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Indian elecampane: Potential medicinal and aromatic crop for sustainable development

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Abstract
Inula racemosa Hook. F. (Indian Elecampane) is little known medicinal and aromatic plant possessing Ayurvedic, diuretic, antiseptic, antitumor, and various other therapeutic properties. It is locally known as Pushkarmool and manu is an herb found wild amongst strong alpine scrub vegetation in cold desert region of Northwestern Himalayan region which has narrow distribution and is recognized as rare and critically endangered species. It is a perennial crop belonging to family Asteraceae and is cultivated at temperate and alpine western Himalayas at an altitude of 5000 to 14000 feet from Kashmir to Kumaon, Afghanistan to Nepal. Fragile nature of its habitat, ruthless extraction and its exploitation due to medicinal properties are some of the reasons for extinction of the species. Locally, it is known as pushkarmool and has prominent ayurvedic and traditional uses. Seeds are aphrodisiac and roots are expectorant. Inulin, a polydisperse carbohydrate and essential oil (Sesquiterpenes) are chief constituents for pharmaceutical industry, perfumery and medicinal purpose. Mass migration of people, small land holdings, lengthy cultivation cycle and fluctuating market prices are some of the reasons associated with declining population. Information is combined on the basis of its various commercial, economic and traditional uses. Implications for better conservation is the need of our for these potential medicinal and aromatic herbs.

Keywords: Indian elecampane, Pushkarmool manu, inulin, sesquiterpenes

Introduction
Inula racemosa Hook. F. Indian Elecampane commonly known as Pushkarmool and Manu at Lahaul & Spiti is critically rare and endangered plant belonging to family Asteraceae distributed in the North Western Himalayas between of 2000 to 3200 m altitudinal range (Anonymous, 1998) [1]. Pushkarmool has a narrow distributional range and is confined to Hindu-Kush Himalayan region across Afghanistan, Pakistan, India, China and Nepal. In India it is mainly found in parts of Jammu & Kashmir, Himachal Pradesh and Uttar Pradesh now in Uttarakhand (Nayar and Shastry, 1988; Khare, 2007) [14]. The plant is about 1.5m tall, stout herbaceous with radical 20-45 cm x 12-20 cm long, stalked, broad elliptical leaves. The leaves have long petioles and are scabrid above and tomentose beneath. The stem is grooved, rough and very hairy with terminally borne yellow flower heads.

Flowers are hermaphrodite, 3-5 cm in diameter and bright yellow in colour and pollinated by bees and flies. Fruits are slender achenes of 0.4 cm long, bearded with 1 cm long pappus hairs. Plant can be propagated through seeds and division of roots. Flowering is from July to August and the seeds ripen from August to October (Chauhan, 1999, Firdous *et al*., 2018) [7, 34]. Fresh roots of *Inula racemosa* have a strong aromatic Odour resembling Orris and camphor; dried roots have a weak Odour. They are used in Kashmir as adulterant of Kuth (Roots of *Saussurea lappa* C.B. Clarke). They contain inulin (10%) and an essential oil (1.3%) containing alantolactone ($C_{15}H_{20}O_2$; m.p.76°). Alantolactone is the chief constituent of the oil obtained from the European species *Inula helenium* Linn; it possesses strong anthelmintic properties and is more potent and less toxic than santonin. Alantolactone in 1:1,000 dilution kills *Ascaris* in 16 hour while santonin in the same dilution requires more than 2 days. It has been used as an anthelmintic for children (Dosage, 0.009-0.2 grams). Alantolactone has antiseptic, expectorant and diuretic properties. The seeds of pushkarmool are bitter and aphrodisiac. It is commercially useful herb and paste of roots is effectively used in dressing the wounds and ulcers as the possess antiseptic properties also alleviates pain along with oedema. The paste of roots is especially recommended, to be applied on the chest in pleurisy and inflammatory conditions of pleura, to mitigate the pain (Kaul, 1997) [13]. Pushkarmool is used to mitigate *Vata-kappa Jawara* (a type of fever) as an indigenous medicine.

The drug is considered more potent and less pungent in taste. It provides relief for *Vata*, nausea, swellings breathlessness, and chest pain. Moreover, it is considered in food, cosmetic, and pharmaceutical industries as well (Nengroo *et al*., 2020) [18].

Internally, pushkarmool is used to boost appetite and digestion. Hence it is beneficial in anorexia *i.e*. loss of appetite and dyspepsia (indigestion). Clinical reports of *Inula racemosa* confirm its use as hypoglycemic agent (Chaturvedi *et al*., 1995) [6]. The rhizome part is also used in Tibetan medicine and it is said to have a sweet, bitter and acrid taste with a neutral potency. It is used in treatment of contagious fevers that have not fully ripened and pain in upper body, especially between the neck and the shoulders (Tsarong and Tsewang, 1992) [30]. Root is the official part of pushkarmool which has at least four sesquiterpene lactones, namely alantolactone, isolantolactone, dihydroalantoctone and dihydro iso lanto lactone. Sesquiterpene lactones are the chief constituents which possess antiseptic, expectorant and diuretic properties e.g., βetasitosterol, daucosterol and inunolide provide the healing properties. Isolantolactone major sesquiterpene lactones have been found to be active against the human pathogenic fungi especially *Aspergillus* flavus, *Aspergillus Niger, Geotrichum candidum*, *Candida tropicalis* and *Candida albicans* (Tan *et al*., 1998) [29]. *Inula racemosa* has gained prominence as a medicinal and aromatic plant and is commercially cultivated in Lahaul Valley of Himachal Pradesh on small scale. The cultivation of Manu was at its peak in the 1960s (Kuniyal *et al*., 2004 [21]; Rawat *et al*., 2004) [21].

However, in the last last few years, cultivation has drastically declined due to the introduction of other cash crops like potato, pea and hops (*Humulus lupulus* L.) which provide greater economic returns. Small land holdings, lengthy cultivation cycle and fluctuating market prices are some of the reasons associated with decline in *Inula racemosa* cultivation in the region (Rawat and Everson, 2011 [21]; Sharma and Sharma, 2010) [24].

Table 1: Population status of *Inula racemosa* from Northwestern Himalayan region

State	Place/District	Altitude (m)	Population Status	Source (s)
Himachal Pradesh	**Lahaul Valley**	**3116-3550**	**Domesticated**	**Singh *et al*., 2018 [28]**
	Parwati valley (Kullu)	1600-4200	Wild	Chauhan,1999 [7]; Sharma and Sood, 2007 [22]
	Dhanshoh (Chamba)	3550	Wild	Gupta, 2011 [9]
	Megad Watershed (Lahul & Spiti)	2200–5000	Domesticated	Rana *et al*., 2010 [19]
	Banks of Chandra, Bhaga and Chenab (Lahul valley)	2400-3600	Domesticated	Kuniyal *et al*., 2004 [21]; Rawat *et al*., 2004 [21]; Rawat and Everson, 2011 [20]
	Khoksar (Lahul & Spiti)	3200		
	Jahlma	3000	Domesticated	
	Hinsa	2700	Domesticated	
	Kuthar	2600	Domesticated	
	Pattan Valley (Lahul & Spiti)	3000	Domesticated	Sharma *et al*., 2006 [23]
	-do-	2950	Domesticated	Sharma and Sharma, 2010 [24]
	Kinnaur, Chamba, Kullu	upto2500	Domesticated	Aswal and Mehrotra,1994
Jammu & Kashmir	Gulmarg (Baramulla)	2300-3700	Wild	Wani *et al*, 2006 [31]; Baig *et al*., 2012 [3]
	Ducksum Kokernag (Anantnag)	2700-3500	Wild	
	Pasi (Anantnag)	3000-3150	Wild	
	Brari-marg (Anantnag)	3240-3450	Wild	
	Thajwas (Sonmarg)	3050-3500	Wild	
	Lidarawat (Pulwama)	2500-3140	Wild	
	Gagarbal, Izmarg, Kanzalwan, Gurez, Leh	2500-4500	Wild	Sharma, 2010 [24]; Vidyarthi, 2010 [35]; Kumar *et al*., 2011 [15]
	Tangmerg, (Budgam)	2690	Domesticated	Singh *et al*., 2018 [28]
	Herbal garden Kashmir University	1700	Domesticated	Wani *et al*., 2006 [31]

Table 2: Morphological and quantitative characteristics of *Inula racemosa*

Research topic	Parameters	Source (s)
Micro-characteristics in *Inula racemosa*		Abid and Qaiser, 2004 [36]
Receptacular surface	Without scaly ridges	
Anther apices	Acute –obtuse	
Cypsela characters of *Inula racemosa*		Shekhar *et al*., 2011 [37]
Shape	Oblongoid	
Size (mm)	3-4 × 0.5-0.75	
Colour	Dark brown	
Surface	Glabrous	
Number of ribs	16-24	
Pappus characters of *Inula racemosa*		
Series of Bristle	1	
Number	30-48	
Size (mm)	8-9	
Colour	Reddish brown	
Cypselae characters of *Inula racemosa*		Abid and Qaiser, 2002 [38]
Mean weight of 50 cypsela (gms)	0.275	
Shape	Oblong	

Surface (hairs)	Glabrous	
Number of ribs	16-24	
Colour	Dark brown	
Size (mm)	3.4×0.5-0.275	
Pappus characters		
Bristles (Series)	1	
Scales (Series)	0	
Number	30-48	
Size (mm)	7-8	
Colour	Reddish brown	
Carpopodium		
Shape	Slightly angular–narrow circular ring without any interruption	
Position	Basal-sub basal	
Diameter of carpopodium (µm)	463.62	
Diameter of foramen of carpopodium (µm)	275.75	
Endothecium pattern in *Inula racemosa*		Abid and Qaiser, 2004 [36]
Endothecial Type	Transitional	
Capitula diameter, Arrangement	3.5-5.0 cm, cymosely	

Table 3: Qualitative and quantitative parameters of essential oil of *Inula racemosa*

	Unit (S)	**Source (s)**
Essential oil	1.96%	Singh *et al.*, 2018 [28]
	0.05%	Bokadia *et al*., 1986 [4, 5]
	0.04%	Jabeen *et al*., 2007 [39]
	1.3%	Anonymous, 1959
	1.3-2.6%	Singh *et al*., 1959 [40]; Mehra *et al*., 1967 [41]; Anonymous, 2001; Wani *et al*., 2006 [31]
Inulin (Polydisperse carbohydrate)	10.0%	
Roylene (Alkaloid)	3%	
Petroleum ether extract with (Major constituents): Alantolactone and isoalanto lactone); (Minor constituents) dihydroalantolactone, dihydro iso alanto lactone and inunolide	5.7-6.2%	
Soxhlet extraction (Column chromatography) Alantolactone and Isoalantolactone	2%	Kataria and Chahal, 2013 [12]
Sesquiterpenes	(*ca* 60%)	Bokadia *et al*., 1986 [4, 5]
Heptadeca-1, 8, 11, 14-tetraene (Aplotaxene)	(*ca* 22%)	
Phenylacetonitrile	(*ca* 2%)	
Colour	Dark brown liquid	
Specific gravity	0.9003	
Refractive index	1.5385 at 31ºC	
Viscosity	2.2009 at 23 ºC	
Acid value	20.7020	
Ester value	150.4	
Melting point	76 ºC	
Optical rotation	Inactive	

Table 4: Chemical constituents of *Inula racemosa* and their medicinal properties

Plant part used	**Utilization**	**Source(s)**
Extraction from seeds	Valuable application in food, cosmetic, and pharmaceutical industries due to the presence of Linoleic acid and other functional groups	Nengroo *et al*., 2020 [18]
	Potential nematicide	
Rhizomes and roots	Used as anthelmintic for children, antiasthmatic, antiseptic, anti-inflammatory & diuretic agents and digestive properties in India & Tibetin	Sharma *et al*., 2006 [23]
Pounded roots	Treatment of rheumatism, hypertension, cardiovascular and liver disease respiratory tract disorder, pulmonary infections, skin diseases, gastrointestinal disorders, fever and pain	Gholap and Kar, 2005 [42]; Rawat and Everson, 2011 [20]
Seeds	Aphrodisiac	
Veterinary medicine	Tonic and stomachic	
Flowers	Flowers used as offerings to various deities in religious ceremonies,	
Leaves and stems	Leaves and stem fodder and fuel wood	
Roots and Rhizomes	Extract prepared from roots is frequently used for diarrhea in children and abdominal pain, dosage 0.5-1 ml once in in day in alternate days till cure. For boils paste prepared from root powder is applied twice a day for seven days. Dried roots are chopped and boiled in water at low temperature till water turns brownish-red. One spoon of the decoction is taken daily as cure for boils	Liu *et al*., 2001 [43]; Lal and Singh, 2008 [44]; Malik, *et al*., 2011 [45]

Table 5: Production and marketing profile of *Inula racemosa* reported

Source of supply	Cultivated and forests	
Demand 1999-2000	375.9 tonnes	Anonymous, 2002
Demand 2004-2005	757.4 tonnes	
Average growth rate of demand	15.1% per annum	
Manufacturers purchase price	Rs 40 per kg	
Production 1 hectare cropped area	80 quintals	
Estimated cost of cultivation /hectare	Rs 37 800	Anonymous, 2008
Market demand 2006-07	3 tonnes per annum	
Root yield/ hectare	4260 Kg	Rawat and Everson, 2011 [20]

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