Indian Journal of Traditional Knowledge
Vol 18(2), April 2019, pp 250-260

Indigenous knowledge and phytochemical screening of medicinal *chuk* from *Rhus chinensis*, *Docynia indica* and *Hippophae salicifolia* in Sikkim Himalaya

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Received 17 October 2018; revised 11 February 2019

Under traditional system of medicine, *bhakmilo-ko-chuk* (juice extracted from *Rhus chinensis* fruits) is used to cure diarrhoea, dysentery, diabetes, oral diseases and inflammation; *mel-ko-amilo* (juice extracted from *Docynia indica* fruits) for treating diarrhoea, dysentery, stomach disorder, and *Achuk* (juice of *Hippophae salicifolia* berries) for lung problems, respiratory infections, high blood pressure, heart disorders, gastric ulcer and digestive disorders. *Bhakmilo* (*Rhus chinensis*) is distributed from 300 to 1800 m amsl, *Mel* (*Docynia indica*) occurs from 1200 to 2000 m and *Achuk* (*Hippophae salicifolia*) within 2700 to 4000 m in the Sikkim Himalaya. These are lesser known underutilized species having high socio-cultural, socio-economic and socio-ecological importance. Phytochemical screening of juice extracted from berries of *Hippophae* showed moderate concentration of alkaloids, flavonoides, tannins, steroids, amino acids, proteins and carbohydrates. Screening of *Docynia* fruits showed high concentration of triterpenes and amino acids, and moderate concentration of alkaloids, steroids, proteins and carbohydrates. *Rhus* fruits showed high concentration of tannins, triterpenes, and carbohydrates, and moderate concentration of steroids and amino acids. The local market price for *bhakmilo-ko-chuk* was Rs.1000 L^{-1}, *mel-ko-chuk* was Rs.1500 kg^{-1} and *Hippophaea chuk* was Rs.1200 L^{-1}. Economics showed that juice extracted from a matured *Hippophae* tree berries earn Rs. 10,000-15000 yr^{-1}, a fully grown *Docynia* tree fruits exchange Rs. 10,000 – 12000 yr^{-1} and a *Rhus* tree fruits earned around Rs. 4000 yr^{-1}. Promotion of enterprise-based cultivation, agro-technique development, suitable processing techniques and value addition, and establishment of market linkage can boost household income of marginal farmers.

Keywords: *Achuk* (*Hippophae salicifolia*), *Bhakmilo* (*Rhus chinensis*), Indigenous system of medicine, *Mel* (*Docynia indica*), Sikkim Himalaya, Underutilized species

IPC Code: Int.Cl.[19] : A01G 13/00, A01G 13/00, A61K 9/00, A01G 13/00, A61K 38/56

Sikkim including the North-eastern region of Indian Himalayan Mountains is infinite source of underutilized and lesser known plant species which are used by indigenous communities for food, fruits, and medicines and for a variety of uses while it harbours as many as 190 food plants that grow in wild habitats[1-4]. Under traditional system of medicine, they are essential to the efficacy of medicines, which should not be seen as 'miracle' cures based on chemical compounds, but due to curative energy that draws its medicinal qualities based on a relationship between the plants and the people[5]. A large number wild edibles have been documented that they are rich sources of vitamins, macro and micro-minerals, fibres, polyphenols and antioxidants which provide health benefits[6-8]. Interestingly, underutilized species contribute to major food security, nutrition, health, economy and environmental services[9]. But many of these species are threatened and in the verge of extinction due to over extraction[10]. Traditional knowledge associated with plant processing is increasingly recognized as key element of the future well-being and sustainable development; on the other hand, they are also economic assets and can be traded or licensed for income-generation and economic development[11]. For instance, use of wild sea buckthorn qualifies as a unique option for the simultaneous management of several problems emanating from the fragility, marginality, inaccessibility and diversity characterising mountain areas[12]. Furthermore, traditional knowledge is threatened by loss of plant diversity, urbanisation,

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modernisation and low income of traditional medicine practitioners[13]. Sikkim in Eastern Himalaya is a hill state of India and has very rich plant diversity with over 6,000 plants[14], among them are 700 medicinal plants, of which more than 200 wild edibles are used traditionally[1,2,3].

The Eastern Himalayan region is the storehouse of a diversity of underutilized wild fruits and vegetables, that are potential sources of traditional food supplements, traditional system of medicine and income generation[15,16]. Many plants are grown at farmlands as a part of livelihood strategies. However, lack of motivation, knowledge, technology, post harvesting techniques, processing, value addition, and marketing channel, etc. are the bottlenecks to capitalize these resources. Appropriate field based inventory and documentation of associated traditional knowledge has not been carried out so far. These resources are traditionally utilized by the local communities as food, medicine, or for a variety of purposes, by and large they possess high therapeutic benefits. Against this backdrop, present study was designed to carry out a research on ecological distributions, phenology, value chain, post harvesting techniques, traditional biotechnology involved in extraction of juices, and phytochemical screening of *bhakmilo (Rhus chinensis), mel (Docynia indica)* and *achuk* (*Hippophae salicifolia*) fruits. Since the species are found growing in the croplands and agroforestry systems and in adjacent forests –the fruits and berries are going waste due to lack of economic evaluation, harvesting techniques, value addition, and marketing although they are constantly used under indigenous system of medicine.

Materials and Methods

Study sites

This study was carried out in 14 different locations in the Sikkim Himalayas (27° 4'–28° 6' N; 88° 3'–88° 56' E): Bering (750 m), Ganchung (1800 m), and Sumik (1500 m) in East Sikkim, Hee-Martam (1600 m), Yuksam (1700 m), and Uttarey (2000 m) in West Sikkim, Dzongu (1200 m), Lachen (2750 m), and Lachung (2800 m)in North Sikkim and Lingee (900 m), Payong (1300 m), Sokpay (1900 m), Niya (1800 m), and Ravangla (2200 m) in South Sikkim. These locations fall in tropical, temperate to sub-alpineregions consisting of agriculture farmlands, agro-forests, and cardamom plantations including important farm-based bio-resources (underutilized crops and medicinal flora). The major ethnic communities living in the study sites are *Lepcha*, *Bhutia* and *Nepali* with agriculture as the main employment (95%). Majority of indigenous communities follow indigenous system of medicine for healthcare. The underutilized wild edibles and medicinal plant are locally consumed in different ways, while the processing techniques are exclusively traditional.

Methods

We conducted extensive field surveys in different ecosystems: in agricultural fields, agroforestry systems, *khasmal* forests, *gaucharan* forests, orchards, sacred forests, reserved forests and protected areas to identify the occurrences of the *Rhus chinensis, Docynia indica* and *Hippophae salicifolia* . The species were identified following Flora of Bhutan and the Flora of British India. Fourteen focussed group discussion were conducted in the selected sites targeting the knowledge holders of ethnic communities consisting of village elders, women groups, gram panchayats, *Dzumsa* (indigenous traditional institution) members of Lachen and Lachung, traditional practitioners (*Dhami/Jhankri*, *Bijuwa, Bungthing, Purohita, Lama, Lameni*) and elderly women. Also, semi-structured questionnaire survey was conducted to interview 210 households across 14 sites. We documented the utilization and consumption pattern of selected species and carried out market survey in eight popular markets of Sikkim for one year.We documented the detailed information on traditional food processing of fruit extracts called *chuk*. Economic valuation and information with regard to species starting from collection to end product development and marketing was also collected. We interviewed village community knowledge holders on cultivation, utilization and sale of products through household survey. Habitat identification, plant population and ecological studies (10 m x 10 m quadrats, 14 transect walks) were carried out simultaneously.

For phytochemical screening, fresh fruits of *Hippophae*, *Docynia* and *Rhus* were collected and brought to the laboratory. Fruits were washed, sliced, and oven dried at 60ºC until constant weight. The sample were powdered in a grinder and stored in a desiccator. Fifty gram of powder was macerated in 250 mL of distilled water, and put on orbital shaker for 48 h. Extract was filtered through muslin clothes, and Whatman filter paper. Three filtrates were

concentrated under rotavac at 50ºC, brought to room temperature, and again incubated at 80ºC overnight and lyophilized. Preliminary chemical tests were carried out from the extract to identify phyto-constituents[17,18]. For alkaloids Salhi and Murmaghi[19] (1992) was followed, for flavonoids Dave[20] (2010) method was followed. Similarly, for tannins Sagelman *et al*.[21] (1969) was followed, for phlobatanins and triterpenes Harborne[17] (1973), for steroids acetic anhydride and H_2SO_4 methods was followed. For analysing saponins Kapoor *et al*.[22] (1969), glycosides, anthraquinones, aminoacids, and carbohydrates Kumar *et al*.[23] (2009), cardiac-glycosides Ajaiyeobu[24] (2002), resins Treas and Evans[1,25] (1989), and for proteins Santra *et al*.[26] (2010) was followed.

Results and Discussion

Distribution and morphology

Bhakmilo (*Rhus chinensis* Mill., Anacardiaceae) is an important representative of genus *Rhus*, distributed within 300–1800 m in the Sikkim Himalaya (Table 1). It is a subtropical plant, flourishes well in rocky and sandy slopes of hills, dry to moist forests and in the cultivated farms within the agroforestry systems and in forest areas. It is a good moisture and shed efficient tree; a native of China, therefore proclaimed as a Chinese sumac or Chinese nutgall[27]. It also grows in dry lands and in the wet temperate riverine habitats. The fruits are long been used by folk medicine practitioners in the Sikkim Himalaya. *Rhus* stem is soft, semi-wood; leaf is green, simple or compound; flower is small, brown in colour; fruits are categorised as berries due to their assemblage in one bunch, size of individual fruit is smaller (1 cm) as compared to that of *Docynia* fruit. Seed is ex-albuminous and size is very small (0.08 cm), (Table 1). *Rhus* is a deciduous tree, first leaf appears during March to April from the lower altitudes, flowering takes place during July to September and fruiting takes place during October to December. At 300 m elevation density of *Rhus* tree was 63±43 ha^{-1}, at 1500 m it was 61±23 $ha^{-1}$and at 2000 m it was 68±31 ha^{-1}. Similarly, its regeneration at 300 m was 81±27, at 1500 m was 97±23 and at 2000 m was 38±15 saplings ha^{-1} (Table 2). The associate species of *Rhus chinensis* are *Schima wallichii, Albizia lebbeck, A.procera, Dendrocalamus sikkimensis, Callicarpa arborea, Shorea robusta, Tectona grandis, Juglans regia, Melia* species *Prunus cerasoides, Bischofi ajavanica, Bombax ceiba, Duabanga grandiflora, Gynocardia odorata, Oroxylum indicum* and *Terminalia myriocarpa*.

Mel (*Docynia indica* (Wall.) Decne., Rosaceae) represents a tree species. It is a native of Eastern Himalaya generally found to be growing in between 1200 and 2000 m (Table 1). *Mel* being a temperate plant, flourishes well in slopes, stream sides and thickets. It is an evergreen deciduous plant, growing up to 30 m tall. It is an excellent associated

Table 1 — Morphological features of *Rhuschinensis*, *Docyniaindica* and *Hippophaesalicifolia*

Particulars	Colour	Number	Type	Shape	Size (cm)	Vigour
Rhus chinensis						
Flower	Brown	Numerous	Fused	Ellipsoid	Minuscule (01)	Soft
Fruit	Brown	Numerous	Berry	Ovate	Small (01)	Soft
Leaves	Green	Numerous	Compound	Elongated	Hefty (02)	Soft
Stem	Brown	Dichotomous	Semi-hard	Cylindrical	Large (200)	Semi-wood
Seed	Grey	Numerous	Exalbuminous	Oval	Small (0.08)	Hardy
Docynia indica						
Flower	White	Few	Open	Round	Medium (02)	Soft
Fruit	Green	Few	Single	Ovate	Medium (05)	Semi-hard
Leaves	Green	Numerous	Simple	Elongated	Medium (06)	Soft
Stem	Brown	Dichotomous	Semi-hard	Cylindrical	Large (300)	Semi-wood
Seed	Black	Few	Albuminous	Flat	Small (0.08)	Hardy
Hippophae salicifolia						
Flower	White	Numerous	Open	Ellipsoid	Minuscule (01)	Soft
Fruit	Green	Numerous	Berry	Ovate	Very small (0.5)	Soft
Leaves	Green	Numerous	Simple	Elongated	Small (04)	Soft
Stem	Brown	Dichotomous	Hard	Cylindrical	Medium (30)	Wood
Seed	Grey	Few	Albuminous	Flat	Very small (0.05)	Hardy

Table 2 — Density, regeneration and phenology of *Rhuschinensis*, *Docyniaindica*, and *Hippophaesalicifolia*

Species/ Occurrence (m)	Habitat	Tree density	Regeneration (saplings ha^{-1})	Flowering	Fruiting	Harvesting time
Rhus chinensis						
300	Rocky/ sandy/riverine slopes, degraded areas, forests, agroforestry practices in the cultivated agroecosystems in the Sikkim Himalayas	63±43	81±27	June – September	October-November	December
1000		61±23	97±23	July-October	October-December	December-January
1800		68±31	38±15	July-October	October-December	December-January
Docynia indica						
1200	Wet temperate forests, riverine slopes, agroforestry practices in the cultivated agroecosystems in the Sikkim Himalayas	59±13	63±16	April-May	June - October	November-December
1500		66±18	82±23	Late April-Late May	June-November	November-December
2000		56±17	61±15	Late April-May	June - December	November-December
Hippophae salicifolia						
2800	Temperate to sub-alpine forests, riverine slopes, landslides areas, farmlands, grazing areas, agroforestry practices, habitat restricted to Lachen and Lachung valleys of North Sikkim	350±123	1000±381	May-June	July - October	November-December
3500		1200±500	10,000±487	June-July	July-November	November-December
3900		500±223	5000±289	June-July	July - November	November-December

species with *Alnus nepalensis, Euriya acuminata, Viburnum erubescens*, *Castanopsis tribuloides, Quercus lamellosa, Castanopsis hystrix, C. indica, Edgworthia gardneri, Macaranga indica, Acer campbelli, Schima wallichii,* and *Engelhardtia spicata*.

Mel bears leaves from December-January; flowers during April-May, fruit matures from September through November. *Mel* stem is hard wood, used in manufacturing household implements or sometimes as fuel wood. Leaf is green; lamina is simple and compound, elongated, firmly papery. Flower is white in colour. Fruit diameter is 05 cm; ovate, yellow in colour when mature, matured fruit edible, sourly-sweet in taste, slightly pubescent when young. Fruiting occurs during June through October and ripens during November. Seed is albuminous and very small in size (0.08 cm), (Table 1). Density of *Docynia* has sharply declined in the recent years. *Docynia* tree density at 1200 m was 59±13 ha^{-1}, at 1500 m was 66±18 ha^{-1} and at 2000 was 56±17 ha^{-1}. Similarly, its regeneration at 1200 m was 63±16, at 1500 m was 82±23 and at 2000 m was 61±15 saplings ha^{-1} (Table 2).

Achuk (*Hippophae salicifolia* D. Don, Elaeagnaceae) is commonly known as Seabuckthorn (vernacular-*Chuk-Achook, Lhala, Tarubo*), is a temperate deciduous tree or a shrub. In India, it is distributed in high-altitude areas of Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, Arunachal Pradesh and Sikkim. The only growing habitat for this species in Sikkim is Lachen and Lachung valleys of North Sikkim between 2300 and 3900 m. It grows vigorously in slopes and riverine areas (Table 1). In Sikkim, *H.salicifolia* grows along the riverside, torrential area, vertical hills and slopes, mostly on the south-east aspect of the Lachen and Lachung valleys. *H. salicifolia* is willow-like small tree or shrub growing up to 6-10 metres. However, a few trees having a height of 17 m are also surviving. Its natural lifespan appears to be 60 to 70 years as per the indigenous Lachungpas and Lachengpas. Regeneration is found up to 5,000 saplings ha^{-1}. *Hippophae* bears leaf in April–May; flowers in June–July; and fruiting in July while maturity takes place during December (Table 1). At 2800 m density of trees was 350±123 ha^{-1}, at 3500 m the density increased to 1200±500 trees ha^{-1} and at 3900 m, the density reduced to 500±223 ha^{-1}. The higher density within 3500 m elevation was attributed to rigorous regeneration (10,000±487 saplingsha^{-1}) and natural establishment of *Hippophae* forest along the riverbeds, while at 2800 m (1000±381 saplingsha^{-1}) and 3900 m (5000±289 saplingsha^{-1}). *Hippophae* grows with other temperate species

such as *Juniperu srecurva, Alnus nepalensis, Tetradium fraxinifolium, Tsuga demosa, Rhododendron lepidotum, R. arboreum, Viburnum nervosum., Arundinaria maling, Daphne cannabina, Abies densa, Berberis* sp., *Salix* sp., *Clematis* sp., *Sorbus* sp., *Rosa macrophylla*, etc.*Hippophae* tree is hard wood, used in manufacturing household tools or as a construction material in making cowshed (Table 2). Leaf is green, elongated; lamina is simple or compound; flower is white, ellipsoid, very small. Fruit is mostly ovate, very small (diameter 0.5 cm), seed albuminous and very small (0.05 cm).

Indigenous medicinal and modern pharmacological importance

Bhakmilo has long been used by folk medicine practitioners in the Sikkim Himalaya. Stem and branch is considered to be a good fuel wood supplement in mountain households (Table 3). Leaf, root, stem, bark, fruit and particularly the galls are recognized to have preventative and therapeutic effects on different ailments (such as diarrhoea, dysentery, diabetes mellitus, sepsis, oral disease and inflammation) and possesses strong antiviral, antibacterial, anticancer, hepatoprotective, antidiarrhoeal and antioxidant properties[27-29]. However, it is critical to separate evidence from anecdote. *Bhakmilo* gall is rich in hydrolysable tannins called gallotannins, used in Chinese medicine to treat coughs, diarrhoea, night sweats, and dysentery and to stop intestinal and uterine bleeding[30]. Gallic acid (3, 4, 5-trihydroxybenzoic acid), isolated from *bhakmilo* induces apoptosis in human monocytic lymphoma cell line and may be a potential chemotherapeutic agent against lymphoma[31]. The gall inhibits alpha-glucosidase activity[32].

Docynia indica is hardy and can withstand temperature about -0.5 to 10°C. It can be grown in sandy-loam to clay soils with well drainage system. The plants are generally propagated by seeds. Wood from *Docynia* is used for making drum, walking stick, tool handles; or used as fuel wood. Fruits have an acidic taste when eaten fresh. The peeled fruits are often used for salad with salt and chilly but excellent source for making pickles and jelly. *Mel-ko-chuk* is highly valued in villages and is used as home remedy for treating diarrhoea, dysentery, stomach disorder, etc. Sour fruits are known to be highly medicinal for gastric ailments and dysentery. The nutritional value contentonper cent of dry matter basis is: moisture (85.1%), ash (4.0%), fat (6.7%), protein (32.2%), carbohydrate (57.1 g), sodium (15.3 mg/l00 g), potassium (202.8 mg/l00 g) and calcium (200.5 mg/l00 g)[33].

Hippophae salicifolia is an important medicinal plant and is effective in ameliorating lung problems, respiratory infections, high blood pressure, heart disorders, gastric ulcer and digestive disorders. Jam andjuice are other fruit products prepared by indigenous tribes of North Sikkim. Leaves are used in making tea adding with local available ingredients. It is one of the best known source of vitamin-C, E, A and flavonoids. This plant is tolerant to extreme freezing temperature of up to –43°C[34] and adapts well to soil acidity and alkalinity[12]. Leaf, bark, pulp and seed are known to possess antioxidants, antimicrobial, anti-inflammatory properties.

Traditional processing of fruits/berries

Bhakmilo

Fruits of *Rhus* are collected during November until the first week of January. Harvesting is done through hand picking or by cutting of branches mainly from

Table 3 — Local traditional methods of processing and income generation

Species	*Chuk*/juice processing method	Techniques involved	Traditional tools used	Amount of fruit used	Amount of *chuk* extracted	Firewood required	Income (Rs)
Rhus chinensis	Traditional methods used by Nepali community	Harvesting, cleaning, soaking, meshing, sieving, boiling, packaging	Jute sac, pot, *nanglo, mandro, khurpi, chalni, khadkudo, dadu*	20	4.0 litre	30 kg	4000
Docynia indica	Traditional methods used by Nepali community	Harvesting, cleaning, crushing, pressing, boiling, sieving, packaging	*Doko*, pot, *nanglo, khurpi, dhiki, mandro, col, pecha, chalni, khadkudo*	70	4.5 kg	45 kg	6750
Hippophae salicifolia	Traditional methods used by Lachenpa and Lchungpatribes of North Sikkim	Harvesting,cleaning, hand crushing, sieving, boiling, packaging	Pot, *mat, khurpi, chalni,* hand gloves, buckets	40	35 litre	25 kg	63000

private agroforests or nearby forests. Local processing involves drying up of fruits initially and cleaning them appropriately. Individual fruits/seeds are separated from their pedicels. Fruits are then soaked in lukewarm water for around half an hour. Then it is hand rubbed in lukewarm water and squeezed to separate extract, again soaked, hand rubbed and squeezed. The process is repeated for 3–4 times on the same batch, same process can be repeated for a new batch. The extract is then filtered through a sieve (Fig. 1). The filtrate is boiled for 6 h in a *khadkudo* (a traditionally designed copper vessel). During boiling, a piece of iron is put in the extract; scientific reason for this is unknown. Boiling completes when thick dark-black colour *bhakmilo* juice (*chuk*) is developed. Final *chuk* obtained is allowed to cool completely. It is stored in bottles or airtight containers and can be used for 4–5 years, consumed at home or sold in the market. The residual fruit peel is also stored for making pickles, or used as veterinary medicine for livestock (Table 3).

Mel

Docynia is harvested in the month of October-November. Under traditional practice; the harvested fruits are cleaned, and crushed into small pieces in wooden *dhiki/okhli* (traditional wooden crusher). The crushed pieces are then put into a bamboo *pecha* (woven bamboo basket). The *pecha* containing source material is then compressed by a wooden plank, whose one end is fixed to a stone wall and weight is applied from the rear end, to release the extract which is collected in a bowl drained through a wooden flat collector called *col*. The extract is immediately boiled along with small iron piece for 4–5 h in '*khadkudo*'. A thick reddish-dark coloured c*huk* is obtained after rigorous boiling (Fig. 2). The lukewarm *chuk* obtained is stored in an airtight container and consumed locally orsold in the markets.

Achuk

Fruits of *Hippophae* are very soft and delicate, needs careful collection skills, since it contains

Fig. 1 — Showing traditional process of *Bhakmila-ko-chuk*extraction

Fig. 2 — Showing traditional process of extraction of *Mel-ko-chuk*

numerous piercing spines on its branches. Traditionally, it is collected by cutting branches/twigs in early morning hours before sunrise when the temperature is very low. Low temperature in the early morning hours makes it harder, and can be plucked easily.

Fruits are separated from the harvested twigs over aplastic sheet by beating with a stick. Then the fruits are squeezed on a bucket for extract. The extract is filtered through a sieve (Fig. 3). The juice concentrate is boiled at 100°C until it becomes thick and then allowed to cool. It is then mixed with *chasni* (thick sugar concentrate boiled for 20 minutes) prepared separately (1.3:1.75 water:sugar ratio) at the same temperatures. A light yellow coloured final juice will be obtained. The total volume of juice will be four litres (ratio; 2:2). For use, 16 L of juice can be prepared from 4 L of juice-concentrate adding 12 L of pure water (1:3 ratio). This juice can be stored in an airtight container, and can be consumed until two months. Till date, juice is prepared only at Lachung, North Sikkim. The traditional food processors are discouraged due to lack of advance techniques for processing and value addition.

Economic potential

We found that the economic potential of *Hippophae, Docynia* and *Rhus* is very high as these species are in use since time immemorial for a variety of traditional practices for consumption and for curing various health related ailments. This study revealed that the potential of *Hippophae, Docynia* and *Rhus* to boost the local economy and ecology is yet to be explored as no elite genotype of these plants and their proper characterisation has been carried out. When calculated on per annum basis, a matured *Hippophae*

Fig. 3 — Showing traditional process of *Achuk*juice extraction

trees when in its full fruiting can earn around Rs. 10,000-15000, a fully grown *Docynia* tree on full fruiting can exchange around Rs. 12000 and a well grown *Rhus* tree if bears good fruiting can earn around Rs. 4000. The ecological services of these plant species are high, they play an important role in soil erosion control, slope stabilisation and the reclamation of degraded and wastelands along the elevations from 300 m to 4000 m altitudes. *Rhus*, *Docynia* and *Hippophae* are well suited to grow in the diversity of agroforestry systems in Sikkim. The agroforestry systems managed by small-scale marginal farmers has contributed to ecological, economical and food security while providing employment to over 80% of the population directly or indirectly dependent on them[35]. In a study managed by *Orang Asli* tribe in the peninsular Malaysia, concluded that agroforestry systems are the main source of their income (70–90% of household income), provide safe and healthy food and ensure self-employment[36].

Under the traditional extraction methods, around 20 kg of *Rhus* fruit was used to make 4 litre of *bhakmilo-ko-chuk,* while 70 kg of *Docynia* fruit was used to make 4.5 kg of *mel-ko-chuk*. Similarly 40 kg of *Achuk* berries was used to obtain 35 L of extract (Table 3). Local market price for 1 L of *bhakmilo-ko-chuk* is Rs.1000, while for 1 kg of *mel-ko-chuk* it is Rs.1500. One litre of *chuk* concentrate of *Hippophae* costs around Rs.1500–2000 in Lachung and Lachen, North Sikkim (Table 3). Firewood used for boiling the juice extracted from *Hippophae* (2 kg L^{-1} of juice), *Docynia* (5 kg $L^{-1}$of juice) and *Rhus* (10 kg $L^{-1}$of juice) was high, while farmers can meet this demand from their own agroforestry systems.

Phytochemical screening

The water extract of *Hippophae*, *Docynia*, and *Rhus* were subjected to preliminary phytochemical analysis (Table 4). In *Hippophae* alkaloids, flavonoids, tannins, steroides, amino acids proteins

Table 4 Preliminary phytochemical screening of *H. salicifolia*, *D. indica*, and *R.chinensis*
(+ low concentration, ++ moderate concentration, +++ high concentration,– absent)

Phyto-constituents	*H. salicifolia*	*D. indica*	*R.chinensis*
Alkaloids	++	++	+
Flavonoides	++	+	+
Tannins	++	+	+++
Phlobatanins	–	–	–
Triterpenes	+	+++	+++
Steroids	++	++	++
Saponins	–	–	–
Glycosides	–	–	–
Cardiac glycosides	–	–	–
Anthraquinones	–	–	–
Resins	–	–	–
Amino acids	++	+++	++
Proteins	++	++	+
Carbohydrates	++	++	+++

and carbohydrates were in moderate concentrations. In *Docynia,* triterpenes and amino acids were present in high concentrations, while alkaloids, steroids, proteins and carbohydrates were present in moderate concentrations. In *Rhus* tannins, triterpenes, and carbohydrates were present in high concentrations, while steroids and amino acids were present in moderate concentrations. Resins, anthraquinones, cardiac glycosides, glycosides, saponins and phlobatanins could not be found in the extracts.

Juice extracts for traditional pickle making

The indigenous communities in the Sikkim Himalayas constantly use *bhakmilo-ko-amilo*as the principal ingredient for making as many as 15 different pickles which are cultural foods (Table 5). Similarly, as many as 13 different pickles are prepared mixing *mel-ko-chuk* as the main ingredient. Both *bhakmilo-ko-chuk* and *mel-ko-chuk* are often used by communities in their day-today-food

Table 5 — Traditional food item and ingredients

Traditional food product	Ingredients/constituents	Traditional food product	Ingredients/constituents
Rhus chinensis		*Docynia indica*	
Philungey-ko-dhuloachaar	Salt, oil, chilli, bhatmas, *Bhakamilo-ko-chuk*	*Dhuloachaar*	Salt, oil, dalley-chilli, soyabean, *Mel-ko-chuk*
Khalpiachaar	Salt, oil, chilli, radish, *Bhakamilo-ko-chuk*	*Khalpiachaar*	Salt, oil, chilli, cucumber, *Mel-ko-chuk*
Pharsi-ko-biyan-ko-achaar	Salt, oil, chilli, pumpkin seed, *Bhakamilo-ko-chuk*	*Pharsi-kobiyanachaar*	Salt, oil, chilli, pumpkin seed, *Mel-ko-chuk*
Tori-ko-achaar	Salt, mustard oil, chilli, *amilo*	*Tori-koachaar*	Salt, mustard oil, chilli, *Mel-ko-chuk*
Bhatmas-ko-achaar	Salt, oil, chilli, soyabean, *Bhakamilo-ko-chuk*	*Bhatmas-ko-achaar*	Salt, oil, chilli, fried soyabean, *Mel-ko-chuk*
Mula-ko-achaar	Salt, oil, chilli, radish, *Bhakamilo-ko-chuk*	*Khalpi-koachar*	Salt, oil, chilli, radish, *Mel-ko-chuk*
Tilko-ko-achaar	Salt, oil, chilli, til, *Bhakamilo-ko-chuk*	*Til-koachaar*	Salt, oil, chilli, til, *Mel-ko-chuk*
Kinema-ko-achaar	Salt, oil, chilli, boiled bhatmas, *Bhakamilo-ko-chuk*	*Kinema (fermented soyabean) achaar*	Salt, oil, chilli, kinema, *Mel-ko-chuk*
Aduwa-ko-achaar	Salt, oil, chilli, ginger, *Bhakamilo-ko-chuk*	*Aduwa achaar*	Salt, oil, chilli, ginger, *Mel-ko-chuk*
Silam-ko-achaar	Salt, oil, chilli, silam, philunge, *Bhakamilo-ko-chuk*	*Silam-koachaar*	Salt, oil, chilli, silam, philungey, *Mel-ko-chuk*
Bunga-ko-achaar	Salt, oil, chilli, banana spadix, *Bhakamilo-ko-chuk*	Banana spadix, *achar*	Salt, oil, chilli, banana spadix, *Mel-ko-chuk*
Dudhmane/ Karkalo-ko-achaar	Salt, oil, chilli, dudh-mane/karkalo, *Bhakamilo-ko-chuk*	*Toriko-dhuto*	Salt, oil, chilli, *toriko-dhuto*, *Mel-ko-chuk*
Koiral-ko-phul-ko-achaar	Salt, oil, chilli, Koiralko-phul, *Bhakamilo-ko-chuk*	*Mula-kokosa*	Salt, oil, chilli, *Mula-kokosa, Mel-ko-chuk*
Sajana-ko-phul-ko-achaar	Salt, oil, chilli, *Sajanakophul*, *Bhakamilo-ko-chuk*	*Kankra-koachar*	Salt, oil, chilli, *Kankra, Mel-ko-chuk*
Bhakmilodhulo-ko-achar	Salt, oil, chilli, *Bhakmilodhutoachar*, *Bhakamilo-ko-chuk*	*Philungey-koachar*	Salt, oil, chilli, *philungey to dhuto, Mel-ko-chuk*

systems. Majority of the mountain people and ethnic communities, the use of wild edible fruits and their juice extracts are a source of cultural identity, reflecting a deep and important body of knowledge about the environment, survival and sustainable living known widely as traditional ecological knowledge[37].

Conservation threats and loss of TK

There has been a rapid loss of traditional medical knowledge and practices due to peoples dependency on verbal transformation of knowledge, impacts of modern cultural transformation, and rapid land degradation. At the same time there is a depletion of resource base due to over exploitation and lack of management systems. However, several policies, plans, acts and laws interact to regulate and set the context in which medicinal resources are managed and utilised for subsistence and trade. In Sikkim, wild edible plant species are threatened by various natural causes such as landslides and flash-floods, human activities such as conversion of forest or agriculture land into infrastructure development such as hydropower projects, pharmaceuticals, roads, airports, reservoirs and construction purposes. Further, extreme weather caused by global climate change, such as heavy snow in high altitudes, heavy and untimely rainfall pattern or severe droughts, has resulted into phenological changes resulting into decrease and even loss of many wild food plant populations. The situation is again aggravated by various human activities such as land use change, habitat destruction, and over-harvesting.

Conclusion

Cultivation, development of agro-technique, value addition and establishment of forward and backward linkages for *Rhus, Docynia* and *Hippophae* are immediate needs for capitalization of these underutilized species to improve household income of resource poor rural farmers. This study has demonstrated that the indigenous tribes of the Sikkim Himalaya possess collective knowledge of wild edibles, 95% of which are underutilized and that *Rhus, Docynia* and *Hippophae* contribute to their health related and dietary diversity in their day-to-day life. Based on the finding of this study, the indigenously managed habitats within the cultivated systems and in the adjacent forests were highly preferred over natural environments for the collection of wild edibles, suggests that conservation efforts should be extended beyond wild and human-uninhabited landscapes. Species undertaken for the study are highly useful in terms of dietary and medicinal value but due to underutilization and lack of suitable post harvesting and processing techniques and value addition the small-farmers are yet to exchange cash out of these biodiversity elements. It is important that more research needs to be conducted on socio-economically potential wild edible fruits as they possess considerable amount knowledge on their uses since centuries.

Acknowledgements

This work was supported by the National Mission on Himalayan Studies (NMHS) of the Ministry of Environment, Forest and Climate Change funded through GB Pant National Institute of Himalayan Environment and Sustainable Development. Authors acknowledge the facilities provided by The Mountain Institute India, Sikkim Biodiversity Board and Sikkim University. We thank YP Bastola of Bering, Khinamaya Khatiwada of Sumik, and Tamding Lachenpa, Palzor Lachenpa, and Chewang Lachungpa of Lachen and Lachung for their knowledge sharing and field demonstration of the traditional processing techniques.

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