Free Listed Wild Edible Fruit Species of Sikkim Himalayas and Their Uses

C. P. Suresh[1], K. D. Bhutia[2], G. Shukla[2], K. Pradhan[2] and S. Chakravarty[2]

[1]*North Eastern Hill University (Tura Campus), Tura, Meghalaya, India,* [2]*Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal, India*

Abstract

Wild edible fruit species are traditional sources of nuts, fruits, spices, leafy vegetables, edible oil and beverages. In Sikkim, wild edible fruit species is valuable in several other ways pertaining to social, economic and ecological services except in a few species, food value has rather a subordinate role. Thus a study was designed with the purpose of providing baseline information on use of wild fruits in local system through surveys and field visits. Field survey was conducted by collecting information during structured and semi-structured interviews with native people. Free listing technique enlisted 26 wild edible fruits represented by 17 families and 23 genera. Some fruit species are socially and commercially important and also has medicinal value such as *Diploknema butyraceae*, *Terminalia chebula*, *Rubus ellipticus*, *Spondias axillaris*, *Castanopsis hystrix*, *Duchesnia indica* and *Elaegnus latifolia*. Most of the fruits have multiple local uses and were same for all the areas studied. These fruits were mostly eaten fresh and raw. The current level of consumption is very low and the fruits had insignificant role in the diets of the natives. These fruits have a great potential to contribute towards food and nutritional security during food scarcity and can certainly boost the economy of poor people if value addition is encouraged.

Keywords: *Wild edible fruits, Sikkim Himalayas, Conservation*

INTRODUCTION

The Sikkim Himalayas, a part of Indo-Malayan Biodiversity Hotspot (Myers and Mittermeier, 2000) harbors many fruit species grown in wild and indigenously utilized. Most of these are cheap and readily available with vibrant taste appeal. Their potential in nutritional, medicinal, therapeutic and industrial values is well recognized and utilized by the indigenous communities (Rai *et al.*, 2005). These species are threatened and in the verge of extinction due to over extraction, deforestation and pollution (Rai *et al.*, 2000). The information available on wild fruit species is also scanty. Today almost all modern human food is based on a limited number of crops. Since food and phyto-resources are shrinking globally within population, it is need of the hour to find new alternatives. These wild edible fruit species can aid in crop improvement, ecological and food security. Although these species continue to be maintained by cultural preferences and traditional practices but they still remain inadequately characterized and neglected by research and conservation. Lack of attention indicates that their potential value is under-estimated and under-exploited. It also places them in danger of continued genetic erosion and disappearance. This would further restrict development options for poor. Efforts are required to preserve and document the indigenous knowledge base of local and indigenous communities and its sustainable utilization. Therefore, exploration and listing of these plants with their ethno-biological values are important for knowing and evaluating their economic potential. The present study was an endeavour to document the wild edible fruits of Sikkim Himalayas along with its utilization by the natives.

MATERIALS AND METHODS

Sikkim is a small mountainous State in the Eastern Himalayan region (Sundriyal and Sundriyal, 2001$_{a \& b}$, 2003). Agro-climatically, the state is divided into four zones- subtropical zone

(below 1,000 m); humid zone (1,000-1,600 m); mid-hill dry zone (1,000-1,600 m) and high hill temperate zone (above 1,600 m). Distribution of fruits is categorized into low, mid and higher hills. Collection and study sites of these fruits with their geographic location are given in table 1 which covers all four districts of Sikkim. Sikkim is rich in cultural and biological diversity (Sundriyal and Sundriyal, 2003). Lepchas, Bhutias, Limbus and Nepalese are main ethnic groups of Sikkim and they differ from each other in their food habits and lifestyle. Methods employed in this study were designed with the purpose of providing baseline information on use of wild fruits in local system through surveys and field visits to various areas listed in table 1. Field survey was conducted by collecting information during structured and semi-structured interviews with native knowledgeable people. For each fruit tree recorded, one questionnaire was filled. Basic information needed was taken during the conversation with the respondents.

Interview approach following Martin (1995) was used, *i.e.* asking questions about use of fruit plants for different purposes and making forest visits to identify the species. Identification of respondents started from the villages in which there were minor fruit trees available as well as local markets in which the fruit and its local made products were sold. This was done on basis that fruits were likely to be found in the area or that people involved in activity would know others who were producing/cultivating or selling the local by products. Multi-stage random sampling from probability sampling techniques and convenience sampling technique from non-probability sampling were used. From four districts of Sikkim, blocks were stratified depending on availability of indigenous minor fruit crops. Four blocks, one from each district of Sikkim were selected purposively. From four blocks, nine wards were selected purposively based on availability of maximum number of indigenous fruit species. An exhaustive list of people under selected nine wards was prepared to enumerate the sample of respondents. From this exhaustive list, respondents were randomly selected. A total of 120 respondents were finalized to assess status, utilization aspect of wild edible fruits and to identify the most valuable indigenous species from local's perspectives. Important wild fruits were selected on the basis of free listing method (Sinha, 2003). Informants were asked independently the same question to freely name orally all wild edible fruit species they know as it comes into their memory. Species preferences of people were assessed both through individual interviews of informants and in groups. Growth and Morphology was observed visually and compared with the available literatures.

RESULTS AND DISCUSSION

Diversity of Wild Edible Fruits

Free listing technique enlisted 26 wild edible fruit species represented by 17 families and 23 genera (table 2). Twenty one fruit species were tree, one shrub, one herb, one liana and three climbers. Fourteen fruit species were identified as most valuable by the respondents based on their food, medicinal and other values. The general morphology, growth, phenology and habitat of each of these 14 selected fruit species observed in the study area which was in accordance with earlier reports (Bennet *et al.*, 1991; Pakkad, 1997; Sundriyal and Sundriyal, 2004$_{a \& b}$; Rai *et al.*, 2005) is given species wise in table 3. Position of inflorescence was characterized as axillary, terminal, both or others (table 4).

Among these 14 species, six had axillary, five had terminal and two had both characters while *Ficus roxburghii* as others (syconium). Four species had white flowers while remaining eight had varied flower colour. The Himalayan chain that stretches from Indus to Brahmaputra valley including Sikkim is a unique storehouse of precious biotic and abiotic reserves (Sahu, 1986). It is not only mammoth of cultural symbol but also an important determinant in shaping the economy, milieu and climate (Pant, 1980). The Indian Himalayan region endows with bounties of natural and cultural resources evolved and preserved through process of civilization and contain some of the most restricted and threatened ecological systems on earth (Myers *et al.*, 2000). Most of the spectacular and rugged mountain range of the Himalaya is biologically unexplored thus the

biological diversity of entire Himalaya is not properly known (Chettri *et al.*, $2005_{a\ \&\ b}$). The Himalaya offers an array of forest types with diversity in forest produce such as medicine, vegetables, nuts, wild edible fruits and decorative from time immemorial. Sikkim, with a total area of 7,096 sq km, constitutes 0.22 per cent of the total geographical area of India. The entire region of Sikkim is rich in edible wild plants and about 190 wild edible plants are reported having high potential for their use as food (Sundriyal and Rai, 1996; Sundriyal *et al.*, 1998; Sundriyal, 1999; Chettri, 2000; Sundriyal and Sundriyal, $2001_{a\ \&\ b}$, $2004_{a\text{-}d}$; Chettri *et al.*, 2005_a). Some ethnic people sell seasonal wild plants in local markets and are economically dependent upon these products. Varieties of wild fruit species have been found growing in their wild state. Although encouraging initiatives have emerged, documented information specifically dedicated to the past and current indigenous knowledge on wild edible plants and their uses is still inadequate and scattered. In the Sikkim Himalayas 126 species of fruit and nuts/seeds representing 59 families were identified (Sundriyal and Sundriyal, 1998, $2001_{a\ \&\ b}$, 2003, $2004_{a\text{-}d}$, 2005; Sundriyal *et al.*, 1998, 2003). *Baccaurea sapida*, *Diploknema butyracea*, *Eriolobus indica*, *Spondias axillaris*, *Machilus edulis* and *Elaeagnus latifolia* were found to have higher demands by the locals and thus bear maximum pressure on their natural habitats as was also reported by Sundriyal and Sundriyal (2003, 2005). Similarly, many other wild fruits were also used by locals throughout the region but still remains to be explored (Mohan Ram, 2000).

Pertaining to population trend of wild edible species some generalization can be made. Firstly, most species occurring in unprotected landscapes are at a dramatic decline. Secondly, the wild edible fruit species located in the protected forests are in a better status but their relevance can only be seen in terms of conservation rather than utilization. Such species, as suggested by Johnson (2002) can be regarded as nutritionally extinct as they no longer contribute to local household food intakes though they could be ecologically stable. Thirdly, those species frequently integrated in farms, no matter what the purpose of integration may be, are again in a better position seen at tree population aspect but not fruit production. To date, the local people are directing forest use to meet the needs of fodder, fuel wood, and timber through their management prescription in their operational plan. *Juglans regia, Machilus edulis, Spondias axillaris* and *Diploknema butyracea* are the most preferred species by local users. In some areas people have cultivated and preserved some of wild fruits plant species in their private land. Some of these species were domesticated while some grew naturally. Most of the localities were planted with *Machilus edulis, Passiflora indica, Elaegnus latifolia* and *Juglans regia* in their home gardens. Similarly, use and conservation of wild edible plants and their products since time immemorial was also reported from Nepal (Kunwar and Adhikari, 2005).

In Sikkim also a considerable portion of tribal food need is met from forests and other wild areas (Sundriyal *et al.*, 1998). Currently, use of wild edible fruits is limited to subsistence purposes in the local communities. Collection of wild plants or edible fruits plays a role in the livelihood of poor people as they sell these plants/fruits to the nearby markets. These fruits/plants are available for short duration and due to low keeping quality, were sold at low prices as was also reported by Sundriyal *et al.* (1998). For large scale production, commercialization and sustainability of the local level enterprises, an appropriate policy environment and collective cooperation strategies need to be developed. The financial outcome can motivate local people to conserve wild edible fruits plant species and encourage domestication (Sundriyal *et al.*, 1998). There is need for further survey to document more wild edible fruit species of potential use, their growth as well their nutritional status. In addition, information about biology, resource assessment methods, harvesting strategies, and market value of potential promising species is equally important (Dhillion and Shrestha, 2005). Such information is currently lacking for Sikkim. Therefore, to comprehensively understand the role of wild edible fruit species in maintaining biodiversity, more extensive studies are required. Future studies need to span the entire growing season or multiple growing seasons with more ethno-botanical methods as described in Martin (1995). This reveals that keeping fruit production

more remunerative is a necessary condition. Therefore, the present study involving exploration, listing and documenting of wild edible fruit species with their ethnobiological value was an important effort on the aspect discussed above. The study understood and evaluated the human-plant relationship, potential use of these fruits in day-to-day life and for proper management. Similar earlier studies also indicated this importance (Bye, 1979; Alcorn, 1981 $_{a \& b}$).

The population of wild edible fruit trees in Sikkim is declining primarily due to human and livestock population pressure resulting to their over extraction, severe forest degradation and concomitant agricultural expansion as earlier reported from Sikkim (Rai and Sundriyal, 1997; Rai *et al.*, 2000; Chettri *et al.*, 2002; Sundriyal and Sundriyal, 2004$_b$). Similar trend was also reported from South Ethiopia (Kebu and Fasil, 2006). Overall, fruits both in the wilderness and from cultivated sources were constrained by several agro-ecological, economic and socio-cultural factors. Diseases, wild animals and tree related constraints such as low pulp content, low productivity, long juvenile period and higher parishability were major limitations. Apart from physical removal of these fruit species along forest clearing also modifies or destroys their habitat. Forest fires, illegal felling and other factors severely affect the regeneration of these fruit species. Further, as forest were cleared liana species like *Rubus* sp. could disappear or decline to fruit as they will be devoid of support for growing and fruiting. Not only the population of these fruit trees but also their fruiting load has declined. This can be attributed to climatic change and perhaps the elevation in temperature that affects pollen production and fertilization. Many fruit tree species are less resilient to agro-ecological changes as they may take many years to re-grow to maturity (Scoones *et al.*, 1992). Poor socio-economic condition of the people is directly causing to loss of these valuable resources as was also reported by (Chettri *et al.*, 2005$_a$). A growing rivalry in land use between fruits and other cash generating crops (mainly ginger, mandarin and large cardamom) presents another major difficulty. For the perceived high benefits, farmers gave precedence to the latter crops rather than these wild edible fruit species which have a long gestation period and currently fetch low price.

Unless immediate decisive steps are taken to counter the effects of habitat degradation in the remaining wilderness areas, these valuable natural resources will be lost irreversibly (Sundriyal *et al.*, 1998; Chettri *et al.*, 2005$_a$). Due to habitat destruction some species were threatened with extinction. Alternately some species have the scope of domestication, though it needs an in-depth study to avoid adverse effects, if any by introducing a new species. These species can be conserved by cultivation in farm land or *ex situ* (Leaky *et al.*, 2003). Locals have sown their desire to grow a few selected species if planting material is made available to them. There is also a need for *in situ* conservation of representative viable population of these fruit species. Perhaps an awareness campaign regarding the value of natural resources and their sustainable use could help to maintain and preserve these species for long (Sundriyal *et al.*, 1998).

A model has been developed in Cameroon and Nigeria by ICRAF and partners (Tchoundjeu *et al.*, 1998; Kengue *et al.*, 2002) based on involving the farmers about which of the trees from the natural forest they would like to cultivate on their farms (Franzel *et al.*, 1996) and progressed to the development of simple, low-technology plant propagators (Leaky *et al.*, 1990) in the villages. Participatory domestication also allows farmers to be the beneficiaries and guardians of the use of their indigenous knowledge about inter- and intra-specific variation in the population and germplasm derived from it (Leaky *et al.*, 2003). This approach also conforms to aims of the Convention on Biological Diversity which seeks to protect the rights of local people to their indigenous knowledge and germplasm (Chakravarty *et al.*, 2008). It is, thus, in stark contrast to the 'research station model' of tree domestication (Leaky *et al.*, 2003). It does, however, require that the farmers are informed about and understand their rights and know how to maintain and protect these rights (Chakravarty *et al.*, 2008).

The present study, however, disclosed that some ecological niches are serving repository of wild fruit species and there by maintaining their population at an adequate level. In this regard, the

role of Forest Department, Government of Sikkim is noteworthy. They are comparable and play a similar role to what are known as, according to FAO (Anon., 1999_a); sacred groves or scared forests. In these sites, tree logging, burning is prohibited. These places contribute directly in providing reserves of useful plants, a store-house of diversity and thereby provide a reserve of germplasm for enhancing local agricultural productivity. They can also serve a focal point to widening up wild edible fruit species agro forestry in their surroundings (Sundriyal and Sundriyal, 2001_a, 2004_b). Evidence is building that driven by the ever-increasing demand of fruit trees for various purposes there is a recent awakening of their benefits and appreciation of their decline. As a result, though not in full swing some are already taking up steps to changing their management practices, for instance, towards pollarding and or lopping *in lieu* of cutting. Few others have started organized planting of some species signifying that the scope of domestication is bright. These attitudes of the farmers may need to be harnessed for adoption of these species.

Moreover, recently some important measures were initiated by the government that indirectly creates a favorable framework for their domestication. These include assurance of land security through entitling use-rights, permit issuance requirement for the cutting of some high value species and restrictions imposed on wood smuggling. These are important steps forward to sparking strong interest on farmers and enhancing trees and there by wild edible fruit species in their agricultural landscape. Creation of an enabling environment through policy reforms and market development will be essential to achieve socio-economic empowerment of the resource poor people in the state through domestication, utilization and commercialization of fruits and products. There is need for product development research, private sector involvement and strong policy support in order to have tangible impact. Similar environment created in Miombo woodland of Southern Africa and northern Cameroon was reported brought positive results (Akinnifesi *et al.*, $2004_{a\ \&\ b}$; Mapongmetsem *et al.*, 2012).

In the event of worsening climate, the ability of these fruit trees to withstand harsh conditions is expected to be of over-riding importance and a major factor driving their protection and domestication (Sundriyal and Sundriyal, 2004_a). Interview with villagers revealed that they were willing to raise the selected species especially *Baccaurea sapida*, *Diploknema butyracea*, *Eriolobus indica*, *Spondias axillaris*, *Machilus edulis* and *Elaeagnus latifolia* in their farms. This willingness was earlier also reported by Sundriyal and Sundriyal (2004_b). The seeds of these wild edible species show good germination when raised in a nursery (Sundriyal and Sundriyal, 2001_b). Unfortunately they are not yet included in the plantation schemes undertaken by the State Government. Obtaining a supply of such seedlings is a real problem if these species are to be grown by farmers. There is a need to ensure supply quality planting materials of these species so that these species can be adopted by the farmers in agro forestry systems (Leaky *et al.*, 2003).

Moreover, increased priority may need to be given to redress those species inhabiting the unprotected wilderness. Several agro-ecological, economic and socio-cultural factors interact to affect wild edible fruit species enterprise development. Factors like policy and global climate change do also influence the system externally. Moreover, it has also human and institutional dimensions that several stakeholders and organizations are interacting differently. This suggests that interventions aimed at wild edible fruit species based enterprise development may need to consider such interactions and interdependences among several factors and stakeholders. Despite several limiting factors and the low level of farm integration, however, recently there are some positive developments that seem to encourage or expedite the use and integration of these fruits in the farming systems. Further collection of these resources in a sustainable manner substantiates the integrated process development and conservation as was recommended earlier (Hall and Bawa, 1993). This goal of integration can only be achieved if real economic potential of extractive activities and their compatibility with conservation of biodiversity is properly understood (Sundriyal and Sundriyal, 2001_b; Mapongmetsem *et al.*, 2012). Therefore, participatory planning with local people for area specific development and provisions for economic incentives will be a

promising effort for conservation of these valuable resources (Arnold and Ruiz, 2001; Termote *et al.*, 2010).

Traditional use of wild edible fruit species

People in different areas use their local resources independently (Groombridge, 1994). Indigenous fruit trees are important traditional sources of nuts, fruits, spices, leafy vegetables, edible oil and beverages (Okafor, 1985). In Sikkim, every wild edible fruit species is valuable in several other ways pertaining to social, economic and ecological services except in a few species, food value has rather a subordinate role. It was observed that the usage of plants were same for all the areas studied at Sikkim. The various uses of wild fruit bearing species is summarized in table 5. Past studies showed that locals or tribes in India and elsewhere have extensively used wild edible fruit species (Kumbhojkar and Vartak, 1988; Gangwar and Ramakrishnan, 1990; Jeeva *et al.*, 2005, 2006_b; Angami *et al.*, 2006; Bagra *et al.*, 2006; Barua *et al.*, 2007; Kala, 2007; Kayang, 2007; Bhattacharjee *et al.*, 2008; Jeeva, 2009; Deshmukh and Shinde, 2010; Teklehaymanot and Giday, 2010; Tiwari *et al.*, 2010; Marwat *et al.*, 2011; Lulekal *et al.*, 2011; Sasi *et al.*, 2011; Valvi *et al.*, 2011). Some similar wild fruit species such as *Elaeocarpus* sp., *Docynia indica*, *Mangifera* sp., *Myrica esculenta*, *Spondias pinnata*, *Elaeagnus* sp., *Ficus* sp. and *Rubus* sp. were reported to be extensively used by the tribes of north-east India (Arora, 1993). Similarly wild fruit species used by locals in northern Laos were *Baccaurea ramiflora*, *Docynia indica*, *Elaeagnus conferta*, *Ficus auriculata*, *Ficus semicordata*, *Flacourtia indica*, Nephelium *chryseum*, *Phyllanthus emblica*, *Spondias pinnata*, *Rubus* sp., and *Solanum* sp (Jin *et al.*, 1999).

The traditional methods of fruit collection are picking, shaking stems and throwing objects to dislodge the fruits or even destructive harvesting as branches were lopped to harvest fruit in a short time. Another study also had reported similar practice (Mapongmetsem *et al.*, 2012). Most of the wild edible fruit species in Sikkim were eaten fresh and raw as has been reported elsewhere (Guinand and Dechassa, 2000, Murray and Boxall, 2002; Van den Eynden *et al.*, 2003; Bagra *et al.*, 2006; Musinguzi *et al.*, 2006; Tigist *et al.*, 2006; Kayang, 2007; Redzic, 2006; Fentahun and Hager, 2009; Jeeva, 2009; Teklehaymanot and Giday, 2010; Tiwari *et al.*, 2010; Marwat *et al.*, 2011; Sasi *et al.*, 2011). Wild edible fruits play a vital role in subsistence economy and livelihood of people in this Himalayan state. A variety of these fruits with enormous economic potential can be seen grown in the valley regions, mid-slopes, and the highlands of the basin. These fruits are used for food traditionally by native people as nutritional diet. These fruits are also a good source of food for wildlife and birds. Similar observations on wild fruits was reported earlier also (Chettri and Sharma, 2011). In addition to this present research, there has been number of similar systematic documentation on enlisting the wild edible fruit species from Sikkim (Sundriyal and Rai, 1996; Sundriyal, 1999; Sundriyal and Sundriyal, $2001_{a \& b}$, 2003, $2004_{a \& b}$, 2005; Rai *et al.*, 2005).

Most of the identified wild edible fruits reported here have multiple local uses as was also reported by several authors (Sundriyal, 1999; Sundriyal and Rai, 1996; Sundriyal *et al.*, 1998, 2003; Sundriyal and Sundriyal, 1998, $2001_{a \& b}$, 2003, 2004_{a-d}, 2005; Rai *et al.*, 2005). Some fruit species are commercially important and also has medicinal value such as *Diploknema butyraceae* and *Terminalia chebula*. *Rubus ellipticus* and *Elaegnus latifolia* were delicious fruits and relished by those who can't afford expensive fruit from the market. Likewise, *Spondias axillaris* and many others were used for spices and pickle purpose along with medicinal and other uses. These species are free and accessible to the local communities. Some of these food plants are supplementary and nutritionally important especially prior to the harvest of staple foods to the locals as also reported from Nepal (Shrestha *et al.*, 2005).

These plants are eaten in different ways depending upon the conditions of locality and community (Singh 1960; Manandhar, 1974). Some of these fruits were home processed as boiled, roasted and fermented. Most of these fruits were eaten fresh and raw as snacks or sometimes as potion. Fruits of *Ficus* species were eaten either fresh or in dehydrated form while *Castanopsis*

hystrix fruits were consumed dried after roasting and even processed into flour for baking purpose. Rai *et al.* (2005) also reported about fruit processing of *Castanopsis* hystrix, *Spondias axillaris*, *Duchesnia indica* and *Elaegnus latifolia*.

Wild fruits were available year round and have a great potential to contribute towards food and nutritional security during food scarcity as was also earlier reported (Adekunle and Oyerinde, 2004; Jeeva, 2009). Although, the current level of consumption is very low and the fruits had insignificant role in the diets of the natives. By and large, except for a few species, food value appears to have a subordinate role on the part of indigenous minor or wild edible fruit bearing species. Because of slight variations among sites, varietal differences and the level of management, there appeared a constant supply of fruit produce of one kind or another throughout the year. Fruiting of many species like *Elaegnus latifolia, Duchesnia indica* and *Elaeocarpus sikkimensis* occurs during March in dry season to middle of rainy season which coincides with time staple food scarcity. On the whole, the year-round availability of fruits could help to diversify sources and types of micronutrients in the daily diet of indigenous residents of Sikkim.

Nevertheless, a great portion of the produce was sold than consumed and thus there is a danger that the dietary role of fruits for growers/collectors may be lost that would also impact health. However, the rarity and insignificant role of fruits in people's diets is not peculiar to the study areas rather it is a universal phenomenon (Westphal, 1975; Anon., 1999_b). Of course, this is contradictory to reports on role of home garden products in several part of the World (Bennett-Lartey *et al.*, 2002; Wezel and Bender, 2003; Ali, 2005). The low consumption of fruits is partly attributed to ignorance of their nutritional value and method of preparation, need for cash and more importantly dietary custom of people. Experience shows that counseling to change eating behavior is an important component food-based strategy (Talukder *et al.*, 2001). It was also found out that people in the study areas do not explicitly recognize nutritional contribution of the wild fruits rather they value them as snack. However, empirical analysis of the nutrient composition of some of the marketable species brought to light that they are in fact loaded with important nutrients. This is suggestive of the need for nutritional education and social marketing to achieve sustainable behavioral changes of the community towards these fruit consumption.

Moreover, many fruit species were also exploited for various non-fruit utilities. Many species are considered as good fodder for cattle. *Ficus roxburghii* was found abundantly in almost all the home garden for sole fodder purpose only. Also species like *Juglans regia* and *Castanopsis hystrix* were sought for timber purpose though it was mostly found in forest and only a few trees were found growing in homestead gardens. Almost all the wild edible fruit tree species are utilized for charcoal purpose. Fuel wood, construction and fence are the other major non-food use categories, while *Machilus edulis, Juglans regia* and *Castanopsis hystrix* were multiple used species. The harvesting of these multiple use species can put them under threat (Dhillion and Shrestha, 2005) but can also lead to better chances for their conservation (Etkin, 2002). Over utilization of these fruit trees may have detrimental effects on landslide in hilly region. While the multiple uses demonstrate the continuing importance of these resources, the high pressure could also pose them a threat.

The study also revealed that some wild fruits like *Spondias axillaris*, *Machilus edulis*, *Elaegnus latifolia*, *Diploknema butyraceae*, *Terminalia chebula* and *Juglans regia* were actively used fruit species, but were quite limited in number which was brought to the local markets in different quantities for sale to generate additional income. Previous reports from Sikkim also indicated this (Sundriyal and Sundriyal, 2004_d; Chettri *et al.*, 2005_b; Rai *et al.*, 2005). Nevertheless, trade flows, prices and income generated from these fruits were generally very low. This shows that these fruit trees have the potential for commercialization.

Lack of a developed market for these fruits can be explained in part by the fact that many people have free access to wild fruits and do not perceive them as having market potential. The other reason for lack of a developed market for these fruits could be related to consumers taste and

preference for commercial fruits like apples, citrus, mangoes, guava and banana. Many urban consumers relate wild edible fruits as food for the poor. This perception of these fruits affects their market demand and consumption, a problem that needs to be overcome if these fruit trees are to be domesticated and commercialized to improve household food security and nutrition (Hoe and Siong, 1999; Deshmukh and Waghmode, 2011).

Fruit prices of the wild edible species are generally low and vary to some extent by site, market and most importantly season. Low fruit price is further caused by lack of processing plants. Some fruits were commonly available and had a processing potential but mostly the products were either used in household or sold locally especially as butter, dried form and wine (table 6).

Sundriyal and Sundriyal (2003) also reported the processing potential of these fruits in Sikkim. The most common and popular value added product was the far/butter extracted from the fruits of *Machilus edulis* and *Diploknema butyraceae*. Rai *et al.* (2005) also reported that raw fruits of *Spondias axillaris*, *Duchesnia indica* and *Elaegnus latifolia* are processed as pickle. Similarly, wild fruits were also processed into pickle, jam, curry, juices, confectionaries, vinegar and wine or alcohol by local peoples in other areas (Edwards, 1992; Williams, 1997; Maden, 1998; Leaky, 1999; Zemede and Mesfin, 2001; MacLachlan, 2002; Demel and Abeje, 2004; Pauline and Linus, 2004; Angami *et al.*, 2006; Bagra *et al.*, 2006; Kebu and Fassil, 2006; Tabuti, 2007; Fentahun and Hager, 2009; Teklehaymanot and Giday, 2010). Processing these fruits would enhance their utilization by reducing wastage and improve their marketing prospects. This will further increase their contribution to household food security and nutrition. In turn, this would lead to better value recognition of these fruit species and thus promote their conservation. Also, household processing of these fruits as drying and canning could increase their market value and ensures a year-round supply (Marsh, 1998). These wild edible species can certainly boost the economy of poor people if value addition is done to them as is being done to some wild plants in other parts of Himalayas (Dhyani and Khali, 1993; Sundriyal *et al.*, 1998; Maikhuri *et al.*, 1994).

Besides, fruit recipe development and cooking demonstrations may need to be incorporated in the Government promotion plan. In general, low productivity of most fruits with their very low prices, fruit production and its value added products still remains non-lucrative for majority of growers. Still, it was found that a few households and some Self Help Groups (SHG) grew these species in their home gardens for value addition into homemade pickles, local fruit wines, drying of fruits, candies and others. Fruits were processed into refreshing juice either by boiling or adding lukewarm or cold water to which sometimes sugar or honey is added. Fruits were fermented or were added to flavor other drinks. Some of the SHG's have become a role model for the community that their activities were telecast and rewarded by the local authorities. This is suggestive that promotion of fruit production and home gardening in general might have a substantial role in mitigating food insecurity and relieving the locals from clutches of poverty. Processing fruits could enhance their utilization by reducing wastage and improve their marketing prospects thereby further increasing their contribution to household food security and nutrition (Fentahun and Hager, 2009). This in turn would lead to better recognition of the value of fruit species and thus promote their conservation. Owing to the current trend of decreasing agro-biodiversity (Hadgu *et al.*, 2009), there is danger that these fruit species will be lost. Hence there is an urgent need to incorporate research into wild edible fruits and to promote their use as a part of a strategy to improve food security, nutrition and livelihoods (Fentahun and Hager, 2009).

Ethnomedicinal uses of wild edible fruit species

The use of plants as a means to cure certain ailments and disease is an age-old practice throughout the world and Sikkim is not an exception. These fruits have also been used as ethno medicine curing many diseases through local health system. The folk medicinal practices are quite common among the ethno-cultural groups of Sikkim and surrounding areas (Biswas, 1956). Out of 14 selected wild edible fruit species most of them have medicinal properties to cure the different

ailments and diseases (table 7). Most of the species were found to have many therapeutic uses. Survey has revealed that specific plant parts are used to treat different diseases and ailments. The most frequently utilized plant parts are bark, followed by roots, fruits and seeds. Additionally, some have medicinal value in their flowers, rhizomes, tubers and heart wood. In some cases, the whole plant including the roots was utilized. It is important to note that the removal of bark and roots can have significant detrimental effects on plant survival and regeneration (Dhillion and Amundsen, 2000). Although the exploitation of some plant parts (e.g. fruits and seeds) is less damaging than others (e.g. bark, stem and roots), almost any form of harvesting has an impact on the structure and function of plant population. Considering this fact appropriate sustainable harvesting system should be applied to ensure future generation's needs are met.

The plant products are consumed raw or in the form of a decoction, juice (mix with water or milk), capsule, curry/spices or an infusion for oral treatment and as burnt product, ointments or raw paste when applied externally. Majority of the plants parts were prepared in the form of juice followed by paste and powder. This is in agreement with earlier report (Dhillion and Shrestha, 2003). Internal administration is predominating over external. For current use, administration of formulation was direct in form of paste or ointment. Mode of preparation is based upon nature of the ailments. There is no set and precise formula for determining the quantity of application used. Knowledge and practices were not directly related to any organized system but has come entirely through oral tradition and personal experience (Bhattarai, 1998). Majority of the species were used against stomach-ache problems (diarrhea, dysentery, cholera and gastric), rheumatic and arthritis. Traditional system of medicine notably Ayurvedic and Tibetan practices from wild plants including fruit plants are extensively used in day-to-day life by the people in Sikkim Himalaya (Rai and Sharma, 1994). A number of researchers had documented the use of medicinal plants was based on tradition in Sikkim and elsewhere (Sundriyal and Sharma, 1995; Chanda *et al.*, 2002; Maity *et al.*, 2004; Angami *et al.*, 2006; Hussain and Hore, 2007; Pradhan and Badola, 2008; Bharati and Sharma, 2010; Hebbar *et al.*, 2010; Deshmukh and Waghmode, 2011; Namrata *et al.*, 2011). Traditional health care system is also an age old practice in India and elsewhere and most of the wild edible fruit plants are used (Jeeva, 2009; Marwat *et al.*, 2009 $_{a \& b}$). Earlier studies also reported that about 90 % of rural population in hilly terrain depends on traditional health care system (Kingston *et al.*, 2006; Jeeva, 2009).

Mostly, traditional use of wild edible fruit species for medicinal purposes was by herbal healers as well as faith healers rather than consumption for nutritive purposes. It was evident from the study that these wild edible fruit species are important sources of medicine to the households. An earlier study also reported that more than 80 % of the world's population (mostly in the developing countries) relies on traditional medicine for primary health care (Mander and Le Breton, 2006). The households interviewed were aware of these species and self medicate a range of minor ailments. The healing properties of these species as medicines are closely tied to cultural beliefs of the people as was also observed by Mander and Le Breton (2006).

CONCLUSION

Sikkim has great potential in development of enterprises based on these fruits that can be linked with conservation and economic development (Chettri and Sharma, 2011). The agro-techniques for many of these wild edible fruit species needs to be developed. These agro-techniques need to be disseminated to the communities for cultivation along with incentives from the government. Further value addition and marketing of this important natural resource is of great challenge and opportunity for future development of this mountainous state. Wild edible fruits had thus crucial contribution towards subsistence economy and livelihood of Sikkim. Further, such documentation will benefit the community through the use of locally and freely available health giving foods which will also help preserve their cultural pride. In order for wild edible fruit species to be better appreciated, more work should be undertaken to determine their nutritional composition

so that they can be compared with widely cultivated major fruit crops. Nutritional value of these fruits and their value added products needs further study so as to determine how they compare nutritionally with the modern diet. Use of these fruits also has the potential through selective conservation and domestication which can contribute to the maintenance of plant biodiversity. Traditional conservation practices related to these species are a dimension of indigenous knowledge that can be researched into. Further research should address the issue of marketing and pricing of wild edible fruits and their products. There is a need to distinguish/recognize these fruits and their value added products in the local or national or international market.

REFERENCES

Adekunle VAJ and Oyerinde OV (2004) Food potential of some indigenous wild fruits in lowland rainforest ecosystem of South West Nigeria, Journal of food Technology 2: 125-130.

Akinnifesi FK, Kwesiga FR, Mhanga J, Mkonda A, Chilanga T and Swai R (2004_b) Domesticating priority Miombo indigenous fruit trees as a promising livelihood option for small farmers in southern Africa, Acta Horticulturae 632: 15-30.

Akinnifesi FK, Chilanga T, Mkonda A and Kwesiga FR (2004_a) Domestication of *Uapaca kirkiana* in southern Africa: a preliminary evaluation of provenances in Malawi and Zambia. pp. 85-92. In: Rao MR and Kwesiga FR (Eds.) Proceedings of Regional Agroforestry Conference on agroforestry impacts on livelihoods in Southern Africa: putting research into practice. World Agroforestry Centre Nairobi, Kenya.

Alcorn JB (1981_a) Huastec noncrop resource management, Human Ecology 9: 395-417.

Alcorn JB (1981_b) Factors influencing botanical resource perception among the Huastec: suggestions for future ethnobotanical inquiry, Journal of Ethnobiology 1: 221-230.

Ali AMS (2005) Homegardens in smallholder farming systems: Examples from Bangladesh, Human Ecology 33: 245-270.

Angami A, Gajurel PR, Rethy P, Singh B and Kalita SK (2006) Status and potential of wild edible plants of Arunachal Pradesh, Indian Journal of Traditional Knowledge 5: 541-550.

Anonymous (1999_a) Use and potential of wild plants in farm households, FAO Rome, Italy.

Anonymous (1999_b) Agricultural Research Master Plan, Volume III- Part 5. Horticultural crops research technical report. Bahir Dar. Bureau of Agriculture (BOA).

Arnold JEM and Ruiz PM (2001) Can non-timber forest products match tropical forests conservation and development objectives? Ecol. Econ. 39: 437–447.

Arora RK (1993) Himalayan Plant Resource: diversity and conservation. In: Dhar U (Ed.) Himalayan Biodiversity Conservation Strategies. Gyanodaya Prakashan Nainital, India.

Bagra G, De LC and Singh VB (2006) Collection and evaluation of some indigenous lesser known fruits of Arunachal Pradesh. In: Horticulture for Sustainable Income and Environmental Protection. Vol. 1. pp. 224-231.

Barua U, Hore DK and Sarma R (2007) Wild edible plants of Majuli Island and Darrang districts of Assam, Indian Journal of Traditional Knowledge 6: 191-194.

Bennet SSR, Biswas S, Chandra V, Singh PJ, Chandra S and Dayal R (1991) Food from Forests. ICFRE, New Forest, Dehra Dun.

Bennett-Lartey SO, Ayernor GS and Markwei CM (2002) Contribution of home gardens to in situ conservation of plant genetic resources farming systems in Ghana, 83-96.

Bharati KA and Sharma BL (2010) Some ethno-veterinary plant records from Sikkim Himalayas, Indian Journal of Traditional Knowledge 9: 344-346.

Bhattacharjee PK, Dipti D and Bhattacharjee S (2008) Underexploited Wild Plants of Tripura Edible Fruits, Advances in Plant Science 21: 355-357.

Bhattarai NK (1998) Traditional Medicine, Medicinal plants and biodiversity Conservation in the global and Nepalese contexts, Plant Research 1: 22-31.

Biswas K (1956) Common medicinal plants of Darjeeling and Sikkim Himalaya. M/s Bengal Government Press, West Bengal.

Bye RA (1979) Incipient domestication of mustards in north-west Mexico, Kiva 44: 237-256.

Chakravarty S, Shukla G, Malla S and Suresh CP (2008) Farmers Right in Conserving Plant Biodiversity with special reference to North East India Journal of Intellectual Property Rights 13: 225-33.

Chanda R, Mohanty JP, Bhuiyan NR, Kar PK and Nath LK (2002) Medicinal plants used against gastrointestinal tract disorder by traditional healers of Sikkim Himalayas, Indian Journal of Traditional Knowledge 6: 606-610.

Chettri DR, Parajuli P and Subba GC (2005_b) Antidiabetic plants used by Sikkim and Darjeeling Himalayan tribe, Indian Journal of Ethnopharmacology 99: 199-202.

Chettri N (2000) Impact of habitat disturbances on bird and butterfly communities along the Yuksom- Dzongri trail in Khangchendzonga Biosphere Reserve. Ph. D. thesis, University of North Bengal.

Chettri N and Sharma E (2011) Non timber forest produce: Utilization, Distribution and Status in the Khangchendzonga Biosphere Reserve, Sikkim, India. pp. 165-180. In: Arrawatia ML and Tembe S (eds.) Biodiversity of Sikkim. Exploring and Conserving a Global Hotspot. Information and Public Relations Department, Government of Sikkim, Gangtok.

Chettri N, Sharma E and Lama SD (2005_a) Non timber forest produces utilization, distribution and status in a trekking corridor of Sikkim, India, Lyonia 8: 89-101.

Chettri N, Sharma E, Deb NC and Sundriyal RC (2002) Effect of firewood extraction on tree structure, regeneration and woody biomass productivity in a trekking corridor of the Sikkim Himalaya Mountain Research and Development 22: 150-158.

Demel T and Abeje E (2004) Status of indigenous fruits in Ethiopia. In: Chikamai B, Eyog-Matig O and Mbogga M (Eds.) Review and Appraisal on the status of Indigenous fruits in Eastern Africa. A synthesis report for IPGRI – SAFORGEN. http://www.bioversityinternational.org/Networks/saforgen/publications.htm.

Deshmukh BS and Shinde V (2010) Fruits in wilderness: A potential of local food resource, International Journal of Pharmacology and Bio Science 2: 1-5.

Deshmukh BS and Waghmode A (2011) Role of wild edible fruits as a food resource: Traditional knowledge, International Journal of Pharmacy and Sciences 2: 919-924.

Dhillion SS and Amundsen C (2000) Bioprospecting and the maintenance of biodiversity. pp. 103-131. In: Svarstad H and Dhillion SS (Eds.) Responding to Bioprospecting: From Plants in the South to Medicines in North. Spartacus Forlag, Oslo.

Dhillion SS and Shrestha PM (2005) Conservation needs and regulations for locally managed forests in the Highlands of Dolakha District, Nepal. In: Salleh H and Aziz S (Eds.) Environmental and Development Aspects of Natural Resource Management in Mountains. Pelanduk Press, Singapore.

Dhillion SS and Shrestha PM (2003) Medicinal plant diversity and use in the highland of Dolakha District, Nepal, Nepalese Journal of Ethnopharmacology 86: 81-96.

Dhyani P P and Khali MP (1993) Fruit yield and economics of jelly and jam production from fruits of some promising Ficus (fig) tree crop, Ecology of Food and Nutrition 30: 169-178.

Edwards SB (1992) Traditional tree crops in Ethiopia. Historical records and economic importance. In: Proceedings of the second Natural Resources Management for conservation and development conference. Institute of Agricultural Research, Natural Resource Management for Conservation and development, Addis Ababa. pp. 10-13.

Etkin NL (2002) Local knowledge of biotic diversity and its conservation in rural Hausaland, Northern Nigeria, Economic Botany 56: 73–88.

Fentahun MT and Hager H (2009) Exploiting locally available resources for food and nutritional security enhancement: wild fruits diversity, potential and state of exploitation in Amhara region of Ethiopia, Food security 1: 207-219.

Franzel S, Jaenicke H and Janssen W (1996) Choosing the right trees: setting priorities for multipurpose tree improvement. ISNAR Research Report 8. 87p.

Gangwar AK and Ramakrishan PS (1990) Ethnobiological notes on some tribes of Arunachal Pradesh, North Eastern India, Economic Botany 44: 94-105.

Groombridge B (1994) Biodiversity Data Sourcebook. World Conservation Press, Cambridge, U.K.

Guinand Y and Dechassa L (2000) Indigenous food plants in southern Ethiopia Reflections on the role of 'famine foods' at the time of drought. UNEUE Survey, Addis Ababa.

Hadgu M, Rossig WA, Kooistra L and Van Bruggen AH (2009) Spatial variation in biodiversity, soil degradation and productivity in agricultural landscapes in the highlands of Tigray, Northern Ethiopia, Food Security 1: 83–97.

Hall P and Bawa KS (1993) Methods to assess the impact of extraction of non timber forest products on plant populations. A case study from Garhwal Himalayas, International Journal of Sustainable Development and world Ecology 47: 234-247.

Hebbar SS, Hegde G and Hegde GR (2010) Less known wild edible fruits and seeds of Uttar Kannada district of Karnataka, Indian Forester 136: 1218-1222.

Hoe VB and Siong KH (1999) The nutritional value of indigenous fruits and vegetables in Sarawak, Asia Pacific Journal of Clinical Nutrition 8: 24-31.

Hussain S and Hore DK (2007) Collection and conservation of major medicinal plants of Darjeeling and Sikkim Himalayas, Indian Journal of Traditional Knowledge 6: 352-357.

Jeeva S (2009) Horticultural potential of wild edible fruits used by the Khasi tribes of Meghalaya, Journal of Horticulture and Forestry 1: 182-192.

Jeeva S, Laloo RC, Venugopal N, Kharlukhi L and Misra BP (2006) Traditional knowledge and biodiversity conservation in the sacred groves of Meghalaya, Indigenous Journal of Traditional Knowledge 5: 563-568.

Jeeva S, Mishra BP, Venugopal N and Laloo RC (2005) Sacred Forests: traditional ecological heritage in Meghalaya, J. Scott. Res. Forum 1: 93-97.

Jin C, Yin-Chun S, Gui-Quin C and Wen-Dun W (1999) Ethnobotanical studies on wild edible fruits in southern Yunnan: folk names; nutritional value and uses, Economic Botany 53: 2-14.

Johnson N (2002) Environmental change in northern Thailand: impact on wild edible plant availability, Ecology of Food and Nutrition 41: 373 - 399.

Kala CP (2007) Prioritization of cultivated and wild edibles by local people in the Uttaranchal hills of Indian Himalaya, Indian Journal of Traditional Knowledge 6: 239-244.

Kayang H (2007) Tribal knowledge on wild edible plants of Meghalaya, Northeast India, Indian Journal of Traditional Knowledge 6: 177-181.

Kebu B and Fassil K (2006) Ethnobotanical study of wild edible plants in Derashe and Kucha Districts. South Ethiopia, Journal of Ethnobiology and Ethnomedicine 2: 53.

Kengue J, Anegbeh P, Waruhiu A, Avana ML, Kengni E, Tsobeng A, Tchoundjeu Z and Leakey RRB (2002) Domestication du Safoutier [*Dacryodes edulis* (G Don) H. J. Lam] un etat des lieux. pp 60-72. In: Kengue J, Kapseu C and Kayem GJ (Eds.) 3eme Seminaire International sur la Valosation du Safoutier et autres Oleagineux Non-conventionnels. Yaounde, Cameroon. 3-5 October, 2000. Presses Universitaires d'Afrique, Yaounde

Kingston C, Jeeva S, Shalini RS, Febreena GL, Jasmine TS, Laloo RC and Mishra BP (2006) Anti-venom drugs used by indigenous community in traditional healthcare system, J. Natl. Conserv. 18: 137-143.

Kumbhojkar MS and Vartak VD (1988) Ethnobotanical studies on wild edible grapes from sacred groves in Western Maharashtra, Journal of Economic and Taxonomic Botany 12: 257-263.

Kunwar RM and Adhikari N (2005) Ethnomedicine of Dolpa district, Nepal: the plants, their vernacular names and uses, Lyonia 8: 41-47.

Leakey RRB (1999) Potential for novel food products from agroforestry trees, Food Chemistry 64: 1-14.

Leakey RRB, Mesen JF, Tchoundjeu Z, Longman KA, Dick JMCP, Newton AC, Matin A, Grace J, Munro RC and Muthoka PN (1990) Low-technology techniques for the vegetative propagation of tropical trees, Commonwealth Forestry Review 69: 247-257.

Leakey RRB, Schreckenberg K and Tchoundjeu Z (2003) The participatory domestication of West African indigenous fruits, International Forestry Reviews 5: 338-347.

Lulekal E, Asfaw Z, Kelbessa E and Van Damme P (2011) Wild edible plants in Ethiopia: A review on their potential to combat food insecurity, Afrika Focus 24: 71-121.

MacLachlan M (2002) Manual of highland Ethiopian trees and shrubs. Injibara, SIM forestry study project.

Maden K (1998) General survey and biochemical analysis of wild edible fruits of Koshi Zone. Department of Botany, P.G Campus, Biratnagar. Unpbl. Thesis.

Maikhuri RK, Semwal RL, Singh A and Nautiyal MC (1994) Wild fruit as a contribution to sustainable rural development: A case study from the Garhwal Himalaya, International Journal of Sustainable Development World Ecology 1: 56-68.

Maity D, Pradhan N and Chauhan AS (2004) Folk uses of some medicinal plants from north Sikkim, Indian Journal of Traditional Knowledge 3: 66-71.

Manandhar NP (1974) A Glimpse of Useful Plants of Nepalganj, Kathmandu, The Rising Nepal 63: 6.

Mander M and Le Breton G (2006) Overview of the medicinal plants industry in southern Africa. pp 3-8. In: Diederichs N (Ed.) Commercializing medicinal plants: A southern African guide. Sun press South Africa.

Mapongmetsem PM, Kapchie VN and Tefempa BH (2012) Diversity of local fruit trees and their contribution in sustaining the rural livelihood in Northern Cameroon, Ethiopian Journal of Environmental Studies and Management 5: 32-45.

Marsh R (1998) Building on traditional gardening to improve household food security, Food, Nutrition and Agriculture 22: 4-14.

Martin GJ (1995) Ethnobotany: A people and plants conservation manual. Chapman and Hall London, New York, Tokyo.

Marwat SK, Fazal-ur Rehman Usmaan K, Khakwani AA, Ghulam S, Anwar N, Sadiq M and Khan SJ (2011) Medico-ethnobotanical studies of wild edible fruits plants species for the flora of north western Pakistan (D.I. Khan District), Journal of Medical Plant Research 5: 3679-3686.

Marwat SK, Khan MA, Ahmad M, Zafar M, Rehman F and Sultana S (2009_a) Fruit Plant Species Mentioned in the Holy Qura'n and Ahadith and Their Ethno medicinal Importance, Am. Eurasian J. Agric. Environ. Sci. 5: 284-295.

Marwat SK, Khan MA, Khan MA, Rehman F, Ahmad M, Zafar M and Sultana S (2009_b) *Salvadora persica, Tamarix aphylla* and *Zizyphus mauritiana* - Three Woody Plant Species Mentioned in Holy Quran and Ahadith and their Ethnobotanical Uses in North Western Part (D.I. Khan) of Pakistan, Pakistan Journal of Nutrition 8: 542-547.

Mohan Ram HY (2000) Plant Resources of Indian Himalaya. 9th G.P. Pant Memorial Lecture, G B Pant Intititute of Himalayan Development, Gangtok, Sikkim.

Murray G and Boxal P (2002) The distribution, abundance and utilization of wild fruits by the Gwich in the Mackenzie River delta. Sustainable forest management network project report, 2002-7. Edmonton, University of Alberta.

Musinguzi EL, Kikafunda JK and Kiremire BT (2006) Utilization of indigenous food plants in Uganda: a case study of south Western Uganda, African Journal of Food, Agriculture, Nutrition and Development 6: 1-21.

Myers N and Mittermeier RA (2000) Biodiversity hotspots for conservation priorities, Nature 403: 853-854.

Myers N, Mittermeier RA, Mittermeier CG, Gustava AB, Da Foseca and Kent J (2000) Biodiversity hotspots for conservation priorities, Nature 403: 853-858.

Namrata KL, Ghosh D, Dwivedi SC and Singh B (2011) Wild edible plants of Uttarakhand Himalaya: A Potential Neutraceutical Source, Research journal of Medicinal Plant 5: 670-684.

Okafor JC (1985) Selection and improvement of indigenous topical trees, Journal of Tropical Resource 1: 87-95.

Pakkad G (1997) Morphological Database of Fruits and Seeds of Trees in Doi Suthep-Pui National Park. M.Sc. thesis. Chiang Mai University, Chiang Mai, Thailand.

Pant DD (1980) Science and rural development. In: Singh JS et al. (Eds.) Science and Rural Development in Mountains. Gyanodaya Prakashan, Nainital.

Pauline M and Linus W (2004) Status of indigenous fruits in Kenya. In: Chikamai B, Eyog-Matig O and Mbogga M (Eds.) Review and appraisal on the status of Indigenous fruits in Eastern Africa. A synthesis report for IPGRI-SAFORGEN. http://www.bioversity international.org.

Pradhan BK and Badola HK (2008) Ethnomedicinal plant use by Lepcha tribe of Dzongu valley, bordering Khangchendzonga Biosphere Reserve, in North Sikkim, India, Journal of Ethnobiology and Ethnomedicine 4: 1-18.

Rai AK, Sharma RM and Tamang JP (2005) Food value of common edible wild plants of Sikkim, Journal of Hill Research 18: 99-103.

Rai LK and Sharma E (1994) Medicinal Plants of Sikkim Himalaya. Status, Uses and Potential. Beshen Singh Mahendra Pal Singh, Dehra Dun.

Rai LK, Prasad P and Sharma E (2000) Conservation threats to some important medicinal plants of Sikkim Himalaya, Biological Conservation 93: 27-33.

Rai SC and Sundriyal RC (1997) Tourism development and biodiversity conservation: A case study from the Sikkim Himalaya, Ambio 26: 235-242.

Redzic SJ (2006) Wild edible plants and their traditional use in the human nutrition in Bosnia-Herzegovina, Ecology of Food and Nutrition 45: 189-232.

Sahu KC (1986) Himalayan resources for progress or preservation: a dilemma. . pp. 3-12. In: Joshi SC, Martin JH, Pangtey YPS, Joshi DR and Dane D (Eds.) Nepal Himalaya: Geoecological prospective. D. H. R. Publisher, Delhi.

Sasi R, Rajendran A and Maharajan M (2011) Wild edible plant diversity of Kotagiri Hills- a part of Nilgiri Biosphere Reserve, southern India, Journal of Research in Biology 2: 80-87.

Scoones I, Melnyk M and Pretty JN (1992) The hidden harvest: Wild foods and Agriculture systems, A literature review and annotated bibliography. WWF, SIDA, IIED, London.

Shrestha DP, Margate DE, Meer FVD and Anh HV (2005) Analysis and classification of hyperspectral data for mapping land degradation: An application in southern Spain, International Journal of Applied Earth Observation and Geoinformation 7: 85-96.

Singh SC (1960) Some wild plants of food value in Nepal, Journal of Tribhuvan. University Kathmandu 4: 50–56.

Sinha R (2003) Beyond card sorting: Free-listing Methods to Explore User Categorizations. Technical report. Boxes and Arrows. www.boxesandarrows.com/view/beyondcardsorting _free_listing_methods_to_explore_user_categorizations.

Sundriyal M (1999) Distribution, Propagation and Nutritive value of some wild edible plants in Sikkim Himalaya. Ph. D. thesis. H.N.B. Garhwal University, Srinagar, Uttaranchal, India.

Sundriyal M and Rai LK (1996) Wild edible plants of Sikkim Himalaya, Journal of Hill Research 9: 267-278.

Sundriyal M and Sundriyal RC (1998) Wild plants of food value in Sikkim Himalaya: Aspects of diversity and utilization. pp. 138-149. In: Sundriyal RC, Shankar U and Upreti TC (Eds.) Perspectives for Planning and Development in North East India. Himavikas Occasional

Publication No. 11, G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora, India.

Sundriyal M and Sundriyal RC (2001_a) Wild edible plants of the Sikkim Himalaya: Nutritive values of selected species, Economic Botany 55: 377-390.

Sundriyal M and Sundriyal RC (2001_b) Seed germination and response of stem-cuttings to hormonal treatment in six wild edible fruit species of Sikkim Himalaya, Indian Forester 127: 695-706.

Sundriyal M and Sundriyal RC (2003) Underutilized edible plants of the Sikkim Himalaya: Need for domestication, Current Science 85: 731- 736.

Sundriyal M and Sundriyal RC (2004_a) Dietary use of wild plant resources in the Sikkim Himalaya, India, Economic Botany 58: 626-638.

Sundriyal M and Sundriyal RC (2004_b) Structure, phenology, fruit yield and future prospects of some prominent wild edible plant species of Sikkim Himalaya, India, Journal of Ethnobiology 24: 113-138.

Sundriyal M and Sundriyal RC (2004_c) Wild edible plants of the Sikkim Himalaya: Nutritive values of selected species, Economic Botany 58: 286-299.

Sundriyal M and Sundriyal RC (2004_d) Wild edible plants of the Sikkim Himalaya: marketing, value addition and implication for management Economic Botany 58: 300-315.

Sundriyal M and Sundriyal RC (2005) Seedling growth and survival of selected wild edible fruit species of Sikkim Himalayas, India, Acta Oecologica 28: 11-21.

Sundriyal M, Sundriyal RC and Sharma E (2003) Dietary use of wild plant resources in the Sikkim Himalaya, India, Economic Botany 58: 626-638.

Sundriyal M, Sundriyal RC, Sharma E and Purohit AN (1998) Wild edibles and other useful plants of Sikkim Himalayas, India, Oecologia Montana 7: 43-54.

Sundriyal RC and Sharma E (19950 Cultivation of Medicinal Plants and Orchids in Sikkim Himalaya. Symposium on medicinal plants. University of Peshawar, Peshawar. Bishen Singh and Mahendra Pal Singh, Dehra Dun. 139p.

Tabuti JRS (2007) Status of non-cultivated food plants in Bulamogi County, Uganda, African Journal of Ecology 45: 96-101.

Talukder A, De Pee S, Taher A, Hall A, Moench-Pfanner R and Bloem MW (2001) Improving food and nutrition security through homestead gardening in rural, urban and peri-urban areas in Bangladesh. UA- Magazine. Leusden: Resource Centre in Urban Agriculture and Forestry. pp. 45-46.

Tchoundjeu Z, Duguma B, Fondoun JM and Kengue J (1998) Strategy for the domestication of indigenous fruit trees of West Africa: cause of *Irvingia gabonensis* in southern Cameroon, Cameroon Journal of Biology and Biochemical Sciences 4: 21-28.

Teklehaymanot T and Giday M (2010) Ethnobotanical study of wild edible plants of Kara and Kwego semi pastoralist people in Lower Omo River Valley, Debub Omo Zone, SNNPR, Ethiopia, Journal of Ethnobiology and Ethnomedicine 6: 23-30.

Termote C, Bwama Meyi M, NDjango JB, Van Damme P and Dhed'a Djailo B (2010) Use of socio economic importance of wild edible plants in tropical rainforest around Kisangani, district Tshopo, Democratic Republic of Congo. pp. 417-427. In: Van der Brugt X, Van der Maesen J and Onana JM (Eds.) Systematique et conservation des plantes Africaines. Yaounde, Cameroun.

Tigist W, Zemede A and Ensermu K (2006) Ethnobotanical study of food plants around `Dheeraa` town, Arsi, Ethiopia, Sinet: Ethiopian Journal of Science 29:71-80.

Tiwari JK, Ballabha R and Tiwari P (2010) Some promising wild edible plants of Srinagar and its adjacent area in Alaknanda valley of Garhwal Himalaya, India, Journal of American Science 6: 167-174.

Valvi SR, Deshmukh SR and Rathod VS (2011) Ethnobotanical survey of wild edible fruits in Kolhapur district, Journal of Applied Biology and Pharmaceutical Technology 2: 194-197.

Van den Eynden V, Cueva E and Cabrera EO (2003) Wild Foods from Southern Ecuador, Economic Botany 57: 576-603.

Westphal E (1975) Agricultural systems in Ethiopia. Agricultural research reports 826. Center for Agricultural Publishing and documentation, Wangeningen.

Wezel A and Bender S (2003) Plant species diversity of home gardens of Cuba and its significance for household food supply, Agroforestry System 57: 39-49.

Williams JT (1997) Uses and products of tamarind. In: Williams JT, Smith RW and Haq NE and Dunsiger Z (Eds.) Tamarind, *Tamarindus indicus* L. Centre for Underutilized Crops, Southampton.

Zemede A and Mesfin A (2001) Prospects for sustainable use and development of indigenous food plants in Ethiopia, Economic Botany 55: 47-62.

Tables

Table 1: Collection area of wild edible minor fruit species with their geographical locations

Sr. no.	Collection area	Ecological Zone	Latitude	Longitude	Elevation (msl) m
1	Rumtek	Low-Mid hills	27°22'29.03"N	88°29'49.08"E	1609
2	Sang		$27^0$13'48.85" N	$88^0$26' 40.17"E	1465
3	Nazitam		27^0 17'22.24 N	$88^0$33'42.35"E	1500
4	Tingbong	Mid-High Hills	27^0 32'39"N	88°28'39"E	1843
5	Gyathang		27^0 32'53"N	88°23'09"E	2298
6	Lingdong		27^0 21'15.35"N	88°31'57.26"E	2516
7	Geyzing	Mid Hills	27^0 17'34.46" N	88°15'17.34"E	1560
8	Namthang	Low Hills	27^0 11'18.05" N	88°29'34.30"E	386
9	Turung	Low Hills	27^0 11'18.05" N	88°33'2"E	367

Table 2: Free listed wild edible fruit species of Sikkim

Sl. No	Family	Species Name	Local Name	English Name
1	Anacardiaceae	*Spondias axillaris* Roxb. (Burtt & Hill)	*Lupsi*	Hog Plum
2	Arecaceae	*Calamus flagellum* var. flagellum Griff	*Phyakre, Bet Gainra*	
3	Combretaceae	*Terminalia chebula* Retz.	*Harra*	Chebulic Myrobalan
4	Clusiaceae	*Garcinia cowa* Roxb.	*Ban Suntala*	Garcinia
5	Ebenaceae	*Diospyros virginiana*	*Halle Beth*	Persimmon
6	Elaeagnaceae	*Elaegnus latifolia* L (Roxb.)	*Musleri*	Oleaster
7	Elaeocarpaceae	*Elaeocarpus sikkimensis* Roxb.	*Badrasey*	
8	Euphorbiaceae	*Baccaurea ramiflora* Lour	Kusum	Burmese Grape
9	Fagaceae	*Castanopsis hystrix* Miq.	*Kattus*	Chestnut
10		*Castanopsis tribuloides* (Smith) A.DC.	*Musure Kattus*	Chestnut
11	Flacourtiaceae	*Gynocordia odorata* R. Br.	*Bandarey*	
12	Juglandaceae	*Juglans regia L.*	*Okher*	Wild Walnut
13	Lauraceae	*Machilus edulis* King	*Pumsi*	Wild Avocado
14	Mimosoideae	*Entada scandens* (L.) Benth.	*Pangra*	
15	Moraceae	*Ficus roxburghii* Wall.	*Nebaro*	Fig
16		*Morus alba* Wall.	*Kimbu*	Mulberry
17	Passifloraceae	*Passiflora edulis* var. flavicarpa L.	*Garendel*	Passion Fruit
18		*Passiflora foetida* L.	*Garendel*	Passion Fruit
19	Rosaceae	*Duchesnia indica* (Andr.) Focke	*Bhuin Kaphal*	Indian Strawberry
20		*Eriobolus indica* Schn. (Wall.) Decaisne	*Mehel*	Indian Crab Apple
21	Rosaceae	*Prunus cerasoides* D. Don	*Painyuu*	Himalayan Bird Cherry
22		*Prunus persica* Batsch	*Arru*	Peach
23		*Pyrus pashia* (Buch.-Hamex Don.	*Naspati*	Pear
24		*Rhus semialata* Murr.	*Bakimlo*	Chinese Sumac
25		*Rubus ellipticus* Smith.	*Aiseylu*	Yellow Himalayan Raspberry
26	Sapotaceae	*Diploknema butyraceae* Roxb. Lam.	*Chuirii*	Indian Butter Tree

Table 3: Growth features of wild edible fruit species

Species Name	Growth Features	Elevation
C. hystrix	Wild evergreen large* tree	Mid to higher hills
D. butyraceae	Wild medium to large deciduous tree	Mid hills
D. indica	Wild evergreen herb	Mid to higher hills
E. indica	Wild medium deciduous tree	Mid hills
E. latifolia	Semi-domesticated deciduous liana	Lower to mid hills
E. sikkimensis	Wild medium to large evergreen tree	Mid to higher hills
F. roxburghii	Semi-domesticated small to medium evergreen tree	Mid to higher hills
M. alba	Wild deciduous small tree	Lower to mid hills
M. edulis	Semi-domesticated large evergreen tree	Mid to higher hills
P. cerasoides	Wild medium to large deciduous tree	Mid to higher hills
P. edulis	Semi-domesticated deciduous climber	Lower to mid hills
R. ellipticus	Wild evergreen shrub	Mid to higher hills
S. axillaris	Semi-domesticated large deciduous tree	Mid to higher hills
T. chebula	Wild large deciduous tree	Lower to mid hills

*Plant size: small - <5 m; medium- 5-12 m; large- >12 m

Table 4: Colour, type and inflorescence position of wild edible fruit species

Name	Colour	Type	Inflorescence Position
C. hystrix	Light to dull yellow green	Monoecious	Terminal
D. butyraceae	White	Hermaphrodite	Axillary
D. indica	Bright yellow	Hermaphrodite	Terminal
E. indica	White	Hermaphrodite	Axillary
E. latifolia	White	Hermaphrodite	Both
E. sikkimensis	Yellowish white	Hermaphrodite/ polygamous	Axillary
F. roxburghii	Yellowish green to purple in colour	Unisexual	Syconium (enclosed within a hollow receptacle)
M. alba	Green	Dioecious	Axillary
M. edulis	Greenish yellow	Monoecious	Axillary
P. cerasoides	Pinkish white	Hermaphrodite	Axillary
P. edulis	Purplish white	Hermaphrodite	Modified terminal
R. ellipticus	white	Hermaphrodite	Terminal
S. axillaris	Dull maroon	Dioecious	Terminal
T. chebula	Dull white	Hermaphrodite	Both

Table 5: Traditional/Indigenous uses of wild edible fruit species

Botanical Name	Indigenous uses
C. hystrix	Fruits edible, fuel wood, leaves are good ingredients for composts. It is highly valued for furniture, agricultural implements *etc*
D. butyraceae	Fruits are edible. Pulps of the fruits are sweet and juicy but cannot be stored for a longer time due to its low keeping quality. The seeds are used to make a special type of butter for burning lamps and culinary purpose as well. Oil though edible is mostly used for burning lamps due to its strong odour. Butter extracted from the fruits is used in treating rheumatism. Also used as live fence and fodder.
D. indica	Preparation of jam and juice Poultices of fresh leaves are deemed effective against snake bites, insect bites and boils. The fruit is sometimes used for the preparation of local alcoholic beverages.
E. indica	Fruit extracts used for curing blood dysentery and bark used for piles.
E. latifolia	Fruits edible and consumed raw. It is used for making jam, pickles other food produce such as in pies, puddings or sweetened and pureed as a sauce and fruit pulp is used for making pickle, chutney, jam, jelly and refreshing drink
E. sikkimensis	Fruits edible, the fruit is used to make pickles and chutney.
F. roxburghii	Fruits edible, leaves are good fodder. Gum is extracted from the fruit and used locally. It is believed to have medicinal properties and prevents constipation.
M. alba	Fruits edible, Locally they are made into wine and also it makes an excellent dried fruit. In traditional and folk medicine, the fruit is believed to have medicinal properties anti-inflammatory and moisturizing properties. It is highly valued for furniture, agricultural implements *etc*
M. edulis	Fruits edible, leaves are good fodder. Butter/ ghee is extracted from the fruits and used as additive in vegetable ghee.
P. cerasoides	Fruits edible, fairly good fodder and fuel wood, The fruits and the leaves give a dark green dye, bark of the tree is used medicinally for fracture and burns.
P. edulis	Fruits are edible. It is commercially used for preparation of beverages like juice and local wine
R. ellipticus	Fruits edible, the fruit can also be used to make jams, jellies, pies, and other desserts.
S. axillaris	Fruits are edible, nutritious and highly valued as a source of traditional medicine. Medicine is prepared from bark against diarrhea, vomit. The finer bark is chewed by local people as a substitute for betel nut. The fruits (ripe or unripe) are traditionally eaten by local peoples as raw with salt and used for making chutney, pickles and various candies. The processed product has a considerably long shelf-life even up to 5 years. Processed products of the fruits are popular among the natives.
T. chebula	Fruits edible. Traditionally it is used for the removal of Kidney Stones and treatment of diabetes, raw fruits used for curing diabetes and dry fruits for cough and cold. The paste of its fruits is applied on the eyelids in conjunctivitis.

Table 6: Value added products and their processing of some wild edible fruits

Fruit	Value added products	Process
C. hystrix	Flour	**Candies:** Fruits were boiled, peeled, mixed with sugar syrup and boiled again till it thickens. The thickened product was cooled and cut as candies. Salt/Sugar/chili powder was added according to taste. **Pickle:** Fruits were washed, cut into pieces, sun dried, mixed with oil along with required spices and then seasoned under sun. **Fruit wine:** Fruits were sliced, added with few slices of potato and sugar (half kg sugar/1 kg fruits) and the mix are stored in an air tight container for fermentation (during summer for 20-25 days and winter 45-60 days). After fermentation, the product was squeezed in a muslin cloth. Water can be added according to taste. **Butter:** Fruits were crushed to extract the seeds. The seeds kept in a bamboo basket were dried in a fire place for 4-5 days. The dried seeds were crushed and steamed to extract oil.
D. butyraceae	Fat/butter	
E. indica	Pickle	
E. latifolia	Pickles, jam, wine	
F. roxburghii	Dry fruits	
M. edulis	Fat/butter	
P. edulis	Juice	
S. axillaris	Candies, pickle	
T. chebula	Dried with honey or jaggery	

Table 7: Ethnomedicinal uses of wild edible fruit species and their formulation

Species used	Ailment	Formulation	Duration
P. cerasoides, *R. ellipticus*	Burns	Paste mixture of stem and root bark of the two plant species is applied on the burn and left till it loosens	2 weeks
T. *chebula*, *P. cerasoides*	Bone fractures	Bark of the either species is powdered and mixed with milk. A glass of the mixture is taken orally twice a day.	2 weeks
E. indica, *R. ellipticus*,	Piles, Dysentery	Bark of *E. indica* and root of *R. ellipticus* are grounded and one teaspoon of the mixture is taken twice a day with hot glass of water.	1 week
S. axillaris	Diarrhoea, Vomiting	Tree bark is powdered and taken with water. One cup for adult and half a cup for children.	Two days
T. chebula	Piles, Dysentery	Small bark pieces of *T. chebula* are chewed any time in a day.	2 weeks
	Gastritis	Fruits are dried, powdered and boiled in water. One teaspoon taken orally twice a day.	1 week
	Diabetes	Fruits are dried; powdered and 10 g powder is taken twice a day.	1 week
	Kidney stones	Three dry fruits are dipped in a glass of water for 4 hours and then given to the patient to drink.	As long