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Sustainable Utilisation of Medicinal Plants of Ladakh and Lahaul-Spiti of trans-Himalaya

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ABSTRACT

Defence Institute of High Altitude Research (DIHAR) has carried out an extensive Ethno-medico-botanical survey of high altitude regions of trans-Himalaya, covering far-flung and high passes. During this, approximately 1100 plant species were collected along with valuable ethnobotanical information leading to invaluable knowledge generation on medicinal usage of phyto-resources, where at least 500 species were found to be of high medicinal utility. Most widely used medicinal plants from high altitude regions are *Aconitum heterophllum*, *Bergenia stracheiy*, *Capparis spinosa*, *Dactylorhiza hatagirea*, *Ephedra gerardiana*, *Gentiana aligida*, *Hippophae rhamnoides*, *Hippophae salicifolia*, *Hippophae tibetana*, *Inula racemosa*, *Meconopsis aculeata*, *Origanum vulgare*, *Podophyllum hexandrum*, *Rheum webbianum*, *Rhodiola imbricata*, *Saussurea lappa*, *Thymus serpyllum*, *etc*. Based on ethno-medico-botanical studies, it was observed that most of the trans-Himalayan medicinal plants belong to rare, endangered and threatened category. A unique alpine herbal garden established at DIHAR, Leh plays an unparallel role in propagation, cultivation-conservation and sustainable utilisation of trans-Himalayan bio-resources and provides a blue print for various pharmaceutical important compounds. Several herbal health products using trans-Himalayan plants have been formulated, patented and commercialised. This review catalogues available information on plethora of medicinal plants growing in Ladakh sector.

Keywords: trans-Himalaya; Medicinal plants; Seabuckthorn; Bio-resources; Phyto-medicines

1. INTRODUCTION

History of traditional medicinal plants (Ayurveda, Siddha, and Unani) can be traced back to a Vedic period of 2500 and 500 B.C. Most of the world potent drugs and medicines came to light during the 17th century, an era known as the 'Age of herbal medicines'[1]. It is beyond discussion that several plant parts posses medicinal values and are widely utilised for curing variety of human diseases of varying severities[2-3]. It has been reported that approximately 70 percent of medicinal plants in the trans-Himalayan region have come under threatened status due to various anthropogenic activities[4]. These herbal plants have been attributed to offering remedies for employment and foreign exchange for many developing countries[5]. There is a commendable advancement in global consumption of phyto-medicines and the same has attributed in the significant economic growth of developing countries[6]. It has been estimated that about 2000 drugs that have been used extensively in India alone, mere 200 are of animal and mineral origins while the rest are of plant origin. Despite such extensive usage of plant origin drugs, there are scanty reports on phytochemical investigations of trans-himalayan plants in context to their medicinal uses[7]. However, there is an immense scope of phyto-medicines in the global market *via* organised research and shall lead to shaping national economics as well[8]. These plants are providers of solutions for health and sustainable food which in turns facilitate security of livelihood[9]. According to a recent WHO report, over 3/4th of the five billion world population cannot afford the modern medicine products and rely upon the use of traditional medicines of plant origin[10]. In view of this, WHO encourages, recommends and promotes the inclusion of plant-derived drugs in national health care programme owing to their economics, availability, reliability and safety features[11]. India is one of the leading Asian countries in terms of the wealth of conventional knowledge systems related to herbal medicine and employs a large number of plant species for traditional medicine systems including Ayurveda (2000 species), Siddha (1121 species), Unani (751 species) and Tibetan (337 species)[12].

Cold deserts, known to harbor a plethora of valuable medicinal plants, are majorly found in the interior of Asia and the inter-mountain zones of North America. Globally, sixteen percent area of total landmass is under cold deserts. Specifically, Indian cold desert comes under the trans-Himalayan zone and are confined to Ladakh in Jammu & Kashmir (J&K) and Lahul & Spiti in Himachal Pradesh (HP). In J&K cold desert lies between 320 15'-360 N and 750 15' -800 15' E and covers approximately 68,321 sq. km besides 27, 555 sq. km. an area which is under illegal occupation of Pakistan and China. In H.P. the area lies between 310 44' 57" -320 59' 57" N and 760 46' 29" -780 41' 34" E and covers approximately 6,488

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sp. km. Daunting heights and landscapes determine the climate and temperature which during winter months dips down to -30 °C (Leh) and -56 °C (Drass) for about 3-4 months in a year.

The natives of Ladakh and Lahaul-Spiti follow their traditional medical system called '*Amchi* system of medicine' (*Sowa-Rigpa*) and the practitioners are called *Amchis*. The *Amchi* medicine is chiefly based on a skilful use of plants, minerals and animal products for therapeutic purposes and its origin can be traced back to more than 2500 years ago in India. It is believed that the practice initiated when Lord Buddha delivered a medical practice called *Bzi* (Chatustantre) which was later translated into Tibetan language during 8th century AD by Acharya Chandrananda and Varochana. Senior Yusthog Youthan Gonbois known to have amended it further to popularize and make it harmonious with the Tibetan culture and environment. The same is being valued in Tibet as well as entire Himalayan belt even till date. The *Sowa-Rigpa* system of medicine has been in vogue in Ladakh for the past many centuries and has helped *Amchis* to look after at least 60 percent of the public health in these difficult terrains. Keeping in view, the rich ethno-medicinal wealth of cold arid zones of Himalaya, Defence Institute of High Altitude Research (DIHAR) has carried out extensive surveys of all the six valleys *viz.* Indus, Nubra, Changthang, Suru, Zanskar and Lahaul-Spiti valleys, covering far-flung and higher passes since 1993 and collected valuable ethno-medicinal information with the help of tribals, shepherds, senior citizens and *Amchis*. Based on ethnobotanical information, approximately 1100 plant species have been collected, out of which approximately 500 species are of known medicinal values[13]. The widely used medicinal plants from high altitude regions of Ladakh and Lahaul-Spiti are *Aconitum heterophllum* (Aconite), *Bergenia stracheiy* (Pashanbheda), *Capparis spinosa* (Caper Bush), *Dactylorhiza hatagirea* (Spotted Heart Orchid), *Ephedra gerardiana* (Somlata), *Gentiana aligida*, *Hippophae rhamnoides* (Seabuckthorn), *Inula racemosa* (Pushkarmool), *Meconopsis aculeata* (Himalayan Blue Poppy), *Origanum vulgare* (Origano), *Podophyllum hexandrum* (Himalayan Mayapple), *Rheum webbianum* (Himalayan Rhubarb), *Rhodiola imbricata* (Golden Arctic Root), *Saussurea lappa* (Costus), *Thymus serpyllum* (Wild Thyme), *etc*. Based on ethno-medico-botanical studies, it has been observed that most of the trans-Himalayan Medicinal plants belong to rare, endangered and threatened category. Thus, an Alpine Herbal Garden has been established in the premises of DIHAR which is unique for promoting propagation, cultivation conservation and sustainable utilisation of trans-Himalayan plant bio-resources.

1.1 Rare, Endangered and Threatened Medicinal Plants

Rarity is a two-fold concept associated with the biology of the species and ecology of the area. A threat is more difficult to characterise since it may be a natural consequence of biological or geological processes or be the result of past or present human activities directly or indirectly influencing the plant populations or their environment. The plant populations keep changing size and density over a period of time and such changes may make plant species rare, endangered and threatened, eventually may lead to their extinction, if not checked (Table 1).

These cold desert plants have been used for various purposes by the valley people since a long time. Their over-exploitation, grasing, uprooting for fuel, increasing tourism and road construction have made some of the important medicinal plant species endangered and threatened. According to reports over 90 per cent of herbal materials come from wild resources. Due to these activities, cold desert ecosystems are getting destroyed day by day.

1.2 Botanical Curiosities

The flora of Indian Cold Desert comes under alpine and high alpine zones. In Western, Himalaya Alpine zone starts from 8500 ft where the trees are almost absent and the flora is dominated by wild annual and perennial herbs followed by dwarf bushes or shrubs. The alpine zone is mostly covered by beautiful meadows, vast pasture lands, colorful moraines and marshes. The alpine zone where the ground is almost covered permanently with snow for more than six months in a year and where scorching sun (more amount of ultraviolet rays) powerfully stimulates the vegetation, the mountain slopes, meadows, moraines and pasture lands give a spectacular display of flowers to Ladakh's barren mountain during summer months. The principal vegetative growth starts at the commencement of summer when melting snow provides abundant moisture to the herbaceous vegetation to run its full course with great rapidity. The flora is in full bloom in the month of August but starts degenerating by the end of September or beginning of October. The most significant feature of high altitude plants is adaptations in their habitats to withstand the adverse eco-climatic conditions. The commonest adaptation observed is the cushion habit. Species of *Astragalus*, *Caragana* form spinescent cushions while the species of *Androsace, Arenaria, Draba, Rhodiola* form soft cushions with rosette arrangements of their leaves. The rigid mat-forming plants are also frequent and represented by species of *Arenaria, Astragalus, Oxytropis and Stellaria*. The most curious of alpine taxa are species of *Saussurea* on which the development of profuse wool on the vegetative and floral parts is striking. Some species of *Anaphalis, Androsace, Arnebia, Leontopodium* and *Waldheimia* are also characterised by the soft development of white hairs on the whole plant. Another remarkable feature of this zone is vegetative propagation. Most of the taxa are perennial in nature and multiply by means of roots, root-stock, runners, bulbs, bulbils, rhizomes, tubers, etc. These herbs also exhibit a very interesting cycle of growth due to scanty rainfall, low temperature, snow storms, blizzards and extremely frigid conditions at this zone.

2. IMPORTANCE AND SCOPE

2.1 Historical Prospects of Medicinal Plants Usage

Very first evidence of medicinal plants used against various ailments was noticed 5000 years ago on Sumerian clay slab found in Nagpur, India[14]. Beside this, Pen T'Sao, a Chinese book written by Shen Nung in 2500 BC provides a strong evidence against the use of medicinal plants in ancient times[15]. Various archaeological studies revealed that herbal

Table 1: List of endangered plant species

Botanical Name	Habitat	Category
Aconitum heterophyllum	Alpine slopes	Endangered
Aconitum violaceum	-do-	Vulnerable
Allium stracheyi	Alpine slopes	Vulnerable
Arnebia benthamii	Rocky slopes	Critically Endangered
Arnebia euchroma	Rocky slopes	Endangered
Artemisia brevifolia	Open slopes	Endangered
Bergenia stracheyi	Moist alpine	Vulnerable
Betula utilis	-do-	Endangered
Bieberstenia odora	Alpine slopes	Vulnerable
Bunium persicum	-do-	Endangered
Colchicum luteum	-do-	Endangered
Cremanthodium ellisii	High alpine	Vulnerable
Dactylorhiza hatagirea	Alpine meadows	Critically Endangered
Ephedra gerardiana	Rocky areas	Endangered
Epipactis helliborne	Damp places	Endangered
Ferula jaeschkeana	Sub-alpine	Vulnerable
Fritillaria roylei	Moist alpine	Critically Endangered
Gentiana algida	Meadows	Endangered
Gentiana kurroo	Meadows	Critically Endangered
Herminium monorchis	Forest sheds	Vulnerable
Heracleum lanatum	Dry slopes	Vulnerable
Hyoscyamus niger	Waste lands	Lower Risk – Near Threatened
Jurinella macrocephala	Meadows	Vulnerable
Malaxis muscifera	Moist places	Vulnerable
Meconopsis aculeata	Rocky crevices	Endangered
Nepeta longibracteata	High alpine	Vulnerable
Onosma hispidum	High alpine	Endangered
Picrorhiza kurrooa	Alpine rocky	Endangered
Physalis alkekengi	Dry areas	Vulnerable
Physochlaina praealta	Waste lands	Vulnerable
Podophyllum hexandrum	Sub-alpine	Endangered
Polygonatum multiflorum	Moist places	Vulnerable
Polygonatum verticillatum	Moist places	Vulnerable
Rheum moorcroftiana	Alpine slopes	Vulnerable
Rheum spiciforme	Alpine slopes	Vulnerable
Rheum webbianum	Alpine rocks	Vulnerable
Rhododandron anthopogon	High alpine	Vulnerable
Rhododandron campanulatum	High alpine	Vulnerable
Rubia cordifolia	Moist places	Vulnerable
Saussurea gossypiphora	Meadows	Vulnerable
Saussurea lappa	Forest areas	Critically Endangered
Saussurea obvallata	Glaciated moraine	Vulnerable
Thymus serpyllum	Alpine meadows	Vulnerable

medicines were practiced way back 8000 and 60000 years ago in China and Iraq respectively[16]. An onset of Western medicine or conventional medicine provoked herbal medicine but couldn't face the challenge due to lack of various scientific evidence. In contrast, the uses of herbal medicines have been widely accepted as modern medicine have a limitation of various side effects and sometimes lack therapies for various chronic diseases[17].

2.2 Recent Advances in Medicinal Usage

According to US Food and Drug Administration (FDA), only 12000 drugs have been approved which in turn has resulted in enhancement of herbal products[18]. Various pharmaceutical companies have taken an initiative to discover new drugs with the help of natural product which could be beneficial for humankind[19-21].With the advancement in the technology, most of the medical practitioners in India as well as from the globe formulate their own recipes. The updated reports of world health organisation suggest a listing of 21000 medicinal plants around the globe, out of which 2500 species are from India[22]. There is an intense need for an integrated approach to conserve and propagate our natural resources by using modern science application which includes various biotechnological techniques such as plant tissue culture, plant molecular biology etc. this will facilitate in up scaling of secondary metabolites and in turn will provide us with excellent herbal formulations.

3. CONSERVATION STRATEGIES AND SUSTAINABLE UTILISATION

Eco-environment system is a life-support system consisting of biotic and abiotic components - man, animals, plants, micro-organisms, soils, minerals, water and atmosphere all interacting through a trophic structure, biotic diversity and natural cycles so that the system itself is kept viable. Conservation is a must for the prosperity of mankind and without biodiversity, there will be no biosphere. World conservation strategy in 1980 emphasised objectives of preservation of genetic diversity, maintenance of essential ecological processes, life-support systems and sustainable use of species.

Conservation of biodiversity of medicinal and aromatic plants will play a vital role to protect the existing genetic diversity and will be helpful in sustainable exploitation of these valuable resources of cold arid zones for overall economic development. Following measures have been suggested to govt. agencies, various NGO's and farmers for the conservation of medicinal and aromatic plant resources:-

a) In-situ conservation by the establishment of nature reserves or biosphere reserves with a lot of biophysical variabilities, maintenance of large buffer zones for the possible migration of species with response to climatic changes etc.
b) Ex-situ conservation through medicinal & aromatic plant reserve/medicinal plant garden.
c) Creation of medicinal & aromatic gene bank for cold arid zones.
d) Propagation and cultivation study of medicinal & aromatic plants.
e) Sustainable development and creation of ecological awareness.
f) Calculated and planned exploitation of medicinal and aromatic resources.
g) The active role of Govt's agencies, NGO's and Army to preserve the medicinal & aromatic wealth.
h) To popularise the potential of medicinal & aromatic

wealth among the local farmers' for their commercial cultivation.

j) To conduct regular training among the farmers and troops for cultivation, harvesting and sustainable utilisation.

The listed measures will play a vital role in conserving the biodiversity of medicinal & aromatic wealth. The sustainable utilisation of these resources will provide a powerful incentive to conserve species and their supporting ecosystems provided the people most likely to have an impact on the species and ecosystem concerned receive an adequate share of these benefits.

4. PRODUCT DEVELOPMENT

High altitude increases the production of free radical that damages the cells. Antioxidants can reduce the amount of damage to human body caused by altitude exposure. DIHAR has developed several antioxidant rich products from fruit and leaf of Seabuckthorn and other trans-Himalayan medicinal plants to combat high altitude related oxidative stress. Patented SBT-based commercialised products include Seabuckthorn beverage (patent no. 231773), Seapricot beverage (patent no. 635/DEL/2009), Herbal tea (patent no. 242959), Oil capsule (patent no. 1430/DEL/2011), Seabuckthorn jam (patent no. 635/DEL/2009), Antioxidant herbal supplement (patent no. 635/DEL/2009), and Adaptogenic appetiser (987/DEL/2012). Commercialisation of the products since the year 2001 has resulted in huge demand for Seabuckthorn.

4.1 Seabuckthorn Beverage

The beverage is rich in antioxidants and natural vitamins and contains no added colour and flavour. It is refreshing, rejuvenates the antioxidant system of the body, provides vital micronutrients and is fit for human consumption (Picture 1).

4.2 Seapricot Beverage

Seapricot beverage is a natural product based health drink prepared by mixing of optimised ratio of Seabuckthorn and apricot fruit pulp. The beverage is rich in antioxidants and natural vitamins and contains no added flavour. It is refreshing, rejuvenates the antioxidant system of the body, provides vital micronutrients and is fit for human consumption (Fig. 1).

4.3 Seabuckthorn Herbal Tea

Seabuckthorn based herbal tea, having anti-oxidant and anti-stress properties, is formulated from indigenous high altitude medicinal plants of Ladakh Himalaya. Seabuckthorn (*Hippophae rhamnoides*), Salam panja (*Dactylorhiza hatageria*), Local tea (*Bidens pilosa*), Local caraway (*Carum carvi*), Origano (*Origanum vulgare*), Local mint (*Mentha longifolia*), Yarrow (*Achillea sp.*) etc. are the major ingredients of herbal tea formulation. These herbs are commonly used in *Amchi* system of medicine (Tibetan system of medicine) for various ailments such as stress, indigestion, gastritis, headache, cold, cough, fever, high blood pressure, body pain, high mountain sickness, memory lost, and weakness etc. since ages (Fig. 2).

Figure 1. Seabuckthorn beverage and Seapricot beverage.

Figure 2. Seabuckthorn herbal tea.

4.4 Seabuckthorn Oil Soft Gel Capsule

Seabuckthorn oil soft-gel capsule is a formulation from supercritically extracted Seabuckthorn (*Hippophae rhamnoides*) seed oil, which is optimally enriched with bioactive compounds *viz.* Vit 'E', β-Carotene; along with essential (omega-3 & omega-6) and non-essential (omega-7 & omega-9) and others fatty acids; saturated and unsaturated [monounsaturated (MUFA) & polyunsaturated (PUFA)] fatty acids and minerals viz. calcium, phosphorous, iron, zinc, magnesium, selenium etc. that are a natural source of antioxidants (Fig. 3).

Figure 3. Seabuckthorn oil soft gel capsule.

4.5 Seabuckthorn Jam

Seabuckthorn jam is formulated using Seabuckthorn pulp. It is rich in sugar, organic acids, amino acids, and vitamins. The content of soluble sugars ranges from 9.3 to 22.74º Brix for Seabuckthorn juice.

4.6 Herbal Antioxidant Supplement

The herbal antioxidant supplement is based on pulp of Seabuckthorn (*Hippophae rhamnoides* L.) and Aonla (*Emblica officinalis)*, decoction of 15 indigenous herbs (Caper bush, Pushkarmool, Kuth, Revandchini, Yarrow etc.), fine powder of 11 indigenous aromatic & edible dye herbs (Rattanjot, Thyme, Mangistha, etc) and 04 other ingredients (Oregano, Wild mint, etc) (Fig. 4).

Figure 4. Herbal anti-oxidant supplement.

4.7 Herbal Adaptogenic Appetizer

It is a composite herbal nutraceutical comprising of Seabuckthorn (*Hippophae rhamnoides*) pulp, apricot (*Prunus armeniaca*) pulp and rhodiola (*Rhodiola imbricata*) root, mixed at standardised optimal ratio of 100:50:1, respectively, and innovating with other additives (Mint mix) to improve the aesthetic appeal, the additives being - Mint powder, Cumin powder, Coriander powder, dried Mango powder, Stevia extract and Himalyan black salt (Fig. 5).

Figure 5. Herbal adaptogenic appetiser.

4.8 UV Protective Cream

UV protective cream with anti-photoageing and anti-blemishes properties is an herbal formulation that contains Seabuckthorn seed oil as a major ingredient. The formulation also contains uvinul t 150-ethyl hexyl triazone, uvinul mc 80-ethylhexyl methoxy cinnamate, tinisorb m-methylene bis-benzotriazolyl tetra methyl butyl phenol, uvinul a-diethyl amino hydroxyl benzoyl tetra methyl butyl phenol, tinosorb-bis-ethyl hexyloxyphenol methoxy phenyltriazine, petroleum jelly, isopropyl myristicate (IPM), light liquid paraffin (LLP), bees wax, emulsifying wax (E Wax), cetyl alcohol, glycerol monostrearate (GMS), stearic acid, Mucopolysaccharide polysulphate (MPS), Butylated hydroxytoluene (BHT), fragrance, and distilled water. The formulation does not contain zinc and has UV protective efficacy equivalent to SPF > 45 along with anti-blemishes and skin healing properties. The formulation can be used as a prophylactic for low humidity and UV mediated skin damage at high altitude (Fig. 6).

Figure 6. UV protective cream.

5. CONCLUSION

Recent research interest in Trans Himalayan medicinal plants has revealed the importance of these plants as re-emergent. There is a demand of medicinal plants for pharmaceutical and nutraceutical industries. Therefore there is a tremendous urgency to develop suitable technologies to conserve our natural biodiversity so as to overcome our present and future needs. Since our independence, various institutions and universities are coping with these herbs but could not withstand competition due to poor biomass yield. Serious and concentrated efforts have been made by DIHAR, DRDO to cultivate and propagate various medicinal plants through various intense biotechnological approaches. These efforts have intended to save the threatened endangered medicinal plants and have attracted various groups of farmers and cooperative societies to commercially propagate these high-value medicinal plants and in turn, has resulted in attractive income as well as generated unlimited employment opportunities and industrial application.

Conflict of Interest: None

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