March–April when they are commonly seen in the market. Fruits are eaten raw or used as pickle. *E. latifolia* is collected either from the Community Forests or from the Private Forests with other wild edible plants and a small quantity is drawn from natural forests. The density was low in forest stands; however, in recent times few farmers have started domestication of this plant. Fruits are sold in the market at the rate of Rs 10–12 per kg. The mean fresh weight of the fruit is recorded as 8.75 g. Total average fruit yield was recorded as 9–155 kg/plant in different girth classes (Table 1). 'Chutney' of *E. latifolia* is sold in markets and can yield a net profit of Rs 17 per kg, which nearly double the price of the fruits (Rs 6–10 per kg). Leaves are also used as fodder for goat and cow.

(iii) *Machilus edulis* King. syn. *Percea fructifera* Kost. (Pumsi, Lapche kawlo) LAURACEAE

Figure 1. *Spondias axillaris* in fruiting stage.

The species is an evergreen tree of about 15–20 m height, with a straight bole and spreading branches (Figure 3). It is found growing eastward from Nepal to Sikkim, Bhutan, Arunachal Pradesh and the whole northeastern region. It is considered as one of the forms of Avocado (*Percea americana*) in the region. Fruits are commonly sold in the market at the rate of Rs 12–15 per kg and are available during November–March. In good fruiting years, markets remain flooded by Pumsi fruits. Total fruit yield of *M. edulis* was recorded from 5 to 75 kg/tree (cbh 135–300 cm; Table 1). Fresh weight of the fruit is 31.72 g and diameter is 4.5–3.7 cm. After the fruits are picked they are stored in warm, dark, non-airy enclosures for curing. This increases the flavour before bringing the fruits to the market. The outer fleshy pulp, which comes out attached with the skin, is scooped out and eaten. In the forest the species is found in low density (Table 1). *M. edulis* is collected from the forest with other wild edible species like *Diplazium*, *Agaricus*, *Dioscorea* and *Emblica*. The associated tree species are *Cas-*

Figure 2. *Elaeagnus latifolia.*

Figure 3. *Machilus edulis.*

Table 2. Nutritive values of six selected wild edible species

Species	Ash (%)	Protein (%)	Fat (%)	Carbohydrate (%)	Total sugar (%)	P (%)	Na (%)	K (%)	Ca (%)	Fe (%)
S. axillaris	2.70	4.11	0.05	52.28	2.31	0.153	0.039	0.673	1.583	0.109
E. latifolia	3.16	7.80	0.52	74.06	2.10	0.096	0.051	0.910	1.470	0.180
M. edulis	2.65	4.51	25.50	51.50	2.40	0.120	0.024	0.610	0.150	0.253
D. butyracea	3.20	3.81	1.57	81.63	8.21	0.090	0.065	0.816	0.817	0.178
B. sapida	3.85	5.58	0.73	51.90	10.83	0.132	0.035	0.730	0.158	0.075
E. indica	3.03	1.75	0.35	71.73	12.89	0.142	0.033	0.431	0.124	0.110

tonopsis indica, *Eriolobus indica*, *Eurya acuminata*, *Prunus cerasoides* and *Juglans regia*[1]. The average number of retailers selling this wild edible species was 2–10 per week. Generally, the collectors directly sell the fruits in the markets. The main bulk of fruits comes from the temperate forests, 1700 m a msl. The fruits are highly nutritious, with high fat and carbohydrate content (Table 2).

(iv) *Diploknema butyracea* (Roxb.) Lam. syn. *Bassia butyracea* Roxb. *Aesandra butyracea* (Roxb.) Baehni (Chiuree) SAPOTACEAE

The species is distributed throughout the Himalaya, from Garhwal, Kumaon through Nepal in Central Himalaya to Sikkim, Darjeeling, Bhutan and Arunachal Pradesh in the eastern Himalaya (Figure 4). The tree grows up to a height of about 15 m, and is commonly known as butter tree throughout the Himalaya. *D. butyracea* grows in hill slopes between 300 and 1300 m elevations, all over the Himalaya. Most of the trees are found in wastelands near the villages, and density inside the forest is thin (Table 1). Fruits are scented and sweet to taste. The average fruit yield was estimated to be 5–155 kg/tree in different girth class sizes. Fruits are sold at the rate of Rs 12–16 per kg in the local market during April–June. The seeds produce a butter which is edible and is also used in soaps, candles, and as medicine to treat gout and rheumatic conditions. The leaves are considered to be good fodder; therefore, most of the trees are lopped for the purpose. High lopping of trees significantly reduces fruit productivity. The associated trees of *D. butyracea* in the forest stand are *Bambusa nutans*, *B. sapida*, *Artocarpus lakoocha*, *E. officinalis*, *Bauhinia variegata* and *Macaranga* sp. Three different forms of the fruit are noticed from different parts of Sikkim Himalaya, which vary in shape from oval to round. The seed is used to make a special type of butter for burning as well as culinary purpose. Pulp of the fruit is sweet and juicy, but cannot be stored for a longer time due to low keeping quality. Fruits are rich in sugar and other nutrients (Table 2). The net profit can be increased at least 2–3 fold by preparing jam, which will help in improving the economy of the rural people.

Figure 4. *Diploknema butyracea.*

Figure 5. *Baccaurea sapida.*

(v) *Baccaurea sapida* (Roxb.) Muell.-Arg. syn. *B. ramiflora* Lour. (Kusum) EUPHORBIACEAE

The species is distributed in the sub-Himalayan tract, mainly on the eastern side from Nepal to Sikkim, Darjeeling hills and Arunachal Pradesh to Assam, Tripura, Bhu-

tan, Burma, South China and Malaya peninsula. It is also found in the Andamans. *B. sapida* is a small-to-medium size, ornamental tree, particularly when the stem is laden with flowers and fruits (Figure 5). It is a semi-evergreen tree which grows up to 10 m in height. The yellowish fruits are edible when ripe, and are available during May–July. In fact, the flesh or aril around the seed coat can be eaten, and tastes delicious. The rind of the fruits is occasionally used for making chutney. It is sold in the market at Rs 16–20 per kg and the fruit yield is 21–156 kg/tree (cbh 34.4–54.3 cm; Table 1). Squash-making has increased the value of the fruits up to Rs 17.4 per kg. *B. sapida* can be a good source of vitamin C (273 mg/100 g), as recorded in this investigation (Table 2).

(vi) *Eriolobus indica* Schn. syn. *Docynia indica* (Wall.) Decne. (Mehel) ROSACEAE

This is the Indian crab apple – a tree of the lower temperate zone which grows between 900 and 1800 m elevation a msl. *E. indica* is mainly distributed in the eastern Himalaya, particularly in eastern Nepal, Sikkim, Darjeeling and Bhutan. This leaf-shedding tree attains a height of up to 9–12 m. Fruits are round pear-shaped and pale green in colour when ripe. They are eaten either fresh or processed into pickle. Fruits are sold in the market at Rs 8–12 per kg and the total fruit yield was recorded as 6–58 kg/tree (cbh 62–130 cm; Table 1). The fruit extract is made into a semi-solid gel locally known as 'chuk', which is considered to be a good medicine for stomach disorders. Chuk is sold at Rs 200 per kg. Nearly 15 kg of fruit is required to make 1 kg of chuk which can be stored for a longer duration. *E. indica* is found growing with *M. edulis*, *Juglans regia*, *Eurya acuminata*, *Prunus cerasoides* and *Castanopsis indica* in a forest stand. *E. indica* has high nutritive value. The fruit contains about 71.73% carbohydrate, 0.35% fat and 1.25% protein (Table 2).

Seeds of *D. butyracea* and *E. latifolia* started early germination in comparison with other species. This could be due to their thin seed coat (Figure 6). *D. butyracea* completed its seed germination within 30 days of seed sowing, while all other species took 50–60 days. Seeds of *M. edulis* recorded maximum germination (> 90%), followed by *S. axillaris* and *D. butyracea*. For *B. sapida*, only 50% seeds registered germination (Figure 6). Analysis of Variance (ANOVA) for seed germination among different species, between days, and species × days was highly significant (Table 3). Seed viability was as long as > 360 days for *S. axillaris*, up to 250 days for *M. edulis* and 150 days for *B. sapida.* For other species, the period of seed viability was quite low, i.e. < 70 days for *E. latifolia* and < 50 days for *D. butyracea* and *E. indica.*

The local demand and fruit productivity of these six species demonstrate that all have a good economic potential for the region. These species are nutritionally rich (Table 2), even more nutritious than some of the commercial fruits[6,7]. Therefore, consuming wild edible plants can play a major role in meeting dietary requirement of the tribal population in remote areas. Use of wild edible plants can substantiate vitamin, protein and fat contents in the human diet. The value addition can increase the cash return from wild edible plants 2–3 times by processing the products into pickle, jam, jelly and squash. *D. butyracea*, besides yielding edible fruits, is also considered as a good fodder and is therefore lopped heavily. *B. sapida* was also collected from the forest stands for fuel purpose. *M. edulis*, *E. indica* and *S. axillaris* were also cut for fuel and for use as cheap timber. The collection of fruits is done by lopping the branches of big trees; this decreases the yield during the next season. The density of all species is so low in natural stands that managing these species for sustainable harvest does not appear to be a feasible option.

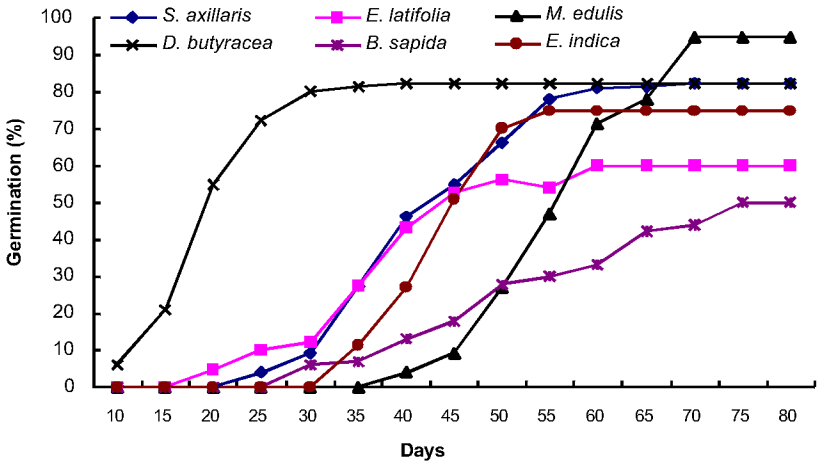

Figure 6. Seed germination (%) of six selected wild edible species of the Sikkim Himalaya.

Figure 7. A local vendor selling edible, wild plants in the local market.

Table 3. ANOVA for the data presented in Figure 6

Source	Sum-of-squares	DF	Mean square	*F* ratio
Days	190840.91	14	13631.49	152.24*
Species	58051.69	5	11610.34	129.67*
Days × species	47195.65	70	674.22	7.53*
Error	16117.17	180	89.54	

*Significant at $P < 0.01$.

In recent times, there has been considerable emphasis to undertake research for bringing about economic benefit to the local communities[8–10]. It is argued that plants which provide edible parts are often over exploited, and such species deserve special protection measures. In the Himalayan region a large variety of food plants are used to meet the subsistence need of the communities[11].

Out of 43 species that are sold in the three markets, *S. axillaris* was sold in the highest quantity followed by *M. edulis*, *Diplazium esculentum*, *Urtica dioca*, *E. latifolia*, *Dendrocalamus hamiltonii*, *Agaricus* sp. and *B. sapida*. Therefore higher number of retailers were involved in the trade of these species. It is estimated that the rural market business involves some 140 tons of the wild edible plants, with a gross income of Rs 15 lakhs in Sikkim annually[1]. It shows that the wild edible species are an important source of cash-earning to the subsistence farm families (Figure 7). Such diverse utility of plants provides the opportunity to exploit them in natural stands.

All the selected species had fairly large-sized fruits and seeds. Though the seeds of all species registered easy germination under nursery conditions, the germination capability of these species was recorded negligible in natural forest stands[8]. This could be attributed to large-scale exploitation of fruits of these species from the forests. Furthermore, the fruits are highly susceptible to insect and pest attack due to their large size and nutritional quality. Often, seeds could not reach the soil due to thick litter on the forest floor, thus hampering germination of the species. Therefore, the species need to be propagated under nursery conditions using quality seeds. This will also ensure ready supply of seedlings to the desired farmers. Due to market demands, some farmers have started rearing a few species that are still found in wild habitats. Though in small numbers, these species are also in the semi-domesticated stage. A few farmers are willing to maintain them in the Private or Community Forests. Such attitudes of the farmers need to be harnessed for adoption of these species in traditional agroforestry systems.

These species need to be conserved in their natural habitats. Plant dwellers and fruit collectors need to be educated about forest associations and adverse impact of felling of branches for fruit collection. Selling of fruits brings minimum return due to fairly low keeping quality and market costs. Therefore some value addition in the form of pickle, chutney, jam, jelly, etc. may increase fruit shelf-life and economic profit to local communities. This reflects a clear need to diversify the product base and to ensure that wild edible plants fetch higher prices per unit weight of produce for long-term interest of the people[12]. Farmers also demand quality seedlings of these species. This is a positive attitude that will help reduce pressure on these species in natural habitats. Domestication of these species will not only improve the economic condition of the local people but will also help in the conservation of biodiversity. Therefore, adoption of these species in traditional agroforestry system, according to local desire, will be a welcome step for harvesting these species for the benefit of the community.

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