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### Livelihood opportunities through leafy vegetables in Ladakh cold desert

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#### ABSTRACT

The wild leafy vegetables (WLVs) are the plant leaves are an important constituent of traditional diets of the tribal community of Ladakh especially when dried and consumed during harsh winter. This region is closed for almost seven months from all the directions except air fields and the cost of vegetables imported is too high that the local community in the region when there is no farming and tourism; they entirely depend and rely on dried leafy vegetables. The present study was carried out to explore the indigenous dietary habits of leafy vegetables and consumption pattern of resource poor community of remotely located capsule region since inception and document the indigenous knowledge related to the diversity and uses of wild leafy vegetables inclusive of weedy species in Ladakh region. A total of 32 different shrubs, and small herbs have been recorded belonging to 25 families are edible either as a vegetable or as medicine or in both forms directly/indirectly. The common wild edible leafy herbs found in Leh region are *Amaranthus viridis*, *Urtiga hyperborean*, *Carum carvi*, *Beta vulgaris*, *Brassica oleracea*, *Brassica* sp., *Lycopersicon esulentum*, *Lactuca sativa*, *Brassica oleracea*, (*Kale*), *Chenopodium album*, *Chenopodium botrys*, *Lepidium* sp., *Fagopyrum tataricum*, *Lactuca dolichophylla*, *Potentilla bifurca*, *Raphanus sativus*, *Raphanus* sp., *Brassica rapa*, *Coriandrum sativum*, *Allium prezewalskianum*, *Elsholtzia* sp., *Staphenomeria diegensis*, *Crepis* sp., *Chenopodium* sp., *Brassica juncea*, *Mentha piperita*, *Physalis alkekengi*, *Cappris* sp., *Peganum harmala*, etc. Few of these species are threatened and may be depleted due to their over exploitation and unsustainable harvesting for foods, medicines. Therefore, there is an urgent need to conserve these valuable wild but weedy edible plants and utilize them in a sustainable manner to ensure future demand. Besides, few of the plants were analysed for their nutritive values so that it can give a scientific basis for the further utilization as herbs as traditional foods.

#### 1. Introduction

Ladakh region has been recognised by India as a union territory, It is a land-locked region encompassed by China (Tibet) to the east, the Indian state of Himachal Pradesh to the south, Jammu and Kashmir and

Gilgit-Baltistan to the west, and the southwest corner of Xinjiang across the Karakoram Pass in the far north (Jina, 1996) and the Indus rivers forms a backbone of Ladakh, located at a height of 9,800 feet and above. It constitutes the easternmost trans-Himalayan part of India and truly described

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as high altitude cold-arid desert (Angchuk *et al*, 2009). Because of hostile environment and harsh winter in the region, cultivation is confined to mono-cropping for 5 months. Under these conditions, one of the major reasons behind human habitation is the ingenuity of local people, who has devised new and sustainable way of living. The annual global radiation varies from 1600 to 2200 kWh/m<sup>2</sup> and the highest radiation is received in parts of Ladakh region. High altitude plants had higher photosynthetic rates, especially when measured at low temperatures (Machler, and Nösberger, 1977). It covers an area of 59,146 sq km situated along the valleys of the Indus river (Anonymous, 1993). Taking into consideration these facts, the tribal community at Ladakh region designed and adapted a unique farming system in the lap of Himalaya with glacier recharge. Because of high mountains all round and heavy snowfall during winter, the area remains inaccessible to the outside world for nearly six months in a year (Angchuk *et al*, 2009). Under such a harsh situation, this ingenuity of traditional foods and beverages, people explored the plants suitable at high altitudes like Ladakh. The most significant feature of high altitude species is specific adaptation to survive against adverse ecological conditions. Plants have always fulfilled primary need of man. The flora of Ladakh Himalaya is of immense importance particularly for edible purpose under prolonged harsh climate and a number of wild species are good source of raw edibles (Hayet *et al.*, 2010). With the time, many wild species were identified and were included as a part of diet in Ladakhi meals. An attempt has been made to bring forth these edible leafy vegetables with dishes and diets, which are in true sense, are representative of fooding system in the region.

## 2. Materials and methods

### Study area

A bio-geographical periodic survey of ethnic groups in remote areas of Ladakh was carried out by Regional Research Station, ICAR-Central Arid Zone Research Institute (CAZRI), Leh during 2016-17 and 2017-18 under the Department of Science and Technology funded project entitled “National Mission on Sustaining Himalayan Ecosystem-Traditional Knowledge Systems (NMSHE-TKS) at randomly selected villages of Leh district at different altitudes (Upper Tukcha-Leh, Leh Market, Thiksey, Nyoma and hosue holds of farming communities. Being cold arid region, the growing season is very short i.e. from May to September with mild summer. The temperature ranges between -40 in winter to + 35<sup>0</sup>C in summer with precipitation ranging around 100 mm and potential evapo-transpiration to the order of 700-800 mm per year. The soil of these villages is gravelly and sandy to sandy loam in texture and medium to

medium high in organic matter with pH 7.85, EC and poor water holding capacity. More than 90 per cent soils are low in phosphorous and high in potassium (Acharya *et al*, 2012).

### Sampling techniques

The survey was carried out to explore the livelihood opportunities through leafy vegetables in village in different altitudes of village where all types of leafy vegetables and sites where weedy herbs could be recorded with the interactions made with farm women as well as self-help groups for making inventory of edible herbs and weedy species, identified by the farming community with the help of old farmers (male and female farmers) for their traditional utilization.

## 3. Results and discussion

A survey was carried out to understand the importance of leafy vegetables and number of leafy plants which are generally consumed and sometimes used as medicinal. Generally, most of the leaves are not directly consumed as fresh but used as boiled, mixed in Ladakhi dishes or mixed with vegetables or soupy materials. These are the biggest sources of Ladakhi nutritional security even during harsh winter season. These leaves are generally picked twice in a season. During July, they are collected and dried for soupy diet as these leaves are quickly dissolve in a solution for which soup is being cooked. While during October, some of the vegetable leaves are collected and dried for winter use as vegetable fry or mixed in dishes. More emphasis is given in growing these leaves and for their drying for securing winter diet as Ladakh is closed from all directions during harsh winter and vegetables becomes a costly affair especially for the resource poor Ladakhi people.

Eco-system security has been a major issue of Ladakh region for many decades. Whereas, issues of food security and its specifics in high mountain regions were often neglected. Ladakhi people have developed their own taste. In the cold arid environment like Trans-Himalaya where mountain agriculture is still dominant land use and importance of subsistence base for staple foods is also focused in current consumption patterns. Therefore, ensuring agriculture sustainable for its long-term sustenance is critical not only for ensuring food security for mountain people but also in the larger context of conserving the biodiversity under varied land use systems, for the wellbeing of peoples of cold region. In Ladakh, leafy vegetables, also synonymously known as leafy greens, salad greens, pot herbs, vegetable greens are popular plant leaves, generally preferred as a vegetable. In this region, people have invented and explored wide variety of plants to be used as leafy vegetables in one or other formats and mixed with other dishes to have a taste.

These leafy vegetables are an important ingredient of Ladakh fooding systems in nutrition and cooking methods. For example, type of particular dish like Tangthur is prepared from various leaves like palak, mongol, salad, Chinese, celery leaves, cabbage. This dish depends upon the locations and if people do not get few leaves and they try other leaves to prepare this dish to have similar taste, then sometimes they use to chrysanthemum leaves (*pato*). Fresh green leafy vegetables such as spinach, celery and lettuce, together with herbs such as mint and coriander are grown and available round the year in both field and under protected polyhouse conditions. The scope of using green fresh leafy vegetables for consumption and livelihood increase under cold arid conditions. These listed important leafy vegetables are picked up and sun-dried for further use during harsh-winter when there is no green patch. The inevitable monotony of dried vegetables has thereby been much relieved, and the diet, has improved in respect of fresh vegetables especially during winter season (Angchuk *et al*, 2009).

It was recorded after discussion that the location-specific plants were identified by old Ladakhi wherever they found and utilize as per their experiences in various dishes and especially soups. The people of Ladakh have lived in isolation for centuries though many eminent travellers like Fa-Hien (400 A.D.), HyderDuglat (1534), Moorcraft (1819-1825), Cunningham (1864) have visited the region occasionally (Kachroo, 1980). However, in 1974, Ladakh was formally opened to tourists and modern facilities were introduced in the region which gradually initiated a change the life of Ladakhis (Buth and Navchoo, 1988).

The region is rich in traditional folktale and has its own deep rooted traditions which have been protected through centuries and are still practiced. The Amchi system is one of these traditions. Amchi is a local medical practitioner and an ancient medical system of making use of minerals, hot water springs (for eg. Aayu of Saboo village, Penamik in Nubra valley in Leh district), puncturing of veins, branding, and herbs is called Amchi system. And this system has led searching plants which could be utilized for direct consumption (Navchoo and Buth, 1989).

Rich diversity of ethno-botanic importance is found in Ladakh region which serve as important dietary resources. Wild and native plants have always played a crucial role in meeting the nutritional needs in general and in remote rural pockets of Ladakh region in particular. Some of these plants form an important component of dietary habit during harsh winter of Ladakh. Historically dietetic plants were being collected by Ladakhi people for use in adverse situation and this is the climatic adaptation under cold arid region like Ladakh. Some of these have medicinal importance also.

The leafy yield for important vegetables (*Chenopodium*, *Lactuca*, *Rumax*, *Urtiga*, *Oxyria*, *Fagopyrum* and *Lepidium*) ranges between 0.7 to 1.4 kg/sq m per cutting (Mishra *et al*, 2010). Survey of local markets was made during morning and evening where about more than hundred vegetable sellers was recorded and shown in Fig. 1.



Fig. 1: Leafy vegetables in Leh market

#### Role of self-help groups and farm women in production and marketing

Ladakhi farm women play an important role in vegetable production system and farmers work using traditional approach called *Buglud* i.e. community approach systems where two families mutually help each other in the light of costly labourers of Rs. 500 per day approx. Fields are prepared well in advance and sowing is carried out in March end and April first week including raising if nursery in polyhouses. By May first week, nursery gets ready and planted timely during May months in second to third week. First weeding is carried in June first to second week so as to have good plant population of leafy vegetables. Weeds compete and achieve fast growth as compared to leafy vegetables and weeding is carried out at every 10 days interval. It has been reported that high altitude plants had higher photosynthetic rates, especially when measured at low temperatures (Mächler and Nösberger, 1977). Local seeds are exchanged at farming community levels and other seeds are provided by the State Department of Agriculture at subsidised rates to each village to maintain livelihood. This assures the leafy growth of vegetables for timely availability in the market. Meanwhile, palak, Bathua/ *Chenopodium*, turnips along with other vegetables capture the markets. During July,

leafy vegetables come to the market and farm women sell their vegetable produce in the local market. In the morning, leafy vegetables including spice leaves are sold directly and whole day, the sale rate declines and gradually increase especially during evening. The leaves are picked twice first last week June to first week September and again the crops are transplanted in Mid-October in polyhouse and weeding in

November. There are about more than 50 SHGs in Leh district constituted of 10-15 farm-women in each SHG and 5 major markets where about more than 100 vegetable sellers gather together and fetch about Rs. 2000-7000 per day each depending upon the type of leafy vegetables and their demand (Table 1). Rates for major vegetables are as follows:

**Table 1.** Livelihood through marketing of major leafy vegetables at Leh

Sl	Leafy vegetables	Rates (Rs. Per kg)	Places / habitat
1	Coriander (Ussu/Dhania)	200	Every household
2	Beet root (Nyung-ma marpo)	40	Thiksey, Stakmo, Saboo, Skara, Chushot, Nubra
3	Knol-khol (Kushutram)	55	Every household
4	Spinach (Palak)	60	Every household
5	<i>Urtiga hyperborea</i> (Zatsote)	120-150	Mountain
6	<i>Sedum tibeticum</i> (Sholo)	80	Mountain
9	<i>Brassica oleracea</i> var. palmifolia (Kale), shor-tam	50	Every household
10	Shang-tek	100	Thiksey, Stakmo, Saboo, Skara, Chushot, Nubra
11	Lettuce (Salad patti)	50	Upper Tukcha, Skara
12	Beet leaf (Mongol marpo)	50	Every household
13	Beet leaf (Mongol green)	50	Every household
14	Faltor/Fatol	40	Upper Tukcha, Skara, Nubra
15	Mustard leaves	50	Every household

The diversity of leafy vegetables along with their utilization pattern has been shown in Fig. 2 and listed in Table 2.

**Table. 2:** Traditional leafy vegetables and their utility

Leafy vegetables Botanical name	Family	Hindi	English	Ladakhi	Uses
<i>Allium cepa</i> L.	Alliaceae	Piyaz	Onion	tSong	In soups and vegetables
<i>Allium przewalskianum</i> L.	Alliaceae	Jangali Lahsun	Wild garlic	Skotche	Ground leaf decoction is recommended against dysentery and stomachache directly with or without meal for 3-4 days. Also used in <i>Tangthur</i> and <i>thukpa</i> . Stem are dried and use for flavouring agent and also frying purpose. In Zanskar, used in <i>Pakthuk</i> (wheat flour noodle soup) in case when onion leaves are not available
<i>Allium przewalskianum</i>	Amaryllidaceae	Jangli	Wild onion	Skotse	It is a substitute of onions use during holy days of Buddhist, both

					stem and roots are used are onion, considered good for indigestion, also used as flavouring agent
<i>A. sativum L.</i>	Alliaceae	<i>Lahsum</i>	Garlic	<i>Sgogpa</i>	Two or three segments are usually taken in a routine with hot water twice daily to improve digestion and appetite.
<i>Chenopodium album</i>	Chenopodiaceae	<i>Bathua</i>	Chenopodium	Niyu/ Snegu	Leaves are cleaned and then boiled for 10 to 15 minutes with ground barley; skew is prepared and taken with paba. It is fried in hot oil for 10-15 minutes and is taken along with rice or roti. Also used as <i>Tangthur</i> (Ladakhi raita)
<i>Chenopodium botrys</i>	Chenopodiaceae	<i>Bathua</i>	Chenopodium	Sagani	
<i>Fagopyrium esculentum</i> <i>Fagopyrum tataricum</i> (buckwheat)	Polygonaceae	<i>Kuttu</i>	Buckwheat	Tao/ Dao/ Tayat	Leaves are boiled with ground barley prepared as skew, also mixed in buttermilk served with <i>paba</i> . Leaves served with rice and roti, also cooked as vegetables. During winter it is generally used as leafy in especial Ladakhi dishes when any non-veg is prepared.
<i>Pisum sativum L.</i>	Fabaceae	Kala Matar	Black pea	Nakshan	Used in Ladakhi dish mixed with pawa, in a powdery form in wheat flour while in Thuppa, it is directly used as pea form. Oftenly used as either forage (leaves, plant material) or silage (fermented, high-moisture fodder) for animals. In Ladakhi dish like <i>Chhu Tag</i> (Bow-tie noodle stew)
<i>Polygonum chinensis</i>	Polygonaceae	Jangli Palak	Creeping smartweed  Chinese knotweed	-	Dried leaves are used during indigestion or Constipations, leaf paste used for skin injuries

<i>Convolvulus arvensis</i>	Convolvulaceae	Hirenkhuri	Field bind weed	Ratrcho/ Tik-tik-mo	Seeds are eaten raw or fried with onion or boiled and taken.
<i>Crepis sp.</i>	Asteraceae	Genda family	Hawksbeard	Remang	Leaves and tender shoots use as vegetables
<i>Beta vulgaris</i>	Amaranthaceae	Chukander	Beetroot	Mongol-red	Beetroot-Fresh chard can be used raw in salads, stir-fries, soups, Chard leaves and stalks are typically boiled or sautéed; the bitterness fades with cooking.
<i>Lactuca sativa</i>	Asteraceae	Salaad patti	Lettuce	Dums	It is most often grown as a leaf vegetable, but sometimes for its stem and seeds. Lettuce is most often used for salads, although it is also seen in other kinds of food, such as soups, sandwiches and wraps
<i>Brassica oleracea</i>	GanthGobhisabji	Wild cabbage Kohlrabi, Knol-Khol,	Kale	Kushu tam	Widely used as leafy vegetables in Ladakh, also used in soups, and mixing with other vegetables preparation.
<i>Artemisia brevifolia</i>	Asteraceae	<i>Kirmala</i>	Worm seed	<i>Khamchuor Phur-nag</i>	Grinding of Artemisia leaves with other herbs, rock salt is used against worms of intestine mainly in children for 5-7 days and stomach problems.
<i>Mentha longifolia</i>	Lamiaceae	<i>Jangali Pudina</i>	Horse Mint	<i>Pholoing</i>	It is a important ingredient in Ladakhi dishes especially in chatni, and soups Extract of leaves and tender shoots mixed with other medicinal herbs is utilised for dysentery, diarrhoea, stomachache and vomiting.
<i>Nepeta coerulascens and N. glutinosa</i>	Lamiaceae	Billilotan	Catmint	<i>Jatukpa</i>	Grown and maintained on bunds as flower in Leh, Stakna, Thiksey, Nimoo, Basgo, and other roadside villages of Ladakh, its extract used against dysentery,

					diarrhoea and stomachache
<i>Peganum harmala L.</i>	Zygophyllaceae	Harmal, Isband, IsbandLahouri	Wild Rue	<i>Sepan</i>	Ethyl acetate, chloroform, butanol and methanol extracts of the leaves of <i>Peganumharmala</i> were tested for antibacterial, antioxidant and antiviral activities. Ground seeds together mixed and used against treat stomachache.
<i>Tanacetum dolichophyllum</i>	Asteraceae	Dhoop, Guggul	Tansy	<i>Khampaserpo</i>	Decoction of leaves and flowers are given in little doses for 7-8 days against intestinal worms
<i>Carum carvi L.</i>	Apiaceae	Kala Jeera	Kumbu	<i>Umbu, Kosnyotor, Gonyodor, Gonyod, sNyod</i>	Every village has this vegetation in kitchen garden, Few seeds take to promote digestion and against rheumatism as a spice. <i>Thukpa</i> , Vegetable, as spice, fry
<i>Geranium pretense L.</i>	Geraniaceae	Kulthi	Meadow Cranesbill	<i>Gugchukor, Gadur</i>	Leaf extract against dysentery and diarrhoea
<i>Hippophae rhamnoides L.</i>	Elaeagnaceae	Brahmaphal	Seabuckthorn	<i>Tsermang or Sastalulu or Cherker or sTarbu</i>	Whole plant is useful for many diseases especially for heart health, skin care etc. Leaves are especially used by local people for use as tea, and other medicinal purposes; its fruit juice is very popular for health point of view having more vitamins, minerals, and useful for digestion and instant energy; its protein-rich leaves are used as tea blend for stress relief and sleep aid.
<i>Senecio</i> species	Asteraceae (Compositae)	Senecio	groundsel and old-man-in-the-spring, Chickenweed	Trubelamindho or HechingrGudrus	Paste of fresh leaves applied on forehead to relieve headache and pain
<i>Brassica oleracea Gongylodes</i>	Brassicaceae	Ganthgobhi	Knol-khol	Kushu-tam	Every household grows this plant in their kitchen garden and utilize its leaves like

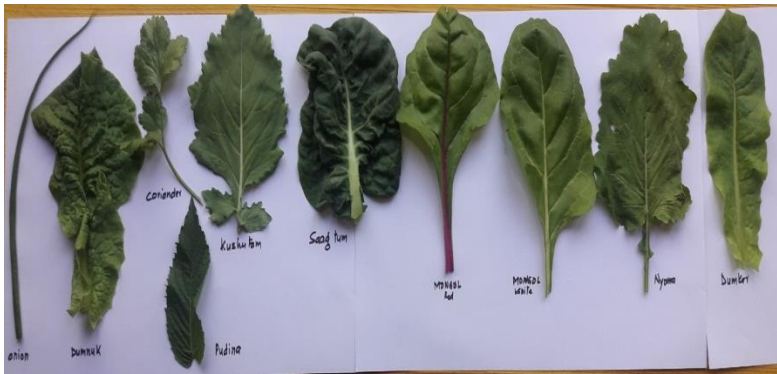
					palak, very popular leafy vegetable at Ladakh
<i>Solanum nigrum</i>	Solanaceae	<i>Makoi</i>	Black nightshade	<i>Tsigma</i>	young leaves are used in Stomachache treatment, cooked leaves are consumed
<i>Capparis spinosa</i>	Capparaceae	Bhotiayas-kabara, kabar, kabra, kiari	Caper	<i>Kabra</i>	Against hyperacidity (Rivera et. al. , 2002)
<i>Plantago asiatica</i>	Plantaginaceae	Lahuriya	Asiatic plantain	Karache	Traditionally leaves are used in many dishes, soups during summer and winter seasons, Food with Plantago seeds licorice (and a quarter-weight Pepper) is useful for chest pain and cough (Haddadian et al, 2014)
<i>Rumex patientiassp</i>	Polygonaceae	Chuk	Sorrel	Shoma	The leaves of this plant are used at par to Amaranthus due to its taste, palatability and acceptability (Rinchen et al, 2018). Leaves should preferably be used after boiling and disposing of the water.
<i>Biden pilosa</i>	Asteraceae	Kumra, Kumur	cobbler's pegs	Solja	The plant is also used to make herbal tea in Leh-region and is taken as a general beverage or as a treatment for worms and flatulence. In addition, it is a natural antibiotic that successfully treats antibiotic resistant bacteria (Comboni, 2017)
<i>Rhodio laimbricata</i>	Crassulaceae	Amar poi	Stonecrops	Shrolo	the young leaves and tender shoots are edible and also used in many dishes and Amchi uses as herbal medicine
<i>Sedum tibeticum</i>	Crassulaceae	-	Stonecrops	Sholo	Dry leaves in semicrushed form are used with curds as diuretic and also used to decrease obesity
<i>Swertia petiotala</i>	Gentianaceae	-	Momiran	Shantik/Zantik	the decoction of whole



					plant in milk is used against headache and bodyache
<i>Lactuca sativa L. var. longifolia</i>	Composite	Salad	Cos lettuce	Idumnak/dumnak	Idum, Cos lettuce is a common salad green, and is the usual lettuce used in Caesar salad.
<i>Lactuca sativa</i>	Composite	Romaine "violet", Indian lettuce	dark lettuce (violet)	Idumnak , Dhum	
<i>Phaseolus vulgaris</i>	Fabaceae	Bakla	Black beans Black pea	Nakshan/ nak-sran	In soups, used in Ladakhi dishes like thupka mixed with pawa, in a powdery form in wheat flour while in Thuppa, it is directly used as pea form.
<i>Brassica rapachinensis</i>	Brassicaceae	Pakchoi	Pakchoi, Bok choy	-	Pakchoi is a Chinese cabbage and often in the form of leaves and used in many Ladakhi cuisines and used as a stir fry or vegetable recipes
<i>Petroselinum crispum</i>	Apiaceae	Ajwain	Parsley	-	Fresh chopped parsley has a spicy, peppery flavor and pairs well with soups, Vegetables potatoes, tomato-based saucesgrain-based salads,
<i>Fagopyrum esculentum</i>	Polygonaceae	Buckwheat	Dyat, dro, bro, fafar	Tao/ Dao/ Tayat	Leaves are used in skew, also mixed in buttermilk served with <i>paba</i> . Leaves with fried onion are served with rice and roti, also cooked as vegetables. During winter it is generally used as leafy in especial Ladakhi dishes when any non-veg is prepared. Tangtur/ vegetable.
<i>Coriandrum sativum</i>	Apiaceae	Dania	Coriander	Wussu	For preparing chatni, used as spices and flavour agent in Gyuma
<i>Raphanus sp.</i>	Bracassiceae	Desi Mooli	Local radish	Lobuk	Pickle/chatni, it is popular leafy vegetable which is not only used in Leh district but also used in Kargil-Zanskar area, radish leaves are used as it is a yogurt

					dip for eating with <i>paba</i> <sup>2</sup> .
<i>Staphenomeria diegenensis</i>	Asteraceae	-	Chicoryleaf wirelettuce silver rock	Khawa	Dry and green both are consumed
<i>Physalis alkekengi</i>	Solanaceae	Rasbhari	Bladder cherry	Dokpa menthog	Flowers are collected for decoration by Brokpa community. The dried fruit of <i>P. alkekengi</i> is called the golden flower in the Unani system of medicine, and used as a diuretic, antiseptic, liver corrective, and sedative
<i>Brassica juncea</i>	Brassicaceae	Sarson	Indian mustard	Nungskar	Leaf decoction given during diarrhea
<i>Brassica rapa</i>	Brassicaceae	Shalgam	Turnip	Nyungma/ Turnip	Cooked with Skyu and thukpa
<i>Elsholtzia sp.</i>	Lamiaceae	-	Shiny Elsholtzia	Saanik	Tangtur/ Thukpa/ and for fragrance also in vegetables
<i>Lepidium latifolium</i>	Brassicaceae	Cansur, Chausaur	Dittander	Shangsho,	Leaves are Boiled, fried with Skotse and serve with Ladakhi bread and Paba
<i>Lactuca dolichophylla</i>	Asteraceae	-	-	Khala	Parts of leaves are consume as vegetable and has medicinal properties
<i>Potentilla bifurca</i>	Rosaceae	-	Silver weed	Troma, Chisheing	Thukpa/ Pola/ mix rice
<i>Brassica oleracea (Kale)</i>	Brassicaceae	Saag/ Kale	-	KhachulaTam	Momo/ Vegetable
<i>Raphanus sativus</i>	Brassicaceae	Mooli	Radish	Gyalabug	Thukpa
<i>Beta vulgaris</i>	Amaranthaceae	Chukander leaf	Beet leaf, table beet, garden beet, red beet	Mangol	Vegetable / all types of Ladakhi dishes including Momo
<i>Mentha piperita</i>	Lamiaceae	Pudina	mentha	Pudina, Phololing	Leaves are commonly used in Tsamik (chatani). Dried leaves are used to flavour local dishes during winter months.
<i>Urtica hyperborea</i>	Urticaceae	Bichhchhu buti, Kali, Kandadli	<i>Urtiga</i>	Zacchaut / Zingral	With Ladakhi-dishes like <i>thukpa</i> and <i>paba</i> ; Tibet and Ladakh people believe that the great Tibetan Yogi Milarepa, while meditating in the

					mountains survived by eating nettle
				Fatol / Thamen	Anti-vomit
				Sholo	Tangtur/ other medicinal uses
<i>Brassica oleracea</i>	Brassicaceae	Bandh gobi	Cabbage	Bandh gobi	Vegetable, Momo
<i>Brassica sp.</i>	Brassicaceae	Phulgobi	Cauliflower	Phul gobi	Vegetable / Momos
<i>Lycopersicon esculentum</i>	Solanaceae	Tamater	Tomato	Tamatter	Vegetable fry
<i>Amaranthus viridis</i>	Amaranthaceae	Palak	Lamanchu or Chulchum	Palak	Simple vegetable dish with rice
<i>Oxyria digyna</i>	Polygonaceae	Boke	Mountain Sorrel	Lamanchu or Chulchum	The leaves of mountain sorrel have a fresh acidic taste and are rich in vitamin C, and are used in salads.



Onion, Damruk, Oudina, Mongol-Red, Mongol-White, Nyoma, Kushutam, Saag-tum, Dumkar, Coriander



Zathuk-Urtiga, Salad-patti, Shantik, Kushutam (knol-khol)



Palak, Niyu, Shagani, Green-lettuce, red-lettuce, Parsley, Mongol, Palak, Beetroot, Malwa, Pakchoi, Local Radish



Black-pea, Green-pea



Tao-Buckwheat, Bidens pilosa, Palak, Cabbage

Oshing, Chhinse, Dhania, Sarson

**Fig 2.** Diversity in leafy green vegetables of Ladakh region

### Nutritional value of leafy vegetables

Green leafy vegetables have important role in foods of Ladakh and nutritional security and is shown in Table 3. These are safe for healthy life and are in use for centuries. Their natural and organic nature makes leafy vegetables an essential part of the diet especially under barren ecosystems at high altitude of Ladakh region. Particularly, green leafy vegetables have been considered as exceptional source for vitamins, minerals and phenolic compounds. Mineral nutrients like iron and calcium are high in leafy vegetables than staple food grains as have been mentioned in Table 3 as reported by various researchers. In addition to these qualities, these possess antioxidants and antimicrobial qualities useful in medicinal uses. These leaves are utilized in various food dishes and some of them are dried

and used during harsh winter season. Number of plant species of leafy vegetables is available in cold desert Ladakh. The important ones are discussed. Coriander is mostly utilized for its green leaves in soups and vegetable preparation. Its leaves are a rich source of nutrition and contains high amount of vitamin A ( $\beta$ -carotene) and vitamin C and vitamin K up to 27 and 310 mg/100 g (Girenko, 1982 and Bhat *et al*, 2014). Seabuckthorn (*Hippophae rhamnoides*) is widely utilized berries and leaves, contains protein to the tune of 249.7 g. *Capparis spinosa* is very rarely available due to its density in an area but has significant content of Polyphenols, Cappaprenols-12, 13, 14-sopreneunit, p-methoxy benzoic acid and leaf contains Isothiocyanate, (Al-said *et al*, 1988; Gadgil and Mishra, 1999 and Mitchel, 1974), respectively.

**Table 3:** Nutritional value of important daily used leafy vegetables under use at Leh region

Leafy vegetables Botanical name	Protein (g)	Fibre (g)	P (mg)	K (mg)	Calories Kcal/g	Riboflavin (mg)	Ca (mg)	Fe (mg)	Vitamins			References
									A (mg)	K (mg)	C (mg)	
<i>Allium cepa L.</i>	1.2	1.9	32	161	44	-	25	0.7	-	-	8.1	USDA National Nutrient Database
<i>Amaranthus viridis</i>	2.0	0.6	21	470	17	0.2	73	10.9	-	-	28	Tewani <i>et al</i> , 2016
<i>Chenopodium album</i>	26.44	16.65	0.317	6.938	261	-	2.172	255	-	-	-	Adedapo <i>et al</i> , 2011
<i>Biden pilosa</i>	19.13	21.48	0.519	3.285	281	-	1.971	986	-	-	-	
<i>Brassica oleracea (Kale)</i>	2.92	4.1	55 (4%)	348 (7%)	148	0.347 (27%)			241 (27%)	389.6 (325%)	93.4 (104%)	Shahi, 2019
<i>Fagopyrium esculentum (buckwheat)</i>	12	10	282	450	355	10.6	110	3.8 -4	-	-	-	Campbell, 1977
<i>Mentha longifolia</i>	3.8	8		569 (16%)	70		25%	28%	84%	52%	-	USDA National Nutrient Database
<i>Beta vulgaris</i>	2.2 (4%)	3.8 (10%)	41 (6%)	762 (16%)	58	0.22 (17%)	117 (12%)	2.57 (32%)	6326 IU (211%)	400 µm (333%)	30 µm (50%)	<a href="https://www.nutrition-and-you.com/beet-greens.html">https://www.nutrition-and-you.com/beet-greens.html</a>
<i>Lactuca sativa</i>	0.49 (0.98%)	0.5 (1.32%)	10 (1.43%)	70 (1.49%)	22	-	13 (1.30%)	0.31 (3.88%)	133 µm (133%)	45.5 µm (19%)	-	<a href="https://www.healthbenefitstimes.com/lettuce/">https://www.healthbenefitstimes.com/lettuce/</a>
<i>Peganum harmala L.</i>	11.5%	22.3%	-	-	382.4	-	-	-	-	-	-	Dastagir <i>et al</i> , 2014
<i>Carumcarvi L</i>	19.77 (35%)	38.9 (100%)	568 (81%)	1351 (29%)	333	0.379 (29%)	689 (69%)	16.23 (203%)	363 IU (12%)	-	21 (35%)	Malhotra, 2012
<i>Hippophae rhamnoides L.</i>	249.7	122	2.47 g	9.12 g	-	5.77	7.38 g/kg dm	177.8	-		-	Biel and Jaroszewska, 2017
<i>Capparis</i>	17.9%	6.8%	135	-	20	-	550	72	-	-	4	Mishra <i>et al</i> , 2015

<i>spinosa</i>												
<i>Rumex spieces</i>	1.85	5.05	54	395	25	-	76	4.02	30 mcg	-	26	<a href="http://www.b4fn.org/resources/species-database/detail/rumex-crispus/">http://www.b4fn.org/resources/species-database/detail/rumex-crispus/</a>
<i>Lactuca sativa L. var. longifolia</i>	0.58	1	14 (2%)	116 (2.47%)	34 KJ	0.031(2.38 %)	16(1.6 %)	0.46(5.75 %)	205 µm (25.29%)	-	1.9(2.11 %)	<a href="https://www.healthbenefitstimes.com/romaine-lettuce/">https://www.healthbenefitstimes.com/romaine-lettuce/</a>
<i>Brassica rapachinensis (Pakchoi)</i>	1.05	0.79	26	176	9		74	0.56	156mcg	31.9mcg	31.5	<a href="https://www.medicalnewstoday.com/articles/280948#nutrition">https://www.medicalnewstoday.com/articles/280948#nutrition</a>
<i>Petroselinum crispum (Parsley)</i>	2.79	3.3	58 (8%)	554 (12%)	36kcal	0.09 (8%)	138 (14%)	6.2 (48%)	421 µm (53%)	1640 µm (1562%)	133 (160%)	USDA FoodData Central
<i>Coriandrum sativum</i>	21.93/100 g	10.40	481	4466	279	1.5	1246 g	42.46	5850 IU	310 (258%)	27 (45%)	Bhat et al, 2014
<i>Raphanus sativus (Radish)</i>	0.79 (1.58%)	1.9 (5%)	23 (3.29 %)	270 (5.74%)	19		29 (2.9%)	0.39 (4.88%)	8IU	-	17.2 (19.11%)	<a href="https://www.healthbenefitstimes.com/radish/">https://www.healthbenefitstimes.com/radish/</a>
<i>Urtica hyperborea</i>	2.71 (5%DV)	6.9 (28%)	71 (2%)	334(13 % DV)	42	-	481 (37%)	16 (9%)	101 µm (11% DV)	498.6 µm (416%)	-	Herbazest, 2020
<i>Brassica oleracea var viridis Collard</i>	5.05 (10.10 %)	4.8 (12.63 %)	46 (6.57 %)	427 (9.09%)	61	-	357 (35.7%)	1.9 (23.7%)	978 µm (139.71 %)	1059.4 µm (882.83 %)	44.9 (49.89%)	<a href="https://ndb.nal.usda.gov/">https://ndb.nal.usda.gov/</a>



### Other new interventions for harsh winter

Ladakh is almost locked for seven months during harsh winter (October- April) from all the directions by roads and it is not possible for every resource poor farmer particularly residing in the remote villages located in deep valleys of mountains of Ladakh region. With the continuous efforts and introduction of low-cost protected agricultural scientific interventions made by different organizations such as polyhouse, low tunnel, trench cultivation has made it possible for Ladakh farming community to have livelihood option for green and leafy vegetables during winter season for nutritional security. Now this has made Ladakh region holding 127326 m<sup>2</sup> area under polyhouses (Gautam and Kumar, 2016). At present, farmers grow all kinds of vegetable crops, including lettuce, fenugreek and spinach, in sub-zero temperatures and shown in Fig. 3.



**Fig. 3:** During winter, vegetables and leafy greens are grown under polyhouse and trench conditions

### 4. Conclusion

Survey revealed that Ladakh is a high altitude region where it becomes difficult for the tribal community to have access to vegetables from plains. But they are costly affair when imported to this region. Under such situation, mountain people have identified many plant species including leafy greens and weedy ones that could suit to their health/ taste and have nutritional security with resilient to adverse climate. These leafy greens adapted to this region have regular supply during the season. While during harsh winter, these leaves are dried and utilized during winter either in the

form of soups, or format for fooding systems. There are many leafy vegetables have equal taste similar to *Amaranthus* and consumed either in the form of food or conserved for medicinal uses.

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