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Vegetable Storage in Freezing Winter: A Survey in Trans-Himalayan Ladakh, India

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Abstract: In the high-altitude region of Ladakh, fresh vegetable availability is limited to the summer months. Due to freezing winters and the area's remoteness, the residents of Ladakh have mastered the art of storing crops such as potatoes, carrot, radishes, onions, cabbage, turnip and swade. These stored vegetables are a crucial source of nutrition during the snow-covered months. This study presents the survey results from 140 households that aimed to gather information on vegetable storage practices during winter. To our knowledge, no similar survey has been conducted in this region. Potatoes and onions accounted for 61.3 percent of the vegetables stored, with cabbage, carrots, radishes, turnips, and swede following in decreasing order of quantity. Carrots and potatoes were the most commonly stored, with over 95 percent of surveyed farmers reporting their storage. The cellar was found to be suitable for storing all seven vegetables, while underground pits were appropriate for all except onions and cabbage. Rooms with natural ventilation were commonly used for storing onions and cabbage. The storage periods varied: cabbage, carrots, potatoes, radishes, and turnips were stored from October to April; swede from October to March; and onions from October to July. Future research and outreach initiatives should focus on addressing challenges related to digging, freezing, and rodent infestations. The results of the survey are intended to help researchers and extension personnel understand critical concerns related to vegetable storage during freezing winters in cold, arid regions.

Keywords: hidden hunger, Leh Ladakh, postharvest management, traditional knowledge, zero energy.

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1. Introduction

Vegetables are a crucial component of a healthy diet, and both variety and quantity are important. Each type of vegetable offers a unique combination of phytonutrients, so it's beneficial to consume a diverse range. Diets rich in vegetables are widely recommended for overall health. However, in the trans-Himalayan region of Ladakh, the availability of fresh vegetables is limited to the summer months. The long, harsh winters shorten the cropping season to just four to five months per year, and heavy snowfall cut off access to the region for over four months annually. As a result, there are significant seasonal differences in dietary intake. The consumption of fresh vegetables drops notably during winter, leading to micronutrient deficiencies—a situation often referred to as "hidden hunger" (Dame and Nüsser, 2011). A survey conducted in 2008 revealed that only 19.4 percent of the population in Ladakh is well-nourished, while 35 percent suffer from malnutrition-related diseases (Dar and Rather, 2014).

Due to the freezing winters and the remoteness of the region, the people of Ladakh have perfected the art of storing crops such as potatoes, carrot, radish, onions, cabbage, turnip and swade (Fig. 1). Their traditional storage methods are entirely reliant on local natural resources. These stored vegetables serve as a crucial source of nutrition during the snow-covered months, helping to break the monotony of relying solely on dried vegetables (Stobdan, 2023). Even with the modernization of various activities in the region, traditional vegetable storage methods continue to play an important role in the lives of the local people. The four most common methods of vegetable storage in the region are *Sadong*, *Tsothbang*, *Charches*, and *Thingches*.

An underground storage pit, locally known as *Sadong*, is used for storing vegetables such as radishes, carrots, turnips, and potatoes. The size of the pits varies depending on the quantity of vegetables being stored. Typically, these pits are 150-180 cm deep, with a surface diameter of 90-120 cm and a basal diameter of 150-180 cm. The pits are dug in October, shortly after the crop harvest. Only vegetables that are free from cuts, cracks, bruises, or other insect or mechanical injuries are placed in the pit, which is filled up to 30 cm above ground level. Once filled, the pit is covered with gunny bags and a 45 cm thick layer of soil is placed on top. In warmer weather during late autumn or early spring, the above-ground soil layer are reduced to 30 cm. Separate pits are constructed for different types of vegetables. However, if a household's total quantity requirement is small, all vegetables are stored in a single pit. To access the stored vegetables for consumption, the pit is dug from the surface. After

removing the desired amount, the gunny bag and soil are replaced to prevent the produce from freezing. It is advisable to avoid repeatedly opening the pit, as this can increase the chances of mechanical injury to the vegetables and lead to deep freezing (Ali *et al*., 2012).

The *Tsothbang* is a rectangular storage structure featuring a small entrance and a window, which serves as a ventilator. The typical dimensions are 12 feet in length, 10 feet in width, and 6 feet in height. This structure can either be located in the basement of a house or built as a separate underground or semi-underground facility. When the *Tsothbang* is constructed in a house's basement, the entrance is usually accessed from the kitchen via a wooden staircase. The ventilator helps maintain the temperature inside, while humidity is regulated by sprinkling water every 15 to 20 days. The *Tsothbang* is primarily used for storing cabbage and root crops. When storing cabbage, it is harvested along with its roots and placed side by side in a 15 cm layer of soil spread across the floor. Root crops are accumulated in one corner of the structure and covered with a 7.5 to 10 cm thick layer of soil. This storage method effectively preserves vegetables for 5 to 6 months (Ali *et al*., 2012).

Charches and *Thingches* are methods used for onion storage in a cold room with natural ventilation and minimal human activity. The *Charches* method involves hanging onions from the ceiling. Onions are harvested when the bulbs are mature and the leaves are still green. The leaves of a bunch of onions are tied together in a knot. Strong sticks, capable of bearing the weight of the onion bunches, are hung parallel to the ceiling of an unheated storehouse using rope hooks. The onion bunches are then carefully hung on these sticks, ensuring that they are not disturbed after hanging. When needed, bulbs are removed from one end without disturbing the entire lot. This method is effective for storing onions for up to eight months, from October to May (Ali *et al*., 2012). The *Thingches* method involves spreading the cured onion bulbs on the floor of a room. This technique is widely practiced for onion storage, as it is considered one of the safest ways to prevent spoilage and sprouting. However, it is not suitable for bulk storage of onion bulbs (Tsewang *et al*., 2023).

The effectiveness of agricultural practices and postharvest management can best be assessed through a field survey. Such a survey is typically detailed and reveals the current status of widely adopted practices. The results of the survey are intended to help researchers and extension personnel understand critical concerns related to postharvest management. The objective of this survey was to gather information on several key aspects: (1) the quantity and types of vegetables being stored during the freezing winter, (2) the most

commonly used storage practices for different vegetables, (3) the storage duration for various vegetables, and (4) the advantages and disadvantages of different storage methods. With the data collected, our goal is to provide an accurate overview of vegetable storage during the freezing winter in Leh Ladakh. To the best of our knowledge, no similar survey has been conducted in this region.

Figure 1: A: Vegetables for sale during freezing winter in Ladakh; B: Vegetables stored in *Sadong* (pit); C: Cabbage stored in *Tsothbang* (cellar); D: Onion stored in room with natural ventilation (*Charches*)

2. Methodolog

The study was conducted through personal interviews with progressive vegetable growers spread across nine villages around Leh town in the Union Territory of Ladakh. The surveyed villages along with altitude were Chuchot (3200 m), Gonpa (3524 m), Nang (3583 m), Phyang (3602 m), Saboo (3489 m), Shey (3250 m), Spituk (3307 m), Skara (3469 m), and Thiksey (3316 m AMSL).

The authors visited the villages, and face-to-face interviews with the growers were held. The survey was initiated on 2nd April 2019, and it closed on 3rd May 2019, at which time 140 vegetable growers had responded. The

survey respondents included 114 female and 26 male. The average age of the respondents was 53.7±11.1 years.

3. Results and Discussion

3.1. Quantity and types of vegetables stored using different methods

Potatoes and onions comprised 61.3 percent of the vegetables stored during winter. The other stored vegetables, in decreasing order of quantity, were cabbage (12.6 percent), carrots (11.2 percent), radishes (9.7 percent), turnips (4.0 percent), and swade (1.2 percent of the total quantity). Carrots and potatoes were the most commonly stored vegetables, with over 95 percent of surveyed farmers storing them. The other vegetables, in order of the number of households that stored them, include onions (90.0 percent), radishes (85.0 percent), cabbage (55.7 percent), turnips (32.2 percent), and swade (9.2 percent of respondents). Swade is not a popular vegetable in the region, and its production is significantly lower than that of other vegetables, leading to its storage in smaller quantities by fewer farmers. The cellar was suitable for storing all seven vegetables, while the underground pit was suitable for storing all except onion and cabbage. Rooms with natural ventilation were extensively used for storing onions and cabbage. The cellar was the most commonly used method for storing cabbage and swade, while the underground pit was preferred for storing carrots, potatoes, radishes, and turnips. Onions were stored using *Charches* and *Thingches* in a room with natural ventilation.

Table 1: Total quantity of vegetables stored and the methods used by farmers in Leh Ladakh during winter

Vegetable	*Quantity stored (tonnes) (%)*	*Primary storage methods used by the vegetable growers (% respondent) (n=140)*			
		Pit (Sadong)	*Cellar (Tsothbang)*	*Room (Charches, Thingches)*	*Total*
Cabbage	41.4 (12.6)	0	35.7	20.0	55.7
Carrot	36.9 (11.2)	73.6	22.1	0	95.7
Onion	77.9 (23.7)	0	5.0	85.0	90.0
Potato	123.8 (37.6)	73.6	21.4	0	95.0
Radish	31.8 (9.7)	64.3	20.7	0	85.0
Swede	4.1 (1.2)	4.2	5.0	0	9.2
Turnip	13.0 (4.0)	29.3	2.9	0	32.2

3.2. Duration of vegetable storage in different structures

Cabbage, carrot, potato, radish, and turnip were stored from October to April. However, swede was stored for a shorter duration, i.e., October to March. Onion was stored for a longer duration, i.e., October to July. The majority of the respondents reported that all seven vegetables were stored from November to March. Storage beyond March by some vegetable growers may be due to a difference in microclimate conditions and the growers' skills.

Table 2: Duration of vegetable storage in different structures by vegetable growers in Leh Ladakh during winter

Vegetable (no. of respondent)	*Storage duration*	*Primary storage methods used by the vegetable growers (% respondent)*		
		Pit (Sadong)	*Cellar (Tsothbang)*	*Room (Charches, Thingches)*
Cabbage (n=78)	Oct-Mar	0	15.4	10.3
	Nov-Mar	0	23.1	25.6
	Nov-Apr	0	14.1	11.5
Carrot (n-=134)	Oct-Mar	16.4	6.7	0
	Nov-Mar	51.5	11.2	0
	Nov-Apr	10.5	3.7	0
Onion (n=126)	Nov-Mar	0	0	36.5
	Oct-Jun	0	0	19.8
	Oct-Jul	0	0	21.4
Potato (n=133)	Oct-Mar	10.5	4.5	0
	Nov-Mar	58.7	10.5	0
	Nov-Apr	10.5	5.3	0
Radish (n=119)	Oct-Mar	11.0	7.6	0
	Nov-Mar	54.6	12.6	0
	Nov-Apr	8.4	5.9	0
Swede (n=13)	Oct-Mar	53.8	46.2	0
Turnip (n=45)	Oct-Mar	17.8	0	0
	Nov-Apr	6.7	22.2	0
	Nov-Mar	44.4	8.9	0

3.3. Major advantages and limitations of storage structures

Growers were asked to identify one major advantage and limitation of three different storage structures. The responses are summarized in Table 3. A total of 42.9 percent of surveyed respondents reported that vegetables remain fresh and firm in the pit, which they considered the major advantage of this

storage method. Additionally, 21.4 percent identified the low cost of preparing the pit as another key advantage. For the cellar, a significant majority of 57.1 percent noted that it helped keep vegetables fresh and firm, and cited this as the major advantage. Another 28.6 percent of respondents mentioned the ease of vegetable storage in the cellar as a primary benefit. Notably, all respondents indicated that the *Charches* and *Thingches* were the best methods for storing onions. Problems associated with digging pits and occasional freezing of vegetables were commonly cited as the main drawbacks of the *Sadong* method. For the cellar, the primary issue reported by most respondents (68.6 percent) was rodent infestations. In the case of room storage, 61.4 percent of respondents noted that the inability to use the room for other purposes during the storage period was a major limitation. Furthermore, 22.9 percent of growers pointed out the unsuitability of the room for storing various types of vegetables as a significant drawback, while 12.9 percent mentioned rodent problems in room storage. To address these concerns, future research and outreach initiatives should focus on the key issues growers face with vegetable storage. If the challenges related to digging, freezing, and rodent infestations are addressed, growers will likely experience positive impacts in their storage practices.

Table 3: Major advantages and limitations of storage methods adopted by vegetable growers in Leh Ladakh (n=140)

Storage method	Advantages (% respondent)	Limitations (% respondent)
Pit (*Sadong*)	Vegetable remain fresh and firm (42.9)	Digging problem (35.7)
	Low cost (21.4)	Freezing (28.6)
	Others (35.7)	Others (35.7)
Cellar (*Tsothbang*)	Vegetable remain fresh and firm (57.1)	Rodents (68.6)
	Easy to store (28.6)	Others (31.4)
	Storage for longer duration (14.3)	
Room (*Charches*, *Thingches*)	Most suitable structure for onion storage (100)	The room cannot be used for other purposes during the storage period (61.4)
		Not suitable for storage of a variety of vegetables (22.9)
		Rodents (12.9)
		Others (2.9)

3.4. Vegetable cellar: variation and adoption

A significant number of survey respondents (35.7 percent) reported having vegetable cellars, while 64.3 percent indicated they did not own cellars (Table 4). Among those who did have cellars, the majority (82.0 percent) were built

underground, 12.0 percent were semi-underground, and 6.0 percent were above ground. Currently, there is no widely accepted structural design for vegetable cellars in the region. The orientation of the door varies significantly among cellars, which can affect the internal temperature. Temperature is crucial for maintaining the postharvest quality of fruits and vegetables, highlighting the need for further research in this area. In a specific underground cellar measuring 18 ft in length, 18 ft in width and 9 ft in height, it was observed that the temperature remained relatively constant from September to March, with mean maximum and minimum temperatures recorded at 4.5 ± 1.1ºC and 2.9 ± 1.2ºC, respectively (Dolker *et al*., 2020).

Most respondents (68.0 percent) expressed satisfaction with their existing vegetable cellars, while a notable portion (20.0 percent) were dissatisfied. This dissatisfaction may stem from the absence of standardized designs and recommended practices for vegetable storage. Furthermore, the use of vegetable cellars was primarily limited to the winter months, with over 95.0 percent of cellar owners not utilizing their cellars during the summer. Additional research in these areas is essential.

Table 4: Use and variation in vegetable cellar (*Tsothbang*) adopted by vegetable growers in Leh Ladakh

Questions/ information sought (no. of respondent)	*Options*	*% respondent*
Do you owned a vegetable cellar? (n=140)	Yes	35.7
	No	64.3
Type of vegetable cellars owned (n=50)	Underground	82.0
	Semi-ground	12.0
	Above ground	6.0
Size of the cellar (L x W x H) (n=50)	12 ft x 12 ft x 6 ft	11.4
	11 ft x 10 ft x 8 ft	11.4
	12 ft x 10 ft x 9 ft	9.1
	Others	68.2
Direction of the door (n=50)	East	30.0
	West	6.0
	North	18.0
	South	22.0
	Roof top	11.0
Are you satisfied with the existing vegetable cellar? (n=50)	Highly satisfied	12.0
	Satisfied	68.0
	Not satisfied	20.0
Do you use the cellar in summer? (n=50)	Yes	5.0
	No	95.0

5. Conclusion

Stored vegetables are a vital source of nutrition during the snowy months in the high-altitude region of Ladakh. The most commonly stored vegetables were potatoes, onions, cabbage, carrots, radishes, turnips, and swade. It is essential to conserve and promote this traditional knowledge. Growers have identified both the benefits and limitations of various storage methods. Future research and outreach initiatives should focus on addressing challenges related to digging, freezing, and rodent infestations. The findings from such efforts will assist researchers, extension personnel, administrators, and policymakers in implementing reforms for better postharvest management of vegetables during the freezing winters in cold arid regions.

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Conflict of Interest: None

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