Defence Life Science Journal, Vol. 2, No. 1, January 2017, pp. 37-45, DOI : 10.14429/dlsj.2.11107

Medicinal Plant Growing under Sub-optimal Conditions in trans-Himalaya Region at High Altitude

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ABSTRACT

Supporting people's culture, income and healthcare, medicinal plants are of a great importance in Himalayas. Trading these herbal formulations worldwide is earning billions. But since the demand of such splendid plant and plant products has tremendously hiked in past two decades, and because of the unstable environmental changes due to global warming and industrialisation, these significant species are in threat of extinction. To preserve these treasures, several technical steps have been adopted by the government. A successful establishment of plants sector will raise rural empowerment, boost international commerce and contribute to health of millions worldwide. Alongside highlighting the major medicinal plant species and their uses, this review also foregrounds traditional medicinal practitioners, regions of trans-Himalayas rich in medicinal plants, major threats to these plants, significant biomolecules and detection techniques, threats to these plants, and government bodies and their responsibilities for their conservation.

Keywords: Amchi; Bio-diverse; Agronomist; Enthobotanist; Horticulturist; Plant pathologist; Taxonomist

1. INTRODUCTION

Medicinal plants have acquired immense popularity worldwide, resulting in a tremendous hike in consumption of herbal medicines. India, particularly the trans-Himalayan region, a habitat to thousands of useful medicinal plant species, has been a major part of India's rich medicinal plant heritage. Physical features of these high altitude cold deserts include coarse and porous sandy soil prone to wind and water erosion; dense influx of ultraviolet and infrared radiations; lower oxygen levels; low atmospheric carbon dioxide; short cultivation seasons; prolonged freezing winters; temperature variations from 40 °C to - 40 °C; low relative humidity and negligible rainfall. Therefore, only those plant species which have adopted to adjust in such harsh climatic conditions can grow in these areas. Sikkim is reported to inherit nearly 424 species of medicinal plants, used in Ayurveda, Homeopathy, Siddha, Amchi, Unani and other folk medicines. With about 4,000 species and around 40,000 herbal formulations, 12 per cent of world's medicinal plant requirement is supplied by India, 90 per cent of which are found in forest habitats[1]. With growing demand for plant based medicines, health products, pharmaceuticals, food supplements, cosmetics etc. in the national and international markets[2]. The urge to alternate artificial antioxidants like butyl hydroxyl toluene, butyl hydroxyl anisole, gallic acid, etc. with naturally occurring antioxidants has increased because of the several negative health consequences[3]. Treeline ecotones are the transition zones between adjacent subalpine forest and open alpine tundra[4]. Shrestha[5], *et al.*, investigated the treeline dynamics of two environmentally contrasting areas of Himalayas in Nepal and discovered that in spite of varying climate, environment, tree species and seasonal climate changes, the treeline dynamics were similar. A team of experts including agronomists (improved cultivation technology), conservation campaigners (sway public for conservation), ecologist (plant growth ecosystem), enthobotanist (identification of plant), health policy-maker (includes conservation and utilisation of plants in policy and planning), horticulturist (cultivation of medicinal plant), legal experts (effective legal mechanism to ensure collection sustainable medicinal plants), park manager (conservation of plants within park and reserve vicinity), park planner (maintaining maximum diversity of medicinal plants in the park and reserve), pharmacogenosist (application of medicinal plants), plant breeder (breed improved strains of medicinal plants), plant genetic resource specialist (assessing and mapping of genetic variation in medicinal plants and maintenance of seed banks), plant pathologist (protection of cultivated medicinal plants from pests and diseases), religious leader (promotion of respect for nature), resource economist (evaluation of patterns of used and economic value of medicinal plants), seed biologist (germination and storage requirement of seeds), taxonomist (accurate identification of plant) and traditional health practitioner (informs about the use and availability of medicinal plants)[6,7].

Received : 19 January 2017, Revised : 08 February 2017
Accepted : 13 February 2017, Online published : 28 March 2017

2. TRADITIONAL MEDICINE PRACTITIONERS

Indians have traditional knowledge of these plants and the local denizens use various herbal remedies for treatment of a vast variety of diseases. Since physicians are not easily approachable for populations of remote and village areas, they prefer to visit the traditional health practitioners who use herbal preparations for ailments and to conserve these beneficial species, local inhabitants cultivate these plants. 'Amchis' in Tibet are skilled traditional medicine practitioners with good knowledge of biology, ecology and herbal formulations. Amchi medicines have 80 per cent of plant origin substances. These are based on Jung-wa-Lna (five elements) and Nespa-gsum (three humours) theories[8]. 'Amchis' in Tibetan language means 'superior to all'. They have developed three methods for examining the patients: inspection, palpitation (by examining the pulse-rate) and interrogation. The treatment techniques include 'moxibustion and puncturing the veins' (generally for skin and blood disorders); 'cold and hot water bath' (generally for backache and sciatica). Amchis have their own specific 'medical formulations', generally made with combination of plant parts from several species. The end product is generally in form of powder, paste, tablet, decoction or ointment. 'Minerals' and stones, in combination with animal and plant parts are used for ailments. Rock extract 'Shilajit' is used individually. Other minerals used are sulphur, borax, sodium sulphate, antimony sulphate, sodium bicarbonate, antimony sulphate, sodium bicarbonate, yellow arsenic, serpentine, quartz. Amchi associations like the Traditional Medico-Cultural Association and the Yuthog Foundation deal with the preservation and promotion of Tibetan medicines. There is a Tibetan Medical Centre in Darjeeling, Higher Tibetan Studies in Sarnath, TMAI in Dharamshala (established by His Holiness, the 14th Dalai Lama in exile)[9].

3. REGIONS OF TRANS-HIMALAYAS RICH IN MEDICINAL PLANTS

3.1 Ladakh, Kashmir

The highest geographical region in the trans-Himalayan region of India, Ladakh, the land of high rising passes, is located in the state of Jammu and Kashmir (32°15' - 36°N; 75°15'80°15'E). Ladakh is popularly known for its rich vegetation, medicinal flora and endemic diversity. Consumption of medicinal plants has increased worldwide, so the medicinal plants of Ladakh open approaches of economic growth in the aggressing world market. Some important species from Ladakh region are *Saussurea lappa*, *Inula racemosa*, *Oxytropis chiliophylla*, *Picrorhiza kurrooa*, *Rubia cordifolia*, *Aconitum violaceum*, *Hippophae rhamnoides*, *Hypecoum leptocarpum*, *Rheum spiciforme*, *Rhododendron* sp., *Carum curvi* and *Hyoscymus niger*. Several conservation techniques are being employed for the conservation and cultivation of these marvellous species. Vegetative propagation through root divisions, tubers, division of bulbs, rhizome cuttings, tuber division, root cuttings, rootstocks, sucker cutting, stem cutting etc. is adopted for improved results[2]. Few other important plant species like *Desideria pumila*, *Ladakiella klimesii*, *Stellaria decumbens* and *Waldheimia tridactylites* are also capable of surviving in extreme climate and environment of Ladakh. Exploiting these species, Dvorsky[9], *et al.*, were able to conclude that vascular plants in these regions are able to maintain elevation limits, and are capable of continuing under adverse conditions and propagation limitations. Also known as 'Rhubabr', *Rheum webbianum* Royale, is also an important medicinal plant containing ample amounts of free anthraquinones, stilbene glycosides, tannins, sennosides, catechins, gallic acid, cinnaminic acid etc. These compounds make the plant an expert cure of health problems like indigestion, abdominal diseases, boils, wounds, flatulence, gastritis and cancer[12].

3.2 Spiti, Kashmir

Arnebia euchroma found in Spiti cold deserts in western Himalayas is an important medicinal plant species. It cures body aches, has antimicrobial activities and possesses anti-HIV properties[13]. Damianakos[14], *et al.*, isolated nine isohexenylnaphthazarins from the n-hexane extracts from callus and suspension culture of *Arnebia euchroma*. These were deoxylkannin, alkannin, acetylkannin, isobutyrylalkannin, β-hydroxyisovalerylalkannin, 2''-(S)-α-methylbutyrylalkannnin, propionylalkannin, teracrylalkannin and acetylshikonin; and their structures were determined by MS and NMR spectroscopy.

3.3 Mustang, Nepal

Mustang district, located in the trans-Himalayan Arid Zone, covers 3,639 sq. Km, has vegetation of mixed forest and grasslands. Around 90 per cent of Nepal's population reside in rural areas with deficient health care facilities, one physician/6500 people. So the residents rely on traditional, herbal formulation medicines. Traditional practitioners in Nepal have vast knowledge of medicinal plants and people preserve these plants in home gardens. The major medicinal plant species are *Alliaceae*, *Amarnathaceae*, *Apiaceae*, *Araceae*, *Asparagaceae*, *Asteraceae*, *Berberidaceae*, *Betulaceae*, *Bignoniaceae*, *Boraginaceae*, *Cannabaceae*, *Caprifoliaceae*, *Chenopodiaceae*, *Convolvulaceae*, *Crassulaceae*, *Cupressaceae*, *Elegnaceae*, *Ephedraceae*, *Ericaceae*, *Fabaceae*, *Gentianaceae*, *Juglandaceae*, *Lamiaceae* and *Liliaceae*. With more than 80 per cent people relying on herbal medicines in developing countries, the thousands of medicinal plant species in Upper Mustang, Himalayas, add to its treasures in health sector. Pandey[17], has enlisted a wide range of plant species from Tibet and Nepal regions, which serve wonderfully to cure health problems like wound healing, cough, cold, fever, gastritis, skin problems, bone diseases, menstrual disorders, as antiseptics, eye problems, tooth decay, body aches, tumors, hypertension, kidney problems, food poisoning, anaemia, liver problems, asthma, sinusitis, oral diseases, blood pressure, dysentery, indigestion, diarrhea, rheumatism etc. Major medicinal plant families from Mustang are *Amaryllidaceae*, *Araceae*, *Berberidaceae*, *Betulaceae*, *Bignoniaceae*, *Boraginaceae*, *Caprifoliaceae*, *Chenopodiaceae*, *Compositae*, *Cupressaceae*, *Dipsacaceae*, *Elaeagnaceae*, *Ephedraceae*, *Ericaceae*, *Gentianaceae*, *Geraniaceae*, *Hypocreaceae*, *Labiateae*, *Leguminosae*, *Liliaceae*, *Malvaceae*, *Orchidaceae*, *Papaveraceae*, *Plantagiaceae*, *Polygonaceae*, *Primulaceae*,

Ranunculaceae, *Rosaceae*, *Salicaceae*, *Scrophulariaceae*, *Solanaceae*, *Thymalaeaceae*, *Umberlliferae*, *Valerianaceae* and *Violaceae*[15]. Rich in biodiversity, Mustang is very well known for timber plantation. This trans-Himalayan region is a unique ethno-ecological area of Nepal, and is enriched with non-timber plantations also, including food, spices, medicines etc. raising popularity of natural resins, dyes, handicrafts, food etc. and providing raw material for such industries, these non-timber forest products (NTFPs) have drawn attention of various multinational companies. Important medicinal plants like *Cordyceps sinensis*, *Arnebia benthamii*, *Thymus linearis*, *Polygonatum cirrhifolium* and *Allium fasciculatum* have drawn attention of national and multinational pharmacists[16]. But such NTFPs have to tackle other situations also. With highly distinguishing and unsure affects of global changes, small-scale farmers in the diverse Himalayan region depend on flexibility to adapt agricultural production to uncertain production conditions. The rising temperature and changing patterns of precipitation, combined with high and volatile food prices in international markets, these small scale farmers get bound to adapt new practices. Defining this 'flexibility' as 'uncommitted potential for change', Homelin & Aase[16], have argues that farming system flexibility may be analysed in terms of the three aspects: flexibility of scope, flexibility of type and temporal flexibility.

4. BIOMOLECULES AND THEIR DETECTION

Significant pharmaceutical compounds from the plants are morphine (first pure medicinal substance from plants), diosgenin, aspirin (now mostly prepared synthetically), alkaloids, polyphenols, glycosides, terpenes[7]. Good sources of natural antioxidants are stems, leaves, barks and/or other parts of the plants *Saussaria lappa*, *Rheum webbanium*, *Arnebia euchroma*, *Inula racemosa*. With major content constunolide dehydrocostus, *Saussaria lappa* is used as an anti-ulcer and anti-carcinogenesis agent. Ample sources of drugs rhein, emodin and rutin are present in the roots of *Rheum webbanium*, serve as laxative, tonic and purgative. *Arnebia euchroma* have anti-inflammatory, antimicrobial and anti-tumor activities. *Inula racemosa* plant parts are utilised for severe health problems like hyperglycaemia, hypercholesterolemia, cough, dyspnea, asthma, pleurisy, tuberculosis and cordial pain. Tiga[3], *et al*. employed techniques like DPPH assay, ABTS diammonium salt assay, FRAP (ferric reducing antioxidant power), TPC (total phenol content) to show ample amounts of phenol, flavonoids, flavonols and proanthocyanidin contents and exhibit antioxidant activities. Dhar[18], *et. al.* has estimated the nutritive values, vitamin content, amino acid composition, fatty acid content and mineral profile of three plants *Hippophae rhamnoides* (seabuckthorn), *Prunus aemeniaca* (apricot) and *Rhodiola imbicata* (roseroot). They used all the latest techniques. RRLC-MS/MS (rapid resolution liquid chromatography/tandem mass spectrometry) for analysis of free vitamin forms; RP-HPLC (reversed phased high performance liquid chromatography) with pre-column derivatisation for identification and quantification of amino acids; GC-FID (as chromatography coupled with a flame ionisation detector) with fatty acid methyl esters derivatisation, to quantify fatty acids; ICP-OES (Inductively coupled plasma optical emission spectrometer) for mineral profiling.

5. THREATS

But unfortunately, these treasuries are facing various threats. A major decline in the population and availability of medicinal and aromatic plants has been noted, which may be because of the climatic changes, high demand but low production, fast pace of tourism in high altitude areas damaging this bio-diverse ecological system[20]. Banerji and Basu[20], have highlighted some major threats to the endangered species. There are habitat degradation and impacts of climate change; high demand levels and unsustainable extraction for herb trade; endangerment of species; impacts on host communities; lack of R&D and policy neglect; lack of protection and conservation.

6. GOVERNMENT INITIATIVES FOR PRESERVATION OF MEDICINAL PLANTS

Along with providing natural healing these plants also provide employment to the populations of these remote areas. Therefore state government also has introduced the several programmes for medicinal plants[1]:

- The 'State Medicinal Plants Board' established in June 2002, creates herbal gardens, and registers medicinal plants' farmers, collectors, traders and manufacturers.
- The 'Forest Development Agency' looks after the plantation of medicinal plants.
- The 'Integrated Watershed Development Project' encourages employment propagation in the rural areas.

The STNM hospital, Gangtok, The Sikkim Manipal Institute of Medical Sciences and Central Referral Hospital, Department of health, Department of Horticulture and Department of Science and Technology are among the major bodies which have played significant roles in research initiatives in the medicinal plant sector, in these areas. Along with the latest research programmes on these herbal treasures, these institutes also avail the former traditional health practitioners for the local populations[1]. Research collaborations of areas rich in these useful medicinal species with government research bodies like CSIR, DBT etc. has proved beneficial for in-situ preservation and propagation of these species through optimised protocols. Also, the certification, preservation and knowledge of these useful plant species are crucial. The National Gene Bank is primarily responsible for the conservation of unique accession on long-term basis, as base collections for posterity, predominantly in the form of seed[15]. The Ministry of Environment, Forests and Climate Change, Govt. of India has ongoing projects for collection of oil crops, pulse and medicinal plant material for enrichment of Botanical Gallery; Micropropagation, phytochemical screening of medicinal plants and molecular characterisation of selected species; inventory of ethno-medicinally important plant at West Kameng; Medicinal and edible mushroom cultivation for income generation in rural areas of Uttrakhand; Studies on diseases of economically important medicinal plants of Assam through organic approach; Survey and mapping of Ashtavarga group of medicinal plants in HP; 'National Medicinal Plants Board' funded projects in Shimla; A training programme titled 'Cultivation of High

Valued Temperate Medicinal Plants and related Issues' in Himalayan Forest Research Institute, Shimla; Development of Agro-techniques for organic cultivation of *Tribulus terrestris* L. and *Cissus quadrangularis* L. medicinal plants[22]. Defence Institute of Higher Altitude Research (DIHAR), Leh has an herbal garden where they have standardised the methods seed germination trials and root cutting for the propagation of *Rheum webbianum* Royale[12]. By providing training and support in cultivation of medicinal plants, The Mountain Institute (TMI), Nepal, increased the income of over 12,500 farmers. TMI established nurseries to plant millions of seed of native tree and fodder species over 500 hectares forestland and meadows, which resulted in a hike in population of medicinal plants by upto 80 per cent, and these wild species have also been preserved[23]. A collaborated set of three projects in India, and on each in Nepal, China and Pakistan, were launched under 'Plant Conservation and Livelihoods Programme', with initial emphasis on medicinal plants, funded for 'Plantlife' from the 'Allachy Trust'. Objectives of the project were to collect and consider the information on medicinal plants, their habitat and threats; Conservation of the existing plant species in Himalayan regions; Identification and maintenance of important plant areas; and Future progress and initiative technologies for conservation of the species and important plant areas. Another part of the project was to overcome some common threat problems faced in Himalayas, viz., habitat loss by extremely harsh climatic conditions, climate change, deforestation, habitat fragmentation, burning, overgrasing and unsustainable harvesting. Below mentioned organisations have also been in a regular action for the conservation of the important medicinal plant species in Himalayas[24]:

- ANSAB: The Asia Network for Sustainable Agriculture and Bioresources is active since 1922 and has followed an enterprise oriented approach for conservation of medicinal plants.
- Dabur, Nepal: A part of an international company, Dabur conducts domestication of medicinal plants for commercial cultivation by maintaining a large nursery in Kathmandu.
- ESON, Rasuwa: Funded by an Allachy Award from Plantlife International, it is a community-based conservation project on medicinal plants, near Langtang National Park.
- HNCC/DPR, Nepal: The Herbal and NTFP Coordination Committee, Development or Plant Resources, is responsible for conservation of medicinal plants and other non-timber forest products in Nepal.
- ICIMOD, Kathmandu: The International Centre for Integrated Mountain Development conserves the Himalayas and hosts Medicinal and Aromatic Plants Programme in Asia.
- IAAS, Chitwan: The Institute of Agriculture and Animal Sciences runs 3 courses on medicinal plants and has several related research and development activities.
- Tribhuvan University: In collaboration with ESON, they compile database on medicinal plants.
- The World Conservation Unit (IUCN): It works with several communities in Nepal to elicit the conservation awareness and sustainable use of NTFPs, including medicinal plants.

7. FUTURE ASPECTS

Such research organisations, when coupled with few more specialised modes can bring out even better results. These can be proper maintenance of gene banks, seed banks, proper documentation; extensive network system in every state for effective dissemination and documentation of information; organised central pool of information by corroborating several medicinal plant conservation activities and their consequences; micropropagation parks employing local people. Rising demands, creating heavy pressure on some selected high-value medicinal plants, increasing rarity, relatively low cultivation, bio-piracy add to the challenges faced by medicinal plants sector[25].

REFERENCES

1. Medicinal plant resources. *In* State of Environment. Sikkim Forest Government, India, 2007. pp. 61-67.
2. Kumar, G.P.; kumar, R.; Chaurasia O.P. & Singh, S.B. Current status and potential prospects of medicinal plant sector in trans-Himalayan Ladakh. *J. Med. Plant. Res*., 2011, **5**(14), 2929-2940.
3. Tiga, S.; Sarangi, P.P.; Chaurasia O.P. & Kumar, B. Antioxidant potential of selected medicinal plants of trans-Himalayan region. *Int. J. Sci. Res*., 2016, **5**(5), 1123-1128.
4. Zeng Yu. Modeling complex dynamics at alpine treeline ecotones. University of Lowa, 2010. (PhD Thesis)
5. Shrestha, K.B.; Hofgaard, A. & Vandvik, V. Recent treeline dynamics are similar between dry and mesic areas of Nepal, central Himalaya. *J. Plant Ecology*, 2014. doi: 10.1093/jpe/rtu035.
6. India's fourth national report to the convention on biological diversity. Edited by Goyal, A.K. & Arora, S. Ministry of Environment and Forest, Govt. of India, New Delhi, 2009.
7. Gopal, N.M.; Tejaswini, J.; Mantry, S. & Kumar, S.A. International standards of medicinal plants. *International J. Innovative Pharmaceutical Sci. Res.*, 2014, **2**(10), pp. 2498-2532.
8. Chaurasia, O.P.; Khatoon, N. & Singh S.B. Field Guide-Floral Diversity of Ladakh. DIHAR, Leh. Ministry of Defence, Govt. of India. 2008.
9. Kala, C.P. Health traditions of Buddhist community and role of amchis in trans-Himalayan region of India. *Current Science*, 2005, **89**(5), pp. 1331-1338.
10. Dvorsky, M.; Chlumska, Z.; Altman, J.; Capkova, K.; Rehakova, K.; Macek, M.; Kopecky, M.; Liancourt, P. & Dolezal, J. Gardening in the zone of death: an experimental assessment of the absolute elevation limit of vascular plants. *Nature*: Scientific Reports, 2016, **6**:24440. doi:10.1038/srep24440.
11. Tayade, A.; Dhar, P.; Ballabh, B.; Kumar, R.; Chaurasia, O.P.; Bhatt, R., P. & Srivastava, R.B. *Rheum webbianum* Royale: A potential medicinal plant from trans-Himalayan cold desserts of Ladakh, India. *Plant Archives*, 2012,

12(2), 603606.
12. Singh, K.N.; Lal, B.; Chand, G. & Todaria, N.P. Ecological features and conservation of *Arnebia euchroma*-A critically endangered medicinal plant in western Himalaya. *Int. J. Conserv. Sci*., 2012, **3**(3), 189-198.
13. Damianakos, H.; Kretschmer, N.; Baranek, K.S.; Pietrosiuk, A.; Bauer, R. & Chinou, I. Antimicrobial and cytotoxic isohexanylnaphthazarins from *Arnebia euchroma* (Royle) Jonst. (Boraginaceae) callus and cell suspension culture. *Molecules*, 2012, **17**, 14310-14322. doi: 10.3390/molecules171214310
14. Bhattarai, S.; Chaudhary R.P.; Quave C.L. & Taylor R.S.L. The use of medicinal plants in the trans-Himalayan arid zone of Mustang district, Nepal. *J. Ethnobiology Ethnomedicine*, 2010, **6**(14). doi: 10.1186/1746-4269-6-14
15. Chhetri, H.B. & Gupta, V.N.P. A survey of non-timber forest products (NTFPs) in upper Mustang. *Scientific World*, 2007, **5**(5), pp. 89-94.
16. Holmelin, N. & Aase, T.H. Flexibility of scope, type and temporality in Mustang, Nepal. Opportunities for adaptation in a farming system facing climatic and market uncertainty. *Sustainability*, 2013, **5**, 387-1405. doi: 10.3390/su5041387
17. Pandey, M.R. Use of plants in traditional Tibetan therapy system in upper Mustang, Nepal. *Our Nature*, 2006, **4**, 69-82.
18. Dhar, P.; Tayade, A.B.; KumarJ.; Chaurasia, O.P.; Srivastava, R.B. & Singh, S.B. Nutritional profile of phytococktail from trans-Himalayan plants. *Plos One*, 2013, **8**(12). doi: 10.1371/journal.pone.0083008
19. Sharma, P.K.; Thakur, S.K.; Manuja, S.; Rana, R.K.; Kumar, P.; Sharma, S.; Chand, J.; Singh, A. & Katoch, K.K. Observations on traditional phytotherapy among the inhabitants of Lahaul valley through Amchi system of medicine- A cold desert area of Himachal Pradesh in north western Himalayas, India. *Chinese Medicine*, 2011, **2**, 93-102. doi: 10.4236/cm.2011.23016
20. Banerji, G. & Basu, S. Sustainable management of the herbal wealth of the Himalayas: prioritising biodiversity for conservation and development. Pre-Congress workshop of 1st Indian Forest Congress. Pragya, India (www.pragya.org), August 2011.
21. Annual Report 2014-2015, Ministry of Environment, Forests and Climate Change. Govt. of India. Environment Annual Report Eng.
22. Klatzel, F. Conserving the Sacred Himalayan Landscape. The Mountain Institute, Nepal. Himalayan Program, 2011. 2011.
23. Identification and conservation of important plant areas for medicinal plants in the Himalaya. Ethnobotanical Society of Nepal. Kathmandu, Nepal. Plantlife International-The Wild Plant Conservation Charity, UK. March, 2007. ISBN: 1 904749-70-4.
24. Kala, C.P.; Dhyani, P.P. & Sajwan, B.S. Developing the medicinal plants sector in northern India: challenges and opportunities. *J. Ethnobiology Ethnomedicine*, 2006, **2**(32).
25. Siwach, M.; Siwach, P.; Solanki, P. & Gill, A.R. Biodiversity conservation of Himalayan medicinal plants in India: A retrospective analysis for a better vision. *Int. J. Biodiversity Conservation*, 2013, **5**(9), pp 529-540.

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Appendix-A

Medicinal plants in trans-Himalayan regions used by traditional health practitioners[1,8]

Medicinal Plant Species	Used in
Acantholimon lycopodioides	Cardiac disorders
Achillea millefolium	Cough and cold, toothache
Aconitum heterophyllum	Rheumatism fever, body pain, antipyretic
Aconitum violaceum	Antipyretic, fever
Aconogonum tortuosum	Abdominal pain
Actinocarya tibetica	Fever
Allium carolinianum	Indigestion
Aesculus indica	Mumps
Alstonis scholaris	Diabetes
Anaphalis busua	Cold and cough
Anaphalis cuneifolia	Skin disease
Anaphalis triplinervis var monocephala	Chronic diseases
Anaphalis triplinervis var intermedia	Skin disease, genital problems
Androsace rotundifolia	Tonic
Androsace villosa	Tonic
Anemone rivularis	Indigestion
Anemone rupicola	Stomach problems
Aquilegia fragrans	Anti-scorbutic, diuretic and diaphoretic
Arabidopsis multiflorum	Diarrhoea
Arabis glandulosa	Abdominal pain
Arctium lappa	Diuretic, depurgative and lung diseases
Arenaria bryophylla	Kidney problems
Arenaria griffithii	Menstrual problems
Arnebia euchroma	Hair tonic and blood purification
Arnebia guttata	Hair tonic and blood purification
Artemisia annua	Anti-malaria
Artemisia biennis	Obesity, stomach problems
Artemisia brevifolia	Anti-worm, stomach problems
Artemisia desertorum	Intestinal problems
Artemisia dracunculus	Diuretic, toothache
Artemisia gmelinii	Cold and cough
Artemisia laciniata	Toothache
Artemisia salsoloides	Intestinal complaints
Artemisia scoparia	Intestinal problems
Artemisia sieversiana	Antimicrobial, intestinal worms
Artemisia starcheyi	Toothache
Artemisia tournefortiana	Intestinal worms
Asperugo procumbens	Stomach problems
Asperula oppositifolia	Tonic
Aster flaccidus	Cough and cold
Astragalus multiceps	Colic problems
Astragalus rhizanthus	Skin disease
Astragalus strictus	Diuretic
Astragalus tribulifolius	Diuretic
Berberis ulicina	Tonic
Bergenia ciliata	Oral inflammation, infection, diarrhea
Bergenia stracheyi	Tonic, kidney problems
Biebersteinia odora	Antiseptic, skin sores
Capparis spinosa	Rheumatism, liver problems
Capsella bursa-pastoris	Stomach problems, lung problems
Carum carvi var. gracile	Carminative, digestive, febrifuge
Centaurea depressa	Fever
Cerastium cerastioides	Headache
Chaerophyllum reflaxum	Stomach problems
Chenopodium botrys	Laxative, stomach problems
Chrysanthemum griffithii	Menses regulation
Chrysanthemum purethoides	Fever, rheumatics
Chrysanthemum tibeticum	Antiseptic
Cicer microphyllum	Adaptogenic
Cirsium wallichii	Stomach problems
Citrus sp.	Worms in children
Clematis tibetana	Indigestion
Codonopsis clematidea	Rheumatism, stimulant
Codonopsis ovata	Rheumatism, stimulant
Colchicum luteum	Colchicines and gout
Corispermum hyssopifolium	Kidney problems
Corydalis cashmeriana	Anti-periodic, diuretic
Corydalis crassissima	Lung problems
Corydalis flabellata	Skin disease
Corydalis govaniana	Anti-pyretic, diuretic
Corydalis meifolia	Diuretic
Corydalis thyrsiflora	Skin disease
Cousinia falconeri	Diuretic
Cousinia thomsoni	Diuretic
Cremanthodium ellisii	Contagious disease, fever
Cremanthodium reniforme	Contagious disease, fever
Crepis flexuosa	Muscle pain
Cuscuta approximata	Sin disease
Cuscuta capitata	Kidney problems
Cuscuta europaea	Kidney problems
Cuscuta gigantea	Antiseptic
Cuscuta reflexa	Purgative, warts
Curcuma zedoaria	Jaundice

Medicinal Plant Species	Used in
Cynoglossum wallichii	Vomiting
Dactylorhiza hatagirea	Energetic, health tonic, nervine tonic
Delphinium brunonianum	Colic, insecticidal
Delphinium cashmerianum	Colic, insecticidal
Dianthus anatolicus	Stomach problems
Dianthus deltoides	Stomach problems
Dianthus jacquemontii	Stomach problems
Draba tibetica	Tonic
Dracocephalum heretophyllum	Cold and cough
Dracocephalum moldavicum	Intestinal problems
Dracocephalum stamineum	Cold and cough
Dipazium polypodioides	Dysentery
Echinops cornigerus	Septic wounds
Ephedra gerardiana	Asthma, hepatic disease
Ephedra intermedia	Asthma
Epipactis helleborine	Blood purification
Erigeron alpinus	Cold and cough
Ermania albiflora	Fever
Ermania lanuginosa	Diuretic, purgative
Euphorbia hispida	Skin eruption
Euphorbia stracheyi	Boils
Euphrasia laxa	Eye complaints
Euphrasia officinalis	Eye complaints
Euphrasia vulgaris	Eye complaints
Ferula jaeschkeana	Rheumatics, septic wounds
Galium aparine	Urinary complains
Galium pauciflorum	Intestinal problems
Galium serpylloides	Diuretic, purgative
Gentiana algida	Analgesic, bronchitis
Gentiana aquatica	Health tonic
Gentiana carinata	Stomach complains
Gentiana humilis	Fever
Gentiana squarrosa	Diuretic
Gentiana starcheyi	Tonic
Gentianella moorcroftiana	Febrifuge
Gentianella paludosa	Febrifuge, tonic
Geranium collinum	Stomach problems
Geranium pratense	Analgesic
Geranium sibiricum	Dysentry
Geranium tuberaria	Kidney problems
Geum eletum	Health tonic
Gnaphalium stewartii	Skin disease
Goodyera repens	Health tonic
Gypsophyla cerastioides	Cold and cough
Hackelia uncinata	Cough and cold
Halenia elliptica	Stomach problems
Halerpestis tricuspis	Stomach ache
Heracleum lanatum	Leucoderma, menses regulation
Heracleum pinnatum	Leucoderma, menses regulation
Herminium monorchis	Health tonic
Hippophae rhamnoides ssp. turkestaica	Source of multi-vitamins, carotenoids, anti-oxidants
Hippophae tibetana	Source of multi-vitamins, carotenoids, anti-oxidants
Hippuris vulgaris	Antiseptic, febrifuge
Humulus lupulus	Nervine tonic, sedative effect
Hyoscyamus niger	Asthma, toothache
Hyoscyamus pusillus	Asthma, toothache
Hypecoum leptocarpum	Septic wounds
Hypericum perforatum	Sciatic neuralgia
Inula falconeri	Sprains
Inula obtusifolia	Internal wounds
Inula racemosa	Anthelmintic, bronchial asthma, expectorant
Inula rhizocephala var. rhizophaloides	Cough, chest pains
Inula royleana	Dermatitis
Juniperus communis	Purgative, anti-inflammatory
Juniperus macropoda	Purgative, anti-inflammatory
Juniperus recurva	Purgative, anti-inflammatory
Jurinea ceratocarpa	Bronchitis
Jurinea macrocephala	Stimulant, fever
Lactuca lessertiana	Skin diseases
Lancea tibetica	Tonic, wound healing
Leontopodium leontopodium	Septic wounds
Leontopodium nanum	Septic wounds
Linum perenne	Emollient, expectorant
Lloydia serotina	Blood purification
Lomatogonium rotatum	Fever
Lonicera spinosa	Asthma, headache
Lychnis himalayensis	Cold and cough
Lychnis nutans	Dysentery
Lycopsis arvensis	Tonic
Malva verticillata	Liver tonic
Mattiastrum thomsonii	DIuretic
Meconopsis aculeate	Ulcer, liver, lung problems
Medicago lupulina	Cough, lung disorders
Mentha longifolia	Headache, stomach ache
Mesua ferrea	Inflammation and septic condition
Microula tibetica	Pulmonary disorders
Minuartia kashmirica	Liver tonic
Morina longifolia	Worm infection
Myricaria squamosa	Febrifuge, poison
Nardostachys jatamansi	Anticonvulsant, cholera, palpitation

Medicinal Plant Species	Used in
Nepeta coerulescens	Dysentery
Nepeta discolour	Cold and cough
Nepeta erecta	Dysentery
Nepeta eriostachya	Eye problems
Nepeta floccosa	Cough and cold
Nepeta glutinosa	Diarrhea
Nepeta laevigata	Pneumonia
Nepeta leucolaena	Skin disease
Nepeta longibracteata	Stomach ache
Onosma hispidum	Cardiac tonic, stimulant
Orchis latifolia	Body-ache, cuts and bruises
Orobanche hansii	Boils
Oxyria digyna	Digestive, purgative
Oxytropis lapponica	Antiseptic
Oxytropis macrophylla	Antiseptic, fever
Papaver nudicaule	Pains
Parnassia laxmanni	Diuretic
Pedicularis brevifolia	Sedative
Pedicularis cheilanthifolia	Stomach complaints
Pedicularis longiflora ssp. tubiformis	Diuretic
Pedicularis mollis	Antiseptic, febrifuge
Peganum harmala	Asthma, diuretic, rheumatic
Perovskia abrotanoides	Laxative
Pimpinella tenera	Carminative, diuretic
Plantago depressa	Anti-diarrhoeal, anthelmintic, stimulant
Plantago major	Anti-diarrhoeal, anthelmintic, stimulant
Physalis alkekengi	Gout, rheumatic, vermifuge
Physochlaina praealta	Narcotic, vermifuge, source of atropine drug
Picrorhiza kurrooa	Dyspepsia, appetizer, malaria fever
Podophyllum hexandrum	Vermifuge, emetic, blood purifier
Potentilla ambigua	Tonic
Potentilla anserina	Astringent, diarrhoea, leucoderma
Potentilla atrosanguinea	Fever
Potentilla fruticosa	Fever
Potentilla multifi da	Insomnia
Prangos pabularia	Carminative, diuretic, stomach complaints
Primula microphylla	Cough
Primula rosea	Muscular pains
Ranunculus brotherusii	Digestive, ulcer
Ranunculus laetus	Stimulant
Ranunculus lobatus	Gum inflammation, toothache
Ranunculus trichophyllus	Diarrhea
Ranunculus tricuspis	Eye inflammation
Rheum nobile	Blood clot, swelling
Rheum spiciforme	Laxative, purgative, source of anthraquinone
Rheum webbianum	Laxative, purgative, source of anthraquinone
Rhodiola crenulata	Anti-stress, restores memory, health tonic
Rhodiola heterodonta	Anti-stress, restores memory, health tonic
Rhodiola imbricata	Anti-stress, restores memory, health tonic
Rhodiola tibetica	Anti-stress, restores memory, health tonic
Rosa webbiana	Vitamin C, hepatitis
Rubia cordifolia	Anthelmintic, blood purifi cation, leucoderma
Rumex acetosa	Laxative
Rumex patientia ssp tibeticus	Purgative, vermifuge
Saussurea bracteata	Boils
Saussurea glaciales	Intestinal problems
Saussurea gnaphaloides	Kidney problems
Saussurea jacea	Diuretic
Saussurea lappa	Asthma, anthelmintic, carminative
Saxifraga cernua	Tonic
Saxifraga jacquemontiana	Liver tonic
Saxifraga pulvinaria	Liver tonic
Saxifraga stenophylla	Blood purification
Scorzonera virgata	Intestinal problems
Scrophularia dentata	Appitizer
Scrophularia koelzii	Joint pain
Scutellaria prostata	Jaundice
Sedum ewersii	Dysentery
Senecio chrysanthemoides	Rheumatism
Senecio tibeticus	Diuretic
Silene vulgaris	Skin disease
Solanum nigrum	Appetizer, diuretic, laxative
Sophora moorcroftiana	Blood purifier
Statice macrorrhabdos	Stomach problems
Swertia chirata	Fever, acidity
Swertia cordata	Fever
Swertia petiolata	Fever, tonic
Swertia thomsonii	Fever, febrifuge
Tanacetum dolichophyllum	Intestinal worms
Tanacetum fruticulosum	Stomach ache
Tanacetum gracile	Intestinal worms
Tanacetum nanum	Intestinal worms
Tanacetum tibeticum	Khamchu
Taraxacum offi cinale	Analgesic, diuretic, liver disorders, tonic

Medicinal Plant Species	Used in
Taraxacum sikkimensis	Febrifuge, Analgesic
Terminalia belerica	Cough
Terminalia chebula	Cough
Thalictrum alpinum	Fever
Thalictrum foetidum	Diuretic, fever
Thermopsis barbata	Pains
Thlaspi alpestre	Digestive problems, fever
Thlaspi arvense	Digestive problems, fever
Thymus serpyllum	Carminative, expectorant, stimulant
Tragopogon gracilis	Wound healing
Tragopogon pratensis	Wound healing
Tribulus terrestris	Diuretic, sexual weakness, tonic
Ulmus wallichiana	Wounds, hair tonic
Urtica hyperborea	Rheumatism
Verbascum Thapsus	Asthma, frost bite
Vincetoxicum hirundinaria	Dysentery
Viola biflora	Tonic
Viscum album	Bone fracture
Waldheimia glabra	Septic wounds
Waldheimia stoliczkai	Septic wounds
Waldheimia tomentosa	Septic wounds
Youngia glauca	Health tonic
Youngia tenuifolia	Health tonic