7 High Altitude Edible Plants: A Great Resource for Human Health and their Socio-Economic Significance

Mohammed Asadullah Jahangir, Abdul Muheem, Syed Sarim Imam, Sadaf Jamal Gilani, Ameeduzzafar Zafar, Sultan Alshehri, and Mohammed Jafar

Abstract

As the name suggests, edible plants are those plants which can be eaten. Out of the twenty thousand species of edible plants found around the world, only twenty species make up the majority of our food. However, there are still numerous plants which are lesser known but can be eaten and also have nutritional and medicinal value. These natural products have been an important part of food, economy and health care for most of the population. Traditional knowledge of high altitude edible and medicinal plants has served as the base for many breakthrough discoveries especially in the medicinal field. Organized and systemic cultivation of high altitude of medicinal plants with efficient procession and

M. A. Jahangir
Department of Pharmaceutics, Nibha Institute of Pharmaceutical Sciences, Rajgir, Nalanda, Bihar, India

A. Muheem
Department of Pharmaceutics, School of Pharmaceutical Education & Research, Jamia Hamdard, New Delhi, India

S. S. Imam (✉) · S. Alshehri
Department of Pharmaceutics, College of Pharmacy, King Saud University, Riyadh, Saudi Arabia
e-mail: simam@ksu.edu.sa; salshehri1@ksu.edu.sa

S. J. Gilani
Department of Basic Health Sciences, Princess Nourah Bint Abdulrahman University, Preparatory Year, Riyadh, Saudi Arabia

A. Zafar
Department of Pharmaceutics, College of Pharmacy, Jouf University, Aljouf, Sakaka, Saudi Arabia

M. Jafar
Department of Pharmaceutics, College of Clinical Pharmacy, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia

M. H. Masoodi, M. U. Rehman (eds.), *Edible Plants in Health and Diseases*,
https://doi.org/10.1007/978-981-16-4880-9_7

marketing strategies may boost up the economy of not only the tribal people but also to the nation's economy. This chapter discusses about the traditional knowledge about the edible and medicinal plants, edible plants of high altitude regions of Himalayas, high altitude medicinal plants as a source for treating major health ailments, modern drugs derived from traditional medicines derived from high altitudes, biological radioprotection by high altitude plants, wealth of ethnic and medicinal high altitude medicinal plants, ethnic veterinary medicinal plants from high altitude regions, description some of the wild edible plant species of the high altitude regions of Himalayas, high altitude medicinal herbs as socio-economic resource, cultivation of high altitude edible medicinal plants of Himalayas for economic growth and management, conservation and prospect of high altitude medicinal plants.

Keywords

Edible plants, Himalayas · Socio-economic · Traditional medicine · Medicinal plants

7.1 Introduction

As the name suggests, edible plants are those plants which can be eaten (Ju et al. 2013). Out of the twenty thousand species of edible plants found around the world, only twenty species make up the majority of our food. However, there are still numerous plants which are lesser known but can be eaten and also have nutritional and medicinal value. Through thousands of years humans have survived by managing and utilizing the available bioresources around him. Humans have been around the forest ecosystem since ancient times (Coates 2013). Being an integral part of this dynamic ecosystem humans have acquired immense knowledge about this ambient biosystem by trial and error, instinct and experimentation to better understand different varieties of flora to meet their basic requirement of food, fibre, fuel, medicines, etc. Humans by its intelligence and innovation carved a better habitat with the available resources. They later build civilization and developed villages, towns and cities. However, still a large population of humans choose to live near or around the forest ecosystem. Communities living in modern cities lost association with the forest and nature and eventually lost the hard-gathered knowledge about the wild edible plants which their forefathers had gained. Further development lead to shrinking of the forests which lead to the disrupted, disturbed and destabilization of the forest peoples causing an imminent danger of their extinction and with them the culture and knowledge they have gained through their peculiar lifestyle. People who got settled in different habitat began to select certain species of plants and perfected them according to their need. Furthermore, globalization occurred which brought its own advantages and disadvantages. Most undesirable of these were narrowing down of edible foods by the world population. The whole world is now dependent upon only 20 edible plants (Despommier 2010; Bidve et al. 2018). With the increase in knowledge and understanding of edible plants it is now a well-known fact that location and climate specific foods are the best ones for humans. The traditional

system of medicine like the Unani, Ayurveda, Siddha and other makes the use of only 2500 plants out of 10,000 listed in the database requiring validation for its use (Sreedevi et al. 2013; Garg et al. 2017). Tribal people use around eight thousand wild edible plants with potential medicinal effect out of which only 950 makes the list with new claims and are marked as worthy for undergoing scientific scrutiny (Chopra and Chopra 1994).

The mighty Himalayan range with its enormous variety of flora and fauna have a long list of high altitude plant which are edible and have life sustaining and medicinal value (Abbasi et al. 2015). Himalayas serve as a reservoir of medicinal herbs for not just people who live in its foothills and nearby villages but also to the mankind who sustains in the far away towns and cities. The Himalayan range in India can be categorized into three different regions, namely the: North Western, Western and Eastern Himalayan range (Kala 2005). The climate of the North Western region is characteristically mild in summer and extremely cold in winter. Alpine vegetation is commonly found in this region which is characterized by the species like- *Juniperus communis, Bunium persicum, Ephedra gerardiana, Picrorhiza kurroa,* etc. The climate of the western Himalayan region warm and humid during summer season and during winter it is cold and humid. *Colchicum luteum, Physochlaina praelta, Sassurea costus, Atropa acuminata,* etc. are some of the most important medicinal herbs indigenous to Western Himalayan region (Chhetri 2014). The climate is warm during summer and cool during winter in the Eastern Himalayan region characterized by some important medicinal herbs like *Panax pseudoginseng, Coptis teeta, Aquilaria malaccenisi,* etc. There is an ever-increasing demand of medicinal herbs from Himalayan region (Yang et al. 2013).

A large population of people still lives in hunger and are malnourished (FAO 2012, 2013). Although this issue has been well debated by UN forum across the globe but the safety and availability of food in the high altitude region has been rarely discussed (Dame and Nusser 2011). In the high altitude region, the wild edible plants play an important part in the livelihood and medicinal needs of people living in such regions (Afolayan and Jimoh 2009). The ethnic communities are solely dependent on wild edible and medicinal plants which are now gaining attraction of many researchers from around the globe. The study of wild edible plants has led to the discovery of many potential compounds which have high medicinal and nutritional value. Proper domestication and application of such wild edible plants could serve as a potential platform to uplift the economic scenario of poor farmers from such rural areas (Bharucha and Pretty 2010). The high altitude of Eastern Himalayan region is quite rich in the wild varieties of flora and fauna which are mainly endemic to this specific part of the Himalayan region (CEPF 2005). Alpine flora is abundant in this Himalayan region of India with its one third alpine floras being endemic to Eastern Himalayan region (Dhar 2002). This region has been ranked as the most species rich temperate forest in the world by the ICIMOD and World Wide fund for Nature (WWF) (WWF and ICIMOD 2001). The Eastern region of Himalaya serves as the cradle of the flowering plants (Takhtajan 1969). It is home to some of the rarest species like *Sapria himalayana, Coptis teeta* and *Magnolia* (Takhtajan 1969). The cultural biodiversity of Eastern Himalayan region makes it a hub of traditional herbal knowledge. *Diplazium esculentum, Ribes*

orientale, Centella asiatica, Fragaria vesca, Houttuynia cordata, Litsea cubeba, Mentha arvensis, Elaeagnus umbellata, Zanthoxylum armatum, Panax bipinnatifidus, longum, Potentilla peduncularis, Phyllanthus emblica, Piper Psidium guajava, Pyrus pashia, Rhododendron arboreum, Plantago major, Urtica dioica, Zanthoxylum rhetsa, Rubus ellipticus etc. are some of the wild edible medicinal plants of the Eastern region of Himalayas (Tag and Tsering 2012).

7.2 High Altitude Edible and Medicinal Plants of the Great Himalayas

Arid, cold climate with scanty rainfall and high velocity winds, high ultraviolet radiation and snowstorm are characteristics of the climatic condition of high altitude regions of Himalayas. The vegetations in these regions have got adapted to extreme environmental conditions. Many microhabitat regions get created in these regions leading to diversity in habitat. These microhabitats act as hotspots for biodiversity of medicinal plants (Effo et al. 2018; Kaul 2010; Pei 1998). Countries like India, Pakistan, China, Nepal, Bangladesh are very strong in traditional system of medicine and possess rich diversity of medicinal plants. China has been very successful in promoting the use of its traditional medicines in the developing countries. Very few countries have capitalized on their herbal wealth by promoting its application in the developing world. The information about medicinal plants found in the high altitude regions is very mere. Indian drug industry uses around 700 medicinal plants out of which 350 are from Himalayan medicinal plants (Ved et al. 1998; Purohit 1997; Dhar et al. 2000). In the high altitude regions of Himalayas, the specific climate and geological conditions there is high possibility of having large quantities of novel active biocompounds (Dhawan 1997; Hazlett and Sawyer 1998). High altitude region has abundant medicinal plants which could promise great therapeutic efficiency. These herbal drugs are in great demand in the USA and the European nations. Drugs derived from plants held a special place in the Russian and German Pharmacopoeias. Even today a large population of the world depends on crude plant drugs to treat their health issues. Many more people are turning towards herbal medicines day by day. The economic turnover of herbal medicines in India is huge as classical, ethical and over the counter herbal remedies of Unani, Ayurveda and Siddha system of medicines makes up about $1 billion with export of $80 million (Kamboj 2000). The export of herbal medicines can be considered as negligible despite the fact that India has a rich source of herbal drugs and tradition knowledge. This is due to lack of quality control and standardization of herbal products. Herbal pharma sector is controlled by Himalaya, Hamdard, Dabur, Baidyanath, Zandu, Maharishi, etc. (Sen et al. 2011).

7.3 Therapeutic Possibilities of High Altitude Plants

The therapeutic possibility of medicinal plants of high altitude may be categorized into five major sections:

- High altitude medicinal plants as a source for treating major health ailments.
- Modern drugs derived from traditional medicines derived from high altitudes.
- Biological radioprotection by high altitude plants.
- Wealth of ethnic and medicinal high altitude medicinal plants.
- Ethnic veterinary medicinal plants from high altitude regions.

7.3.1 High Altitude Medicinal Plants as a Source for Treating Major Health Ailments

Hypericum perforatum, Ephedra gerardiana, Ginkgo biloba, Panax species, Echinacea species are some of the most selling herbal medicines which are grown in the high altitude regions. Germany lists more than 300 herbs as individual monograph based on their therapeutic benefits. Sixteen of them are Indian medicinal plants which have innovative characteristics and eminent therapeutic potential (Vaidya 1996). *Podophyllum hexandrum* is a high altitude medicinal herb, podophyllotoxins derived from these plants are used to develop etoposide and teniposide are developed which has proven therapeutic efficiency in lymphoma, testicular cancer and small cell lung cancer (Gerhart 1986; Jahangir et al. 2020a). Another high altitude species *Taxus wallichiana*, taxol is derived from these plants which are chemically diterpenoid and has potential therapeutic effects on malignant melanoma, metastatic breast cancer and lung cancer (Suffness 1995; George et al. 1995). They have been rated as critically endangered species due to destructive harvesting along their wild habitats. It is the need of the hour to promote large scale cultivation of this outstanding high altitude species to protect them from getting extinct. *Hypericum perforatum* with its unique spectrum of constituent and clinical and pharmacology profile makes them stand as one of the most important high altitude plants. Hyperforin 10 and hypericin derive from these plants have potent antidepressant activity (Erdelmeier et al. 2000; Jahangir et al. 2020b). Apart from that the extracts of *Hypericum perforatum* has been reported with antiviral and antibacterial activity.

7.3.2 Modern Drugs Derived from Traditional Medicines Derived from High Altitudes

Since ancient times, people have relied on herbal medicine and have also documented their traditional knowledge in the form of paintings and writings. These documentations acted as the base for the modern-day pharmacopoeias. Enormous number of currently used medicines like morphine, codeine, hyoscyamine, atropine, quinine, ephedrine, digoxin, colchicine, reserpine, strychnine, artemisinin,

ergot, taxol, etc. have herbal origin. Modern drug discovery is relying on the indigenous cure in different cultures. Belladonna was quite a famous drug in Babylonian culture which served as a base for its modern-day application. In the Chinese culture of medicine Ephedra has been extensively used for asthma and other respiratory disorders. Many other high altitude edible and medicinal plants have been used in different cultures for various ailments. Many classical drugs like Artemisinin, extracted from *Artemisia annua* have been found to be highly effective against both chloroquine resistant and chloroquine sensitive *Plasmodium vivax* and *Plasmodium falciparum* parasites causing malaria. Many reports also suggest their effectiveness against cerebral malaria (Huang 1984). Similarly, digoxin a strong cardiac stimulant and hyoscyamine a potent anticholinergic is still being considered in modern medical system. The Chinese Pharmacopoeia of the 1990s had enlisted more than 750 traditional Chinese medicines of which more than 600 were from herbal origin (Chang et al. 1985; Xiao 1981). Many of them were from high altitude regions. The roots of *Sophora substrata* and sophoradin extracted from the same have been extensively used in the treatment of stomach trouble and gastric ulcer, respectively (Sankawa 1992). Another high altitude plant *Huperzia serrata* has been extensively used in Chinese traditional culture to treat memory disorders of the geriatric patients. Huperzine A isolated from *Huperzia serrata* is a powerful acetylcholine esterase inhibitor and has immense application in Alzheimer's disease. In Indian traditional system like the Ayurvedic and Siddha system of medicine, plants hold an important position in their pharmacopeial preparations. Charaka Samhita stands as one of the oldest recorded documents which was fully devoted to the Ayurveda. It classifies herbals drugs according to their therapeutic action. Charaka divides them into fifty groups while Sushruta put them into thirty-seven different categories (Ray and Gupta 1965; Krishnamurthy 1991). More than 750 plants are being used to prepare more than 1000 Ayurvedic preparations (Anand 1990).

7.3.3 Biological Radioprotection by High Altitude Plants

Some of the high altitude plants have radioprotection activity. They act by increasing the body resistance against exposure to radiation (Goel et al. 2001). In research for the radioprotective agent their non-toxic nature is of outmost importance. For the purpose a number of biological and chemical agents have been screened and studied (Maisin 1992). The extracts of high altitude plant having radioprotective efficacy also contain various bioactive molecules like immunostimulants, cytokines, antioxidants, cell proliferators, etc. which are expected to perform radioprotective efficiency as single entity on in combination. *Hippophae rhamnoides* is a high-altitude shrub having strong antioxidant and radioprotectant activity which is attributed to the presence of large number of molecules like flavonoids, Vit-A, Vit-C, Vit-E, flavones, Vit-K, tannins and trace elements like Cu, S, Zn and Se (Ianev et al. 1995).

7.3.4 Ethnic Veterinary Medicinal Plants from High Altitude Regions

The tribal people of Himalayas majorly depend on the livestock and animal husbandry for their livelihood. Veterinary doctors are seldom available to them, so they mostly depend on herbal plants for treating their animals. Colic, red water, diarrhoea and black water are some of the most common veterinary diseases in the high altitude northern Himalayan region. It has been reported that eighteen different herbs are used to treat diseases in animals in these regions (Sharma and Singh 1989). However, extensive research is required to provide data related to bioactive molecules available from these hers.

7.4 Wealth of Ethnic and Medicinal High Altitude Medicinal Plants

It is complex to understand the wealth of the ethnic and medicinal high altitude plants. Individual different models can be hypothesized. All India Coordinated Research Project on Ethnobiology conducted between 1982 and 1992 has revealed that more than 8000 plant species have ethnic and medicinal significance. More than 300 of them are from high altitudes (Kaul 1997). Many of these high altitude plants are used in combination or as individual as food or medicinal agents. These high altitude plants of Himalayan region are available in most of the households of that area to ensure food security and healthcare during long winter seasons. Some of these high altitude edible plants with medicinal value of Himalayan region are hereby discussed.

Urtrica hyperborea also known as Himalayan Nettle or Zachut in Tibetian culture are wild plants which are extensively used by tribes living in the Himalayas. They are collected and drying is done in shading after which it is stored. They are very highly nutritious and is very healthy to be used for pregnant women both before and after childbirth. It provides vitality and is a strong post-natal energizer. These plant samples have high nutritional value and are rich source for protein, sodium, phosphorous, calcium, fibre and iron.

Dipsacus inermis It is also known as Wopal hack in Kashmiri culture. The leaves of this plant are edible and used in auspicious events, they are collected in large quantity and shade dried. They have potent carminative and stomachic property. They are rich source of starch, fibre, protein, potassium, calcium, iron, sodium and phosphorous (Kaul et al. 1985).

Polygonum alpinum In Kashmiri language it is also known as Chita hola. It has very potent anti-arthritis effect. Water extracts are prepared from the dried roots powder and is consumed by arthritic patients. These plants are abundantly found in the alpine sloped of the Himalayas and are rich source of protein, starch, fibre, potassium, calcium and phosphorous (Kaul et al. 1990).

7.5 Description of some of the Wild Edible Plant Species of the High Altitude Regions of Himalayas

Some of the wild edible high altitude plants of Himalayas having medicinal property is discussed in this section (Table 7.1).

Angelica glauca Edgew: It is known as Hanw or Choru in native language and belongs to the family of Apiaceae. It is cultivated throughout India and is used as herb and vegetables. The root powder is used as veterinary medicine to cure toxic effects in livestock (Tiwari and Pande 2010). It has application in constipation and dyspepsia. Essential oils are also extracted from the dried roots of *Angelica glauca* (Chopra et al. 2002).

Arisaema speciosum mart.: It is known as Bankh in native language and belongs to the family of Araceae. It is cultivated in the temperate Himalayan region and is used in snake bites. The root is considered to have antidote against snake venome (Mhaskar and Caius 1931).

Asparagus filicinus: It is known as Kairua in native language and belongs to the family of Liliaceae. It is cultivated in temperate and tropical Himalayas. It is an evergreen tree with moderate size. The root has astringent properties and is also considered as tonic. It is also used as prophylactic agent in smallpox. The roots have also taeniafuge and vermifuge properties. It has powerful diurectic action and is also given in cholera. It has potent effect in rheumatism (Kiritikar and Basu 1994). The roots have also application in diabetes, dysentery and diarrhoea (Dhiman 2005; Tiwari et al. 2010).

Berberis asiatica: It is known as Kilmora in native language and belongs to the family of Berberidaceae. It is widely available between 500 and 3000 metre in Himalayas and other hilly regions. It is a shrub, and its fresh root has anti-diabetic ability and is able to cure jaundice (Uniyal et al. 2006). The stem has anti-rheumatic effect. Roots also possess anticancer effects. The berries of the plants have laxative effect and are used in children.

Dioscorea bulbifera: It is known as Genthi in native language and belongs to the family of Dioscoraceae. It is found at an elevation of about 2000 metres in Himalayas. The tubers of the herbs are used as vegetable. It is used in syphilis, dysentery and piles. The tubers are dried and powdered and are applied to ulcers. The rhizomes of the plant have anorexic effect. Diuretic effect was reported in the ethanolic extract of aerial parts of *Dioscorea bulbifera* (Asolkar et al. 1992).

Fagopyrum cymosum: It is known as Jhangar in native language and belongs to the family of Polygonaceae. It is found in the elevation of about 4000–10,000 ft. Its seeds are used as vegetable. The grains of the plants are used in fluxes, diarrhoea, abdominal obstructions and colic. The rhizome of the plants is used in pulmonary abscess (Asolkar et al. 2000).

Ficus palmata Forssk: It is known as Bedu in native language and belongs to the family of Moraceae. It is found in the elevation of about 3000 ft. in the Himalayas. The fruits are edible with laxative and demulcient activity. It is also used in constipation and diseases of bladder and lungs (Chopra et al. 2002).

Table 7.1 Plant name, Local name, family, active constituent, therapeutic effects of some of the high altitude edible medicinal plants

Plant Name	Local Name	Family	Active constituents	Therapeutic effect	References
Angelica glauca	Hanw or Choru	Apiaceae	Trans-ligustilide, Z)-3-butylidenephthalide, α-phellandrene, β-phellandrene, p-cymene, (−)-spathulenol	Constipation and dyspepsis	Chopra et al. (2002)
Arisaema speciosum	Bankh	Araceae	n-alkanes, n-alkanols, sitosterols, stigmasterols, cholesterol, campesterol, choline chloride, staychydrine hydrochloride	Antidote against snake venome	Mhaskar and Caius (1931)
Asparagus filicinus	Kairua	Liliaceae	Asparagine, arginine, tyrosine, flavonoids (kaempferol, quercetin and rutin), resin and tannin.	Taeniafuge and vermifuge, diurectic, diabetes, dysentery and diarrhoea	Dhiman (2005); Tiwari et al. (2010)
Berberis asiatica	Kilmora	Berberidaceae	Alkaloids, flavanoids, terpenoids, anthocyanins, sterols, vitamins, lignins, carotenoids, proteins and lipids	Anti-diabetic, anti-cancer	Uniyal et al. (2006)
Fagopyrum cymosum	Jhangar	Polygonaceae	2-Pentadecanone, eugenol, 1,2-benzenedicarboxylic acid, bis (2-methylpropyl) ester, (E,E)-farnesylacetone	Fluxes, diarrhoea, abdominal obstructions, colic, pulmonary abscess	Asolkar et al. (2000)
Ficus palmata	Bedu	Moraceae	Triterpene- germanicol acetate, furanocoumarins-psoralene, bergapten, aromatic acid-vanillic acid, flavone glycoside-rutin	Laxative and demulcient, constipation	Chopra et al. (2002)
Phytolacca acinosa	Jarag	Phytolaccaceae	Alkaloids, flavanoids and glycosides	Narcotic, joint pain, Phytolacca toxin	Chopra et al. (2002)
Rhododendron arboreum	Burash	Ericaceae	Ericolin and glucoside	Stomach diseases, headaches	Uniyal et al. (2006); Tiwari et al. (2010)

(continued)

Table 7.1 (continued)

Plant Name	Local Name	Family	Active constituents	Therapeutic effect	References
Urtica urens	Bichchhughas	Urticaceae	Flavonoids, tannins, volatile compounds and fatty acids, polysaccharides, isolectins, sterols, terpenes, protein, vitamins and minerals	Vesicant and rubefacient, bleeding nose, uterine haemorrhages, blood vomiting and to regulate menstrual periods, scurvy, anti-pyretic, gout and rheumatism	Dhiman (2005), Gangwar and Joshi (2008); Chopra et al. (2002)
Illicium griffithii	Lissi, star anise and Munsheng	Schisandraceae	Linalool, limonene, α-pinene, 1,8-cineole, ρ-methoxyphenyl acetone, terpinen-4-ol, (E)-anethole, safrole, germacrene B, cadinol, myristicin, α-selinene, δ-selinene, α-santalene, β-phellandandrene,(2–4) elemicin, (E)-caryophyllene and eugenol derivatives	Abdominal pain, food poisoning, dyspepsis, stomachic, vomiting, antifungal and preservative properties	Singha (2008); Mukhia et al. (2006); Kirtikar and Basu (1997)
Taxus wallichiana	Teyshing	Taxaceae	Paclitaxel	Anticancer	Wilson et al. (1996); Shukla et al. (1994)

Phytolacca acinosa: It is known as Jarag in native language and belongs to the family of Phytolaccaceae. It is found in the temperate regions of Himalayas at an altitude of 4000–10,000 ft. The plant has narcotic properties. From the roots oil is extracted which is used in the joint pain. It is also reported to have Phytolacca toxin (Chopra et al. 2002).

Rhododendron arboreum Smith: It is known as Burash in native language and belongs to the family of Ericaceae. It is found in the temperate region of Himalayas at an elevation of about 4000 to 12,000 feet. The leaves of the plant contain ericolin and glucoside. The flowers of the plants are eaten raw and juice are extracted from it to be used in stomach diseases. Young leaves are applied externally for headaches (Uniyal et al. 2006; Tiwari et al. 2010).

Urtica ardens: It is known as Bichhoo ghas in native language and belongs to the family of Urticaceae. It is also found in the temperate regions of the Himalayas at a maximum elevation of about 6000 metres. Fruits, flowers and leaves of the plant are used as vegetables. The bark of the root as well as roots of young trees is reported to have vesicant and rubefacient activity. Leaves are used to cure bleeding nose, uterine haemorrhages, blood vomiting and to regulate menstrual periods (Dhiman 2005; Gangwar and Joshi 2008). Leaves of the plants are rich source of Vit-A and Vit-C and thus have application in catarrhal and scurvy. They are also used as emetic agents. Flowers have cholagogue, tonic diuretic properties. Seeds of the plants have antipyretic properties. Oils extracted from seeds are used for external application in gout and rheumatism (Chopra et al. 2002).

Illicium griffithii: It is known as Lissi, Star anise and Munsheng in native language and belongs to the family of Schisandraceae. It is found in the temperate to sub-tropical regions of the Himalayas at a maximum elevation of about 1700–3000 metres. It has star shaped fruits having refreshing flavours. Fruits and dried seeds have commercial and economic importance. The fruits have anethol rich essence and thus have medicinal application. They are used as carminative and stimulant. They also have application in abdominal pain, food poisoning, dyspepsis, stomachic, vomiting, etc. (Singha 2008; Mukhia et al. 2006). Oil extracted from the fruits of the plants have anti-fungal and preservative properties (Kirtikar and Basu 1997).

Taxus Wallichiana: It is known as Teyshing in native language and belongs to the family of Taxaceae. It is found in the temperate to tropical regions of the Himalayas at an elevation of about 900–3700 metres. Leaves of the plants are used by local people for its nutritious value and are also used as fodder for the livestock. It is also used to make tea by the tribal people. They are the chemical precursor of the paclitaxel which is an anticancer drug (Wilson et al. 1996; Shukla et al. 1994).

7.6 High Altitude Medicinal Herbs as Socio-Economic Resource

Asian countries along with Africa and Latin America are heavily dependent on traditional system of medicine to meet their healthcare requirements. A major portion of the African population utilizes traditional drugs for meeting up their

primary healthcare need. In developed nations this traditional system of medicine is known as alternative or complementary medicinal system. In India Ayurveda, Unani and Siddha makes up the traditional medicinal system with a huge number of traditional practitioners registered with the governing authority of Government of India. Herbal medicine market in India is enormous. However, this has not been capitalized for potential export to other countries.

A major portion of modern medicines are derived from herbal source especially from the Himalayan region. *Digitalis purpurea* which is commonly known as foxglove are used for its derived drugs, namely digoxin and digitalin which are potent cardiac drugs. Similarly, an anticancer drug Taxol is derived from *Taxus wallichiana* (Malik et al. 2011). There are many herbal drugs which acts as prototype molecules derived from different plants are used for the development of their synthetic analogues. They are also registered in different pharmacopoeias (Gurib-Fakim 2006). Many of them are derived from high altitude medicinal plants. The global impact and market response of traditional medicines must be considered in designing an imperative economic strategy. India is rich in terms of climate, soil and geographical distribution all these factors assist in producing herbal medications used in both modern and alternative system of medicine (Kala et al. 2006). The high altitude plants are usually harvested from the wild thus endangering many wild species and many of them have already extinct (Rai et al. 2000). Places which are economically backward with limited opportunities of education, poor infrastructure and limited commercial activity these medicinal plants could provide potential opportunities in creating new job opportunities and eventually economic growth. Converting indigenous knowledge and socio-cultural traditions into economic opportunities indirectly provide the advantage of conserving the vanishing cultural practices and knowledge due to globalization. Himalaya is a treasure house of cultural and biological diversity and is in a dire need to protect the cultural and indigenous diversity on priority basis. It can be only achieved by mixing the economic factor with the indigenous and traditional knowledge (Bengwayan 2003). Compounds like taxol, digoxin have awakened the interest towards indigenous knowledge for guiding drug discovery. In the recent times allopathic system of medicine is showing interest in the traditional medicines for healing and is thus assisting in the revival of alternative medical approaches. Accounting the diversity of high altitude medicinal plants there are a number of new therapeutic molecules still waiting to be discovered (Siwach et al. 2013). The great Himalayan region offers an advantage of higher possibility of providing new entity or molecules due to the extreme conditions they face throughout their lifetime (Moore et al. 1998). Drug discovery could be more successful if a selective search on medicinal plant based on traditional knowledge is done rather going on for random search. This technique could be more economic and productive (Patwardhan et al. 2004). There is vast scope of research on the pharmaceutical, pharmacological and biochemical aspects of high altitude plants of the Himalayas. The rich diversity of high-altitude medicinal plants of Himalayas could provide multiple herbal remedies for a single disease for example more than 30 species of plants have been reported to possess antipyretic

property and more than 20 species of herbs were reported with hepatoprotective effect (Kaul 2010).

7.7 Cultivation of High Altitude Edible Medicinal Plants of Himalayas for Economic Growth

Mountains provide an efficient ecosystem which could support its diverse inhabitants, but these systems are also very fragile (Lebel et al. 2006). As globalization impacts almost every part of the world, the farming land in these areas have been fragmented. Apart from that connectivity to roads due to huge number of landslides, scarcity of water, absence of assistance in marketing and lack of communication also hamper the economic growth of farmers who cultivate herbal medicines. Cultivating medicinal plants requires specialized techniques. Local who have been doing this for generations are well equipped for this task (Kala 2009). Traditional knowledge related to many herbal plants are still only confined to the native people of high altitude region due to less accessibility of the regions and very slow rate of development (Kala et al. 2006). During the recent times, the demand of the extracts of medicinal plants is increasing day by day and could be able to give a steady source of income to the native people and provide them an incentive for conserving their nature. For underprivileged communities cultivating medicinal plants could be an alternative source of income (Shinwari 2010). Even the cosmetic industries are now relying on natural ingredients in their products, many of these natural ingredients are extracted from the high altitude medicinal plants (Alamgir 2018). Thus, cultivating high altitude medicinal plants needs special consideration.

Cultivation of medicinal plants in the Himalayan region provides the advantages of: fallow and barren land, requires zero maintenance, less susceptibility to pests and diseases, negligible chance of damage caused by wild animals, cultivation is based on local resources, high economic return, cold climate is convenient for storage, packaging and transportation, limited competition, less incubation period, possibility of organic cultivation, etc. However, people lack awareness about the cultivation of medicinal plants, their scope and importance (Wiersum et al. 2006). Conducting seminars, workshops, field demonstration, exhibitions, etc. by NGOs and small community based organizations as well as government agencies could play an important role in bringing awareness to the native tribal communities in these regions. As more and more native tribes start adopting the cultivation of medicinal herbs, the government must support them with initial finance in the form of grants and loans. The forest rule must be made flexible and more people friendly to promote cultivation. Transit pass must be provided to cultivators of herbal medicines and strict rules must be made to stop illegal extraction of herbal medicines from the wild. Developing agro-technology must be promoted for research. Apart from meeting the demand of herbal medicines, cultivation of the same may help in conserving wild genetic diversity of herbal plants. Uniform material is produced by farming from which standardized products can be obtained consistently. It also provides the advantage of better quality control, species identification and genetic advancement.

Proper and accurate selection of planting material is one of the most important steps. It should be of good quality and rich with active ingredient. It should be resistant to diseases and pests and must have ability to tolerate the stressed environment. Knowledge of monoculture and polyculture is also important in making accurate decision for high yield of product. Continuous research and development must be done in order to get high production. Apart from cultivation area, processing area must also be developed in the nearby regions. These developments will create new economic source for underprivileged high altitude regions. Converting agricultural land into medicinal plant cultivation area is not recommended. However, tribal people can be encouraged to grow medicinal plants in their household garden. Thus, it will help in linking the economic growth of tribal and rural areas with the medicinal plant sector (Mazid et al. 2012). It has become important to secure the farmers economy by allowing them to grow cereals, grains along with medicinal herbs. If by any chance the alternate farming trials fails, then farmers may rely on the cereals for their livelihood (Lithourgidis et al. 2011). The ever rising demand for some specific high value medicinal plants is creating the danger of over-harvesting. Thus, making them more prone to being extinct as most of them have slow growing rate, narrow geographical range and less density in terms of population (McKinney 1997). Factors which affect the medicinal plant sector are: long gestation of some of the medicinal plants, slow growth rate, lacklustre cultivation technology, small quantity of production, inefficient processing technique, unscientific harvesting methods, poor quality control, hampered marketing strategy, etc. (Kala et al. 2006). To overcome these factors, awareness about cultivation, conservation, proper implementation of harvesting, processing, research and development and marketing strategies must be done. Apart from this cultivation of commercially important plants must also be promoted to support economic constraints. It is a known fact that cultivating food grains in the hilly region is not economically friendly. So, it is the need of the hour to immediately diversify ourselves to more economically viable alternatives. Cultivation of wild medicinal plant provides a potential alternative for this (Kremen et al. 2012). On one hand it can serve to save the forests of the high altitude Himalayan region and also it can help to meet the on-going demand of medicinal herbs. The tribal people must adopt the law of comparative advantage according to which the regions which are specialized in producing some specific good at lower rate must adopt to the same rather than opting to produce some other product which can eventually lead to loss. Thus, it is imperative to take the advantage of climatic characteristics of high altitude mountainous region to produce low cost medicinal crops. India has already established itself as a manufacturer of high quality drugs at low cost in the global market. The medicinal plant sector seems to be boon for the growing economy of the country (Mazid et al. 2012).

7.8 Management, Conservation and Prospect of Medicinal Plants

There is a sudden positive drift in the demand of herbal medicines and natural products. This surge has increased our dependence on forests for its natural products (Chivian 2002). But unorganized exploitation has put many of the herbal plants in the danger zone and some of them are even close to extinction. Apart from that excessive deforestation for fuel wood and woods for construction have added additional pressure to the on-going issues. Most of herbs are extracted from destructive harvesting. This aspect needs special attention considering the criticality of the situation as it severely impacts not only the sustainable regeneration process but also the ecological balance of the ecosystem. Most of the people involved in the collection of herbal medicines from wild sources are greedy and do not involve scientific techniques in their methods of harvesting. The forest staffs, research institutions could play an important role in creating awareness by providing scientific information to the collectors on different healthy methods of harvesting wild herbal medicines (Shinwari 2010). The knowledge gained by the local people could play a pivotal role in this regard. The local tribal people mostly who live around the forest knows better about sustainable maintenance of the ecosystem. They are quite familiar with the medicinal plants in their area. This traditional knowledge must be effectively implemented by ecologists, forest officers and policy makes for a sustainable ecological system and wise use of resources simultaneously. Awareness is important because forest product as a wholesome not only add up to the nation economy but also are a reliable source of income for the poor tribal people. Technology based farming must be promoted for more yield and profits. It thus becomes extremely important to involve local people into the forest management system for a more holistic approach in having a sustainable ecological system. A diagrammatic representation of sustainable use of high altitude edible medicinal herbs is shown in Fig. 7.1.

It can be understood from the example that in most of the cases either the rhizome or roots are used from a medicinal plant. So, digging out entire plant has a negative effect on the biomass and regeneration capacity of the wild plants. Uncontrolled and over-grazing has also diminished the forest regions at many places. If such conditions remain persistent, then in the very near future many of the medicinally valuable and economically important plants may get close to extension. For such endangered species of plants propagation and cultivation techniques must be implemented on a priority basis (Schippmann et al. 2002). Knowledge of in situ and ex situ conservation techniques must be passed on to the local people also in order to maintain a valuable and rich biodiversity of that specific region. Thus, mass awareness for economically important medicinal plants and promotion of large scale cultivation in the natural habitat of the species will influence not only the economy output but will also assist in meeting the rising market demand of the herbal plant along with conservation of the species.

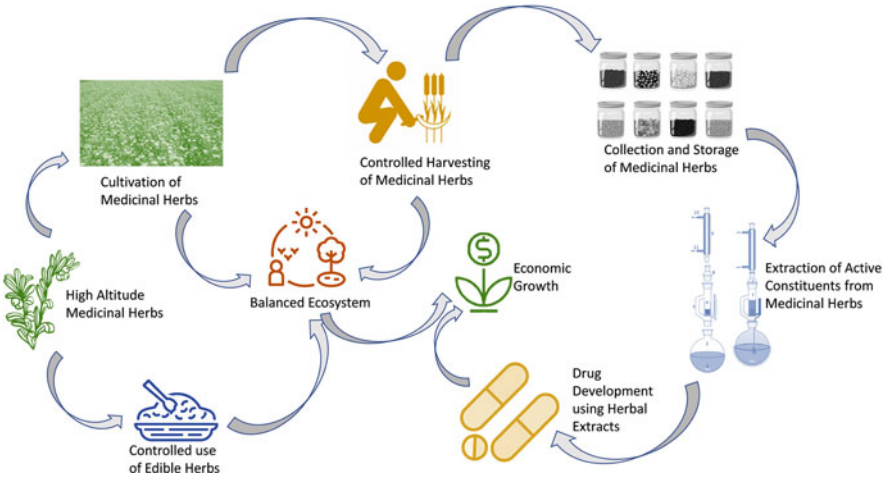

Fig. 7.1 Diagrammatic representation of sustainable use of high altitude edible medicinal plants

7.9 Conclusion

The demand for high altitude medicinal herbs is increasing day by day. Researchers and even common people are moving towards herbal medicines. However, excessive harvesting of high altitude medicinal herbs may cause ecological imbalance or even take some of the plant species on the verge of extension. It becomes important to create awareness among tribal people about scientific methods of cultivation, importance of sustainable ecological system, controlled harvesting, large scale cultivation, new marketing strategies may open new avenues for the income of rural people. Thus, organized and systemic cultivation of high altitude of medicinal plants with efficient procession and marketing strategies may boost up the economy of not only the tribal people but also to the nation's economy.

References

Abbasi AM, Shah MH, Khan MA (2015) Wild edible vegetables of lesser Himalayas. Springer, Cham

Afolayan M, Jimoh F (2009) Nutritional Quality of Some Wild Leafy Vegetables in South Africa. Int J Food Sci Nutr 60(5):424–431

Alamgir AN (2018) Therapeutic use of medicinal plants and their extracts: volume 1. Springer, Cham

Anand N, Comprehensive medicinal chemistry, edited by Hansch C, Sammes PG, Taylor JB, (Pergamon Press, Oxford), (Vol editor Kennewel, PD), 1, 1990, 113–131

Asolkar LV, Kakkar KK, Chakra OJ (1992) Second supplement to glossary of Indian medicinal plants with active principles Part-1 (A-K) 1965–1981. NISC, CSIR, New Delhi, India, pp 265–266

Asolkar LV, Kakkar KK, Chakre OJ (2000) Second Supplement to Glossary of Indian Medicinal Plants with Active Principles. National Institute of Science Communication, New Delhi, pp 116–117
Bengwayan MA (2003) Intellectual and cultural property rights of indigenous and tribal peoples in Asia. Minority Rights Group International, London
Bharucha Z, Pretty J (2010) The roles and values of wild foods in agricultural systems. Philos Trans Royal Soc B Biol Sci 365:2913–2926
Bidve SC, Kadam VB, Malpathak NP (2018) Metabolite profiling and principle component analysis of a mangrove plant Aegiceras corniculatum L (Blanco). Int J Pharm Pharmacol 2:125
CEPF (2005) Ecosystem profile: indo-Burman hotspot. Eastern Himalayan Region. US-Asian Programme/CEPF, WWF-Kathmandu
Chang HM, Yeung HW, Tso WW, Koo A (1985) Advances in Chinese medicinal materials research. World Scientific, Singapore
Chhetri DR. Medicinal plants of the Himalaya: production technology and utilization. Agrobios; 2014
Chivian E (2002) Biodiversity: its importance to human health. Center for Health and the Global Environment, Harvard Medical School, Cambridge, MA
Chopra RN, Chopra IC (1994) Indigenous drugs of India. Academic, New York
Chopra RN, Nayar SL, Chopra IC (2002) Glossary of Indian Medicinal Plants. National Institute of Science and Communication and Information Resources, New Delhi, India, ISBN-10: 81–7236–126-2, pp: 123
Coates P (2013) Nature: Western attitudes since ancient times. Wiley, New York
Dame J, Nusser M (2011) Food security in High Mountain regions: agricultural production and the impact of food subsidies in Ladakh, northern India. Food Security 3:179–194
Despommier D (2010) The vertical farm: feeding the world in the 21st century. Macmillan, London
Dhar U (2002) Conservation implications of plant endemism in high-altitude Himalaya. Curr Sci 82:141–148
Dhar U, Rawal RS, Upreti S (2000) Setting priorities for conservation of medicinal plants-a case study in the Indian Himalaya. J Biol Conserv 95:57–65
Dhawan BN (1997) Biodiversity–a valuable resource for new molecules, in: Himalayan biodiversity: action plan, edited by Dhar U. Gyanodaya Prakashan, Nainital
Dhiman AK (2005) Wild medicinal plants of India (with ethno-medicinal uses). Bishan pal Singh and Mahendra pal Singh, 23-a, New Connaught Place, Dehradun, ISBN: 81-211-0493-9
Effo KE, Djadji ATL, N'Guessan BN et al (2018) Evaluation of the anti-inflammatory activity and Ulcerogenic risk of "Sarenta", an Ivorian herbal preparation. Int J Pharm Pharmacol 2:131
Erdelmeier CA, Koch E, Hoer R (2000) Hypericum perforatum- St Johns wort, Chemical, pharmacological and chemical aspects, In: Atta-ur-Rahman (ed) Studies in Natural Products Chemistry. 22, 643–716
FAO (2012) Economic growth is necessary but not sufficient to accelerate reduction of hunger and malnutrition. Rome 2012:3–35
FAO (2013) The state of food and agriculture. Food Systems for Better Nutrition. Rome, pp. 5–67
Gangwar KK, Joshi BD (2008) Diversity of Medicinal Flora of District Pittoragarh and their uses by the Local Communities. In: Joshi BD, Tripathi CPM, Joshi PC (eds) Biodiversity and Environmental Management. APH Publishing House, New Delhi, India, ISBN-10: 81–313–0440-2, pp: 134–146
Garg A, Vaya RK, Chaturvedi H (2017) Effect of herbal medicine "Diabetocure" on clinical and biochemical parameters of diabetes. Int J Pharm Pharmacol 1:120
George GI, Chen TT, Ojima I, Vyas DM (1995) Taxane: anticancer agents: basic science and current status. American Chemical Society, Washington
Gerhart W (1986) Ullmarin's encyclopedia of industrial chemistry VCH. Weinheim, AS, Verlag 21
Goel HC, Prasad J, Singh S, Sagar RK, Prem Kumar I, Agarwal PK, Sinha AK (2001) Radioprotection by a herbal preparation of Hippophae rhamnoides RH-3, against whole body lethal

irradiation in mice. In: Khosla PK (ed) Singh V. Proc Int workshop Seabuckthorn, New Delhi, pp 205–211
Gurib-Fakim A (2006) Medicinal plants: traditions of yesterday and drugs of tomorrow. Mol Asp Med 27(1):1–93
Hazlett DL, Sawyer NW (1998) Distribution of alkaloid rich plant species in short grass steppe vegetation. Conserv Biol 12:1260–1268
Huang L (1984) Natural products and drug research. Copenhagen. 94
Ianev E, Radev S, Balutsov M, Klouchek E & Popov A (1995) The effect of an extract of seabuckthorn (Hippophae rhamnoides L.) on the healing of experimental skin wounds in rats. Khirurgila Sofila 48(3):30–33
Jahangir MA, Anand C, Muheem A, Gilani SJ et al (2020a) Nano Phytomedicine based delivery system for CNS disease. Curr Drug Metab 1:10. https://doi.org/10.2174/1389200221666200523161003
Jahangir MA, Taleuzzaman M, Beg S et al (2020b) A review of eugenol-based nanomedicine: recent advancements. Curr Bioactive Compound 1:18. https://doi.org/10.2174/1573407216999200525145633
Ju Y, Zhuo J, Liu B, Long C (2013) Eating from the wild: diversity of wild edible plants used by Tibetans in Shangri-la region, Yunnan. China J Ethnobiol Ethnomed 9(1):28
Kala CP (2005) Ethnomedicinal botany of the Apatani in the eastern Himalayan region of India. J Ethnobiol Ethnomed 1(1):11
Kala CP (2009) Medicinal plants conservation and enterprise development. Med Plants Int J Phytomed Relat Indust 1(2):79–95
Kala CP, Dhyani PP, Sajwan BS (2006) Developing the medicinal plants sector in northern India: challenges and opportunities. J Ethnobiol Ethnomed 2(1):32
Kamboj VP (2000) Herbal medicine. Curr Sci 78(1):35–39
Kaul MK (1997) Medicinal plants of Kashmir and Ladakh. Indus Publishing Co, New Delhi
Kaul MK (2010) High altitude botanicals in integrative medicine-case studies from northwest Himalaya
Kaul MK, Bhatia AK, Atal CK (1985) Ethnobotanic studies on north-west and trans Himalaya: contributions to wild plants of Ladakh. J Econ Tax Bot 6(3):523–527
Kaul MK, Katiyar SK, Sharma PK (1990) Nutritive value and medicinal beliefs of some novel wild plants of Gurez valley in Kashmir. Arogya - J Hlth Sci 16:31–134
Kiritikar KR, Basu BD (1994) Indian medicinal plants, 2nd edn. Lolit Mohan Basu, Allahabad, India
Kirtikar KR, Basu BD (1997) Indian medicinal plants Vol I, 2nd edn. Jayyed Press, New Delhi, p 60
Kremen C, Iles A, Bacon C (2012) Diversified farming systems: an agroecological, systems-based alternative to modern industrial agriculture. Ecol Soc. 17(4):75
Krishnamurthy KH (1991) Wealth of Sushruta. International Institute of Ayurveda, Coimbatore
Lebel L, Anderies JM, Campbell B, Folke C, Hatfield-Dodds S, Hughes TP, Wilson J (2006) Governance and the capacity to manage resilience in regional social-ecological systems. Ecol Soc. 11(1):120
Lithourgidis AS, Dordas CA, Damalas CA, Vlachostergios D (2011) Annual intercrops: an alternative pathway for sustainable agriculture. Aust J Crop Sci 5(4):396
Maisin JR (1992) Chemical radioprotection: past, present and future prospects. Int J Rad Biol 73: 443–450
Malik S, Cusidó RM, Mirjalili MH, Moyano E, Palazón J, Bonfill M (2011) Production of the anticancer drug taxol in Taxus baccata suspension cultures: a review. Process Biochem 46(1):23–34
Mazid M, Khan TA, Mohammad F (2012) Medicinal plants of rural India: a review of use by Indian folks. Indo Global J Pharm 2(3):286–304
McKinney ML (1997) Extinction vulnerability and selectivity: combining ecological and paleontological views. Annu Rev Ecol Syst 28(1):495–516

Mhaskar KS, Caius JF (1931) Indian plant remedies used in snake-bites. Indian journal medical research, memoir no. 19. Thacker, Spink and co., Calcutta, India
Moore LG, Niermeyer S, Zamudio S (1998) Human adaptation to high altitude: regional and life-cycle perspectives. Am J Phys Anthropol 107(S27):25–64
Mukhia PK, Tangbi SD, Tshering KD (2006) Will the sale of Illicium griffithii reduce poverty in Aja Nye and Yabrang communities? A series of case studies on communitybased forest and natural resource management in Bhutan. Ministry of Agriculture, Royal Government of Bhutan
Patwardhan B, Vaidya AD, Chorghade M (2004) Ayurveda and natural products drug discovery. Curr Sci:789–799
Pei SJ (1998) Biodiversity conservation in mountain development of Hindu-Kush Himalaya. In: Chou CH, Shao KT (eds) Frontiers in biology, the challenge of biodiversity, biotechnology and sustainable agriculture. Academic Sinica, Taipai
Purohit AN (1997) Medicinal plants: need for upgrading technology for trading and traditions. In: Nautiyal AR, Nautiyal MC, Purohit AN (eds) Harvesting Herbs– 2000. Bishen Singh Mahendra Pal Singh, Dehra Dun, pp 46–76
Rai LK, Prasad P, Sharma E (2000) Conservation threats to some important medicinal plants of the Sikkim Himalaya. Biol Conserv 93(1):27–33
Ray P, Gupta HN (1965) Charaka Samhita. National Institute of Science of India, New Delhi, p 27
Sankawa U (1992) In: Cruz LJ, Conception GP, Mendigo MAS, Guevara BQ (eds) Proc Asian Symp Medicinal Plants. Spices and other Natural Products, University of Philippines, Manila, p 143
Schippmann U, Leaman DJ, Cunningham AB (2002) Impact of cultivation and gathering of medicinal plants on biodiversity: global trends and issues. Biodiversity and the ecosystem approach in agriculture, forestry and fisheries
Sen S, Chakraborty R, De B (2011) Challenges and opportunities in the advancement of herbal medicine: India's position and role in a global context. J Herb Med 1(3–4):67–75
Sharma PK, Singh V (1989) Ethnobotanical studies in north-west and trans Himalaya, V Ethnoveterinary medicines used in Jammu and Kashmir, India. J Ethnopharmacol 27:63–70
Shinwari ZK (2010) Medicinal plants research in Pakistan. J Med Plants Res 4(3):161–176
Shukla GP, Rao K, Haridasan K (1994) Taxus baccata in Arunachal Pradesh. Arunachal Forest News 12(1):1–7
Singha GN (2008) Forest and forestry in Arunachal Pradesh. State Forest Research Institute Information Bulletin 27:1–75
Siwach M, Siwach P, Solanki P, Gill AR (2013) Biodiversity conservation of Himalayan medicinal plants in India: a retrospective analysis for a better vision. Int J Biodivers Conserv 5(9):529–540
Sreedevi P, Ijinu TP, Anzar S, Bincy AJ, George V, Rajasekharan S, Pushpangadan P (2013) Ethnobiology, ethnobotany, ethnomedicine and traditional knowledge with special reference to India. Ann Phytomedicine Int J 2:4–12
Suffness M (1995) Taxol, science and applications. CRC Press, Boca Raton
Tag H, Tsering J (2012) Ethnobotanical Study and Nutritional Analysis on Middle and High Altitude Wild Edible Flora of West Kameng and Tawang Sector of Arunachal Pradesh for Defence Food Security. Technical Report, DRL, Defence Research Laboratory, Defence R&D Organization, Ministry of Defence, Post Bag No.2, Tezpur-Assam784001 (India), pp. 3-98
Takhtajan M (1969) Flowering plants: origin and dispersal. Oliver & Body, Edinburgh
Tiwari L, Pande PC (2010) Ethnoveterinary medicines in Indian perspective: reference to Uttarakhand, Himalaya
Tiwari JK, Ballabha R, Tiwari P (2010) Some promising wild edible plants of Srinagar and its adjacent area in alaknanda valley of garhwal Himalaya. India J Am Sci 6:167–174
Uniyal SK, Singh KN, Jamwal P, Lal B (2006) Traditional use of medicinal plants among the tribal communities of Chhota Bhangal, Western Himalaya. J Ethnobiol Ethnomed 2:12. https://doi.org/10.1186/1746-4269-2-14

Vaidya AD (1996) Therapeutic potential of medicinal plants: a global perspective. In: Handa SS, Kaul MK (eds) Supplement to cultivations & utilization of medicinal plants. National Institute of science communication, CSIR, New Delhi, pp 1–12

Ved DK, Anjana M, Shanker D (1998) Regulating export of endangered medicinal plant species-need for scientific rigour. Curr Sci 75:341–344

Wiersum KF, Dold AP, Husselman M, Cocks M (2006) Cultivation of medicinal plants as a tool for biodiversity conservation and poverty alleviation in the Amatola region. South Africa Frontis:43–57

Wilson P, Buopane M, Allison TD (1996) Reproductive biology of the monoecious clonal shrub Taxus canadensis. Bull Torrey Bot Club 123(1):7–15

WWF, ICIMOD (2001) Ecoregion-based conservation in the Eastern Himalaya: identifying important areas for biodiversity conservation. Kathmandu: WWF-Nepal

Xiao PG (1981) In: Beal JL, Reinhard E (eds) Natural products as medicinal agents. Hippokrates, Stuttgart, p 351

Yang XQ, Kushwaha SP, Saran S, Xu J, Roy PS (2013) Maxent modeling for predicting the potential distribution of medicinal plant, Justicia adhatoda L. in lesser Himalayan foothills. Ecol Eng 51:83–87