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Yield and Palatability of Potential Indigenous Leafy Vegetable of Cold Arid trans-Himalayan Ladakh, India

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ABSTRACT

Not much attention has been paid to a wide range of indigenous leafy vegetables that can grow in high altitude harsh climatic conditions with minimal care. Therefore, a study was carried out on yield potential and palatability of indigenous leafy vegetables (ILV) that grows in trans-Himalayan Ladakh. Seven ILV viz. *Fagopyrum tataricum, Rumex patientia, Fagopyrum esculentum, Amaranthus cruentus, Malva verticillata, Lepidium latifolium* and *Atriplex hortensis* that are being used by native people of Ladakh were recorded for their morphological characters, earliness, yield and other consumer preference traits. The highest yield was recorded for *A. hortensis* (1.80±0.06 kg/m^2). The study suggested that *A. hortensis* and *A. cruentus* have high palatability and are most preferred by the consumers. Yield potential of the cold hardy *A. hortensis* is significantly higher and it is an early maturing crop. Therefore, detail studies on *A. hortensis* are required, and efforts need to be made for large scale cultivation of the species.

Keywords: Indigenous leafy vegetables; Cold desert; Ladakh; Organoleptic

1. INTRODUCTION

The high mountain region of Ladakh is characterised by a rugged topography at an average altitude of over 3000 m. It is separated from the Indian subcontinent by the Great Himalayan Range and edged by the Karakoram Range to the North[1]. The region is characterised by extreme temperature variations, low precipitation, high wind velocity, sparse plant density, thin atmosphere with high UV-radiation and fragile ecosystem. The temperature drops down to -30 ºC in winter[2]. Long harsh winters reduces the total cropping season to just four to five months in a year. Single-cropping is dominant, as double-cropping is possible only in a limited area falling below an altitude of approximately 3000 m. Agriculture production is entirely based on irrigation. The region remains cut-off for over six months in a year due to very heavy snowfall. Availability of locally grown fresh vegetables is restricted to summer months and therefore, there are seasonal differences in dietary intake of food. The availability of fresh vegetable decreases significantly during the winter months, which has resulted in unbalanced diet[3]. Self-sufficiency in food is an important issue for the region. There is a growing demand for local vegetable produce due to the population increase, urbanisation and growth in income. Therefore, meeting the increasing requirements of fresh vegetable in this remote mountain area is a formidable challenge[4].

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Traditionally, people living in cold desert of Ladakh depend on wild edible plants, including indigenous leafy vegetables (ILF), to meet their dietary requirements. They collect such plants from mountain slopes and around agricultural fields. The indigenous plants do not require intensive care and can grow in less fertile soil. Besides, it can withstand harsh climatic conditions due to its abiotic and biotic stress tolerance potential, which is inherent in their genetic makeup by years of natural selection. However, such plants grow quite sparsely in the nature and their production is very low[5]. Increasing production systems and their inclusion in commonly grown vegetable types in the remote regions would contribute towards nutritional security in the mountainous region.

Anthropogenic pressure resulted in fast disappearing of ILF in the nature[6]. Indigenous traditional knowledge among the farmers on use of such plants is fast declining due to easy availability of modern day conventional vegetable types. Moravian missionaries introduced vegetable such as potatoes, spinach, cauliflower, radish, green beans, brussel's sprout and tomatoes in last quarter of the nineteenth century in Ladakh. Defence Institute of High Altitude Research (DIHAR) introduced and distributed seed and seedlings of beans, beet root, cabbage, cauliflower, carrot, lettuce, peas, onion, spinach, tomato, turnip, okra, knol-khol, leek, radish, sugar beet, chillies, coriander, cucumber, Chinese cabbage, mint, brinjal, garlic, methi, pumpkin among farmers in Ladakh between 1965-1975[3]. Modernisation of agriculture and introduction of modern day cultivated vegetables leads to narrowing of the genetic diversity of

the species[7]. Therefore, documentation and collection of diverse local ecotypes becomes extremely important for ensuring food security in the remote mountainous regions. There is a need for crop improvement of ILF through selection. Regeneration, characterisation and standardising agro-practices become necessary steps for further use of the plants[8]. We collected and studied seven species that are traditionally used as vegetable in Ladakh region. The plants including *Fagopyrum tataricum, Rumex patientia, Fagopyrum esculentum, Amaranthus cruentus, Malva verticillata, Lepidium latifolium* and *Atriplex hortensis*. The plants were grown at experimental field of DIHAR at Leh Ladakh, and studied for yield potential and consumer acceptance.

2. MATERIALS AND METHODS

2.1 Plant Material And Morphological Characters

Seeds of *F. tataricum, R. patientia, F. esculentum, A. cruentus, M. verticillata, L. latifolium* and *A. hortensis* collected from farmers in Ladakh were sown in a randomised complete block design in May 2014 and 2015 on experimental field of DIHAR at Leh Ladakh (elevation 3344 m). Morphological characters were recorded as per descriptor developed by National Bureau of Plant Genetic Resource[9] with slight modification. The data were recorded taking three replications of each accession for nine characters. Qualitative traits were recorded for variation after every 10 days interval at vegetative and flowering stages. Leaf area was recorded using portable laser leaf area meter (CI-201, CID Bio-Science). Petiole length was recorded by cutting portion of the leaf from the base of the leaf blade, and leaf thickness was measured using a digital vernier calliper (MITUTOYO, Japan). Plant height was measured from the base of the plant to tip of the leaf using a measuring scale. Shoot diameter was recorded by taking three readings from the lower, middle and top of the shoot. Leaf chlorophyll contents was measured with a chlorophyll content meter (CCM-200plus, Opti-Sciences, Inc., USA).

2.2 Cultivation Practices

Farm yard manure (25 $t.ha^{-1}$) was applied at the time of field preparation. Flat bed 2 m wide and 2 m long were prepared. Seeds were mixed with sand in 3:1 ratio and sown in rows 20 cm apart. Plant to plant distance was maintained at 12 cm by thinning. Irrigation was done by flooding immediately after sowing followed by seven days interval at later stages. Weeding was done manually. Additional FYM (1.5 $kg.m^2$) was applied at the time of hoeing after first picking of leaf. Leaf harvest was made by cutting the plant few centimetres above the ground except in case of *M. verticillata* where it was harvested by topping leaves at middle of petiole.

2.3 Organoleptic Test

Forty-five trained subjects which were healthy and non-smokers in the age bracket of 20 to 55 years, comprising of 20 female and 25 male were selected to participate in the organoleptic test trials. The subjects were asked to refrain from eating or drinking for a minimum of one hour prior to their individual testing sessions. On the day of testing, freshly harvested leaves were washed and trimmed before preparation. It was cooked and a pinch of salt was added. A stir bar was used to mix the salt until it was completely dissolved, and then promptly store in a containers at room temperature. Each subject was asked to score the samples on 9-points hedonic scale on paper ballot[10]. In between each sample, panellists were asked to rinse their mouth at least twice with water during a one minute break. A five minute break was given between testing blocks to prevent fatiguing.

2.4 Data Analysis

The data was analysed for one way analysis of variance (ANOVA). Correlation and 2-sided Tukey's Honestly Significant Difference (HSD) at $p \leq 0.05$ was carried out using Statistical Package for Social Sciences (SPSS) 17.0.

3. RESULTS AND DISCUSSION

3.1 Crop Yield Potential

The yield potential of ILVs are presented in Table 1. Significant difference in yield potential was observed which ranged from 0.45 $kg.m^2$ to 1.86 $kg.m^2$. *A. hortensis* showed the highest yield (1.86 $kg.m^2$) followed *F. tataricum* (1.75 $kg.m^2$) and *R. patientia* (0.86 $kg.m^2$). The crops attain harvesting stage between 25 to 85 days after sowing. Large variation in numbers of days to harvesting ensured availability of the ILV for a longer duration in the harsh environmental conditions.

3.2. Morphological Characters

Significant variation in plant morphological characters were observed between the seven ILVs studied (Table 2).

Table 1. List of indigenous leafy vegetables of trans-Himalayan Ladakh and yield potential

Botanical name	Vernacular name	Common name	Days of harvesting	Yield ($kg.m^2$)
Amaranthus cruentus	Khi snama	Amaranth	60-70	0.65 ± 0.38^{b}
Atriplex hortensis	Phaltora/Phaltor	Mountain orach	25-30	1.80 ± 0.06^{d}
Fagopyrum esculentum	Tayat/bro	Buckwheat	45-50	0.75 ± 0.03^{bc}
Fagopyrum tataricum	Tayat/Kho bro	Buckwheat	50-55	1.75 ± 0.04^{d}
Malva verticillata	Sochilik	Chinese mallow	75-85	0.64 ± 0.35^{ab}
Rumex patientia	Shoma	Garden patience	70-80	0.86 ± 0.33^{c}
Lepidium latifolium	Shang sho	Pepper weed	55-68	0.45 ± 0.43^{a}

For each column, different lowercase letters indicate significantly different at $p < 0.05$

Table 2 Morphological characters of indigenous vegetables of trans-Himalayan Ladakh

Characters	*F. esculentum*	*A. hortensis*	*F. tataricum*	*M. verticillata*	*R. patientia*	*L. latifolium*	*A. cruentus*
Plant height (cm)	19.50±2.02^{c}	12.40±0.55^{ab}	16.87±0.03^{bc}	13.40±0.95^{ab}	9.00±0.58^{a}	13.00±0.58^{ab}	11.33±0.88^{a}
No. of leaf/plant	7.33±0.33^{ab}	14.00±2.00^{bc}	8.00±2.31^{abc}	6.33±1.20^{a}	14.67±1.45^{c}	9.76±0.88^{abc}	14.67±1.45^{c}
Leaf length (cm)	2.86±0.49^{a}	4.18±0.87^{ab}	5.61±0.32^{abc}	4.19±0.17^{ab}	6.49±0.32^{bc}	7.72±1.26^{c}	3.89±0.90^{ab}
Leaf width (cm)	3.33±0.44^{ab}	3.92±0.97^{abc}	5.87±0.23^{c}	4.66±0.12^{bc}	2.43±0.19^{a}	2.98±0.17^{ab}	2.43±0.19^{a}
Leaf thickness (mm)	0.48±0.11^{a}	0.50±0.13^{a}	0.48±0.02^{a}	0.32±0.01^{a}	0.24±0.03^{a}	0.49±0.14^{a}	0.30±0.03^{a}
Petiole length (cm)	3.97±0.26^{bc}	1.83±.75^{ab}	7.90±1.30^{c}	5.77±0.93^{bc}	3.33±1.42^{ab}	0.10±0.00^{a}	1.30±0.35^{a}
Leaf area (cm^2)	6.67±1.47^{a}	10.27±4.41^{a}	16.58±7.06^{a}	12.64±1.06^{a}	11.43±1.27^{a}	14.98±3.16^{a}	8.77±0.41^{a}
Chlorophyll ($mg.g^{-1}$)	28.90±0.89^{a}	55.33±2.02^{d}	38.67±2.70^{ab}	42.67±3.28^{bc}	49.37±2.18^{cd}	45.00±1.15^{bcd}	49.37±2.18^{cd}

Values represented as mean ± SD
For each row, different lowercase letters indicate significantly different at $p < 0.05$

Plant height ranged from 9.0 cm to 19.5 cm depending on the crop. The mean number of leaf ranged from 6.3 to 14.7 per plant. Leaf characteristics and petiole length showed significant differences among the seven ILVs studied. The chlorophyll contents ranged from 28.9 $mg.g^{-1}$ to 49.4 $mg.g^{-1}$.

3.3. Correlation among Variables

Table 3 present correlations among variables. Significant correlation was observed between plant height with leaf length (r = 0.438), leaf width (r = -0.435) and yield (r = -0.540). However, none of the values were highly significant. Number of leaf per plant is significantly correlated with leaf thickness (r = 0.537) and chlorophyll contents (r = -0.789). Leaf length is positively correlated with chlorophyll contents (r = 0.592), and negatively correlated with leaf width (r = -0.509). Leaf thickness is positively correlated with petiole length (r = 0.671), leaf area (r = 0.515) and yield (r = 0.549).

3.4. Organoleptic Test

Consumer preference for ILVs based on organoleptic test and its comparison with spinach is presented in Table 4. *A. hortensis* is preferred over all other leafy vegetables in terms of taste, flavour, palatability and overall acceptability. *A. cruentus* is at par with the spinach in terms of taste, flavour, palatability and overall acceptability. Other ILVs ranked lower in terms of acceptability as compared with spinach. Therefore, *A. hortensis* and *A. cruentus* need to be studied in details and promoted among the people living in the mountain terrain.

4. CONCLUSION

The study suggested that *A. hortensis* and *A. cruentus* have high palatability and preferred by the consumers. Yield potential of the cold hardy *A. hortensis* is significantly higher and it is an early maturing crop. Therefore, detail study on *A. hortensis* is required, and efforts need to be made for large scale seed production and cultivation of the species.

Table 3. Pearson's correlation coefficients of morphological characters, chlorophyll contents and yield of indigenous leafy vegetables of trans-Himalayan Ladakh (Please check, figures are incorrect)

Variables	Plant height	Leaf/ plant	Leaf length	Leaf width	Leaf thickness	Petiole length	Leaf area	Chlorophyll content	Yield
Plant height	1	0.356	0.438*	-0.435*	-0.338	-0.410	0.129	0.429	-0.540*
Leaves/plant		1	-0.335	0.325	0.537*	0.418	-0.081	-0.789**	0.141
Leaf length			1	-0.509*	-0.095	-0.412	-0.069	0.592**	0.112
Leaf width				1	-0.091	-0.170	0.616**	0.297	-0.099
Leaf thickness					1	0.671**	0.515*	-0.172	0.549**
Petiole length						1	-0.097	-0.240	0.235
Leaf area							1	-0.372	0.367
Chlorophyll content								1	0.139
Yield									1

*Significant at $p \leq 0.05$, **Significant at $p \leq 0.01$

Table 4. Organoleptic test for preference of indigenous leafy vegetables of trans-Himalayan Ladakh in comparison to spinach

Vegetable	Taste	Flavour	Palatability	Overall acceptability
Spinach	7.50±0.43^{bc}	7.33±0.49^{bc}	7.00±0.36^{bc}	7.33±0.49^{bc}
Amaranthus cruentus	7.33±0.49^{bc}	7.17±0.48^{bc}	7.17±0.48^{bc}	7.00±0.45^{bc}
Fagopyrum tataricum	7.33±0.75^{bc}	6.83±0.40^{bc}	6.50±0.50^{abc}	6.67±0.61^{bc}
Malva vertiselester	6.17±0.21^{b}	5.67±0.61^{ab}	5.67±0.92^{ab}	5.17±1.11^{ab}
Atriplex hortensis	8.67±0.45^{c}	8.33±0.21^{c}	8.33±0.33^{c}	8.33±0.33^{c}
Fagopyrum esculentum	6.00±0.60^{b}	5.83±0.48^{ab}	5.83±0.60^{abc}	5.83±0.60^{abc}
Rumex patientia	5.83±0.33^{b}	5.33±0.76^{ab}	5.50±0.67^{ab}	5.50±0.67^{abc}
Lepidium latifolium	3.33±0.27^{a}	4.00±0.26^{a}	4.33±0.33^{a}	3.12 ±0.60^{a}

Values represented as mean ± SD

For each column, different lowercase letters indicate significantly different at $p < 0.05$

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He has contributed towards conducting field experiment, data generation, analysis and manuscript preparation.

Mr Samar Bhadur Maurya is a Technical Officer 'A' in Vegetable Science Division at DIHAR, Leh. He is technically well versed in handling germplasm conservation, maintaining quality in seeds, seed production, greenhouse and vegetable cultivation in Ladakh. He is assisting in plant protection through various research and development projects.
He has contributed towards data collection and field experiment.