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Effect of curing and topping on quality and shelf life of kharif onion in low hill sub-Himalayan conditions

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Abstract
This study examines the effect of curing duration and presence/absence of leaves on the post-harvest quality and shelf life of Agrifound Dark Red variety of Kharif onion, under sub-tropical conditions at College of Horticulture and Forestry, Neri, Hamirpur, Himachal Pradesh, during the 2021-2022 kharif season. The experiment was laid out as a RCBD factorial with three replications, involved in the storage of bulbs with and without tops, subjected to curing periods of 0, 5, 10, and 15 days. Data on fresh bulb weight loss, rotted bulbs, sprouted bulbs, total soluble solids (TSS) and pyruvic acid were systematically recorded at 0, 30, 60 and 90 days of storage. Bulbs stored without leaves exhibited greater weight loss over time and were more prone to rotting and sprouting as compared to those with leaves. 15 days curing of bulbs with leaves showed maximum TSS, but had minimum pyruvic acid content. Bulbs cured for 15 days and with leaves until 90 days storage period would be recommended as a good practice to maintain quality, solve the shelf life problem and encourage kharif onion cultivation.

Keywords: Curing, kharif onion, shelf life, sprouting bulbs, quality

Introduction
Onion (*Allium cepa* L.) holds significance as an underground bulb crop within tropical and subtropical region across the globe (Kindeya *et al.*, 2020) [5] The bulbs are frequently utilized as vegetables and spices in diverse dishes, establishing it as one of the most economically significant vegetable products in the country (Abdissa *et al*., 2011) [1].
India holds the top position in the world, in terms of area, the second position in production and the third position in export of onions. The majority of onion cultivation in India takes place during the rabi season (60%), followed by 20% each in the kharif and late kharif seasons. In India main onion produce comes from *rabi* season crop, some of which is exported and rest is stored for domestic consumption. The stored onion gets exhausted by August- September and people of India face onion crises every year from October to March till fresh produce comes to the market (Sharma and Dogra, 2017) [12]. The kharif crop plays an important role in fulfilling consumers demand and stabilizing the prices of onion in the country. Onion is recognized as a highly valued crop with versatile uses and is consumed worldwide for its flavor, taste, and pungency (Dabhi *et al*., 2008) [4].
Post-harvest storage of onions poses significant challenges for farmers due to the semi-perishable nature of the bulbs. Issues such as rotting, sprouting, and physiological weight loss are common during storage, leading to notable losses in both quality and quantity (Biswas, 2010) [2]. Kharif onion is a delicate commodity to store because of higher water con tent and serious losses occur due to rotting, sprouting, physiological loss in weight and moisture evaporation, resulting in 50–90% storage losses depending on genotype and storage conditions (Shivakumar, 2014) [13]. Use of improved cultivars, adoption of precision farming and innovative techniques to properly cure the bulbs and to increase post-harvest life can prove to be important steps in increasing *kharif* onion production. (Sharma and Chauhan, 2024) [11].
Curing, an essential post-harvest operation in onion processing, plays a crucial role in mitigating post-harvest decay and moisture loss. The purpose for curing onion is to remove excess moisture from onion scales and neck, thereby reducing infection from disease carrying organisms and minimizing shriveling by removing moisture from the interior. Farmers are forced to sell the

crop immediately after bulbs cured in the field at very low prices because of lack of storage awareness. The problem related to kharif onion is its poor shelf life but curing before storing may enhance shelf life provided that it is done properly and timely. Therefore, the objective of this study was to investigate whether to store onions with or without tops and optimize the number of days required for curing of kharif onion for better shelf- life and quality.

Materials and Methods

a) Description of the study site

The study was carried out in the Experimental Farm of Department of Vegetable Science, Dr. Yashwant Singh Parmar UHF, College of Horticulture and Forestry, Neri, Hamirpur during the kharif season 2021-22. The experimental farm was located at an altitude of 620 m above mean sea level with average mean maximum and minimum temperature levels of 31.3 and 12.4 °C, respectively and represented the low hill region of Himachal Pradesh.

b) Treatments and experimental layout

The sets of onion variety Agrifound Dark Red were planted on well prepared beds of 1.5 x 1.5 m at a spacing of 15 x 10cm. Throughout the investigation period, the climate at the storage room in the Vegetable Research Farm was typically sub-humid and sub-temperate, characterized by cool winters. The crop was harvested in first week of December. Harvested bulbs were sorted based on uniformity with absence of defects and cured in field with leaves and without leaves and kept at room temperature (average 18.10 °C) and replicated thrice. 100 bulbs in each replication were taken.

The study involved storing onion bulbs without and with tops (T_0 and T_1) along with curing duration of 0 days, 5 days, 10 days, and 15 days in a well-ventilated airy room stored for 90 days. The experiment was laid out in factorial RCBD with three replications. Data on fresh bulb weight loss, rotted bulbs, sprouted bulbs, total soluble solids (TSS) and pyruvic acid were systematically recorded at 0, 30, 60 and 90 days of storage.

c) Data collected and analysis

Data were recorded at every 30 days interval on parameters like bulbs fresh weight loss (%), sprouted bulbs (%), rotted bulbs (%) and quality traits like total soluble solids (^{0}B) and pyruvic acid (µmol/g).

Fresh weight loss of bulbs was determined by the weight of the bulb on 0 (initial weight), and 30 days interval for 90 days after storage using an electronic balance then follow:

Fresh weight loss percentage = (P_0-P_n/P_0) * 100 where P_0 = initial weight and P_n is nth days weight

Sprouting percentage and Rotting percentage

To calculate sprouted and rotted percentage, the sprouted and rotted bulbs were counted separately in each treatment combination with interval of 30 days for 90 days and divided by the total number of bulbs and then multiplied by 100.

Sprouting percentage = Number of bulbs sprouted/ Total number of bulbs * 100

Rotting percentage = Number of rotted bulbs / Total number of bulbs * 100

Since the observations on sprouting and rotting of bulbs do not show any variation from 0- 30days of storage, the data was recorded only at 60 and 90 days of storage. The data obtained from the present investigation was subjected to statistical analysis by adopting the standard procedure of (Panse and Sukhatme, 1985) [9]

Results and Discussion

1. Bulbs fresh weight loss

Combinations of topping, curing and storage find a significant difference in bulb fresh weight loss. Respectively, whereas Bulbs cured for 15 days with leaves shows significantly reduced bulb fresh weight loss of 0.64% after 30 days, 1.81% after 60 days and 3.39% after 90 days of storage while bulbs without leaves and not cured at all show maximum bulb fresh weight loss of 6.81% after 30 days, 10.43% after 60 days and 14.46% after 90 days of storage. As the storage period of bulbs increases, the bulb fresh weight loss also increases. Weight loss in onion bulbs during storage is due to moisture loss in respiration (Ward, 2008) [14]. While considering the combination of leaf presence and curing, the data highlighted that curing for 15 days is particularly effective due to minimum fresh weight loss of bulbs compared to bulbs without leaves. (Nega *et al.*, 2015) [7] recommended bulb harvesting with leaf intact method to enhance storage life of onion suggested maximum physiological loss in bulb weight was noticed when bulbs were stored without leaves. This may be due to absence of foliage resulting in full exposure of the bulbs to the temperature leading to increased surface temperature and moisture reduction.

Table 1: Effect of topping, curing and storage time on fresh weight loss (%) of bulbs in kharif onion

Topping	Curing time (days)	Bulb fresh weight loss (%)			
		0	30	60	90
T_0 (without leaves)	0	0.00	6.81 (2.80)	10.43 (3.38)	14.46 (3.93)
	5	0.00	4.84 (2.42)	8.44 (3.07)	12.76 (3.71)
	10	0.00	2.85 (1.96)	6.37 (2.72)	10.83 (3.44)
	15	0.00	0.70 (1.31)	2.43 (1.85)	4.23 (2.29)
T_1 (with leaves)/ with tops	0	0.00	3.08 (1.28)	5.84 (1.68)	8.74 (2.10)
	5	0.00	1.28 (1.32)	2.92 (1.86)	5.36 (2.12)
	10	0.00	0.73 (1.51)	2.47 (1.98)	3.49 (2.52)
	15	0.00	0.64 (2.02)	1.81 (2.62)	3.39 (3.12)
S.E(m) ±		0.00	0.03	0.02	0.03
CD at 5%		0.00	0.08	0.06	0.09

*Values within parenthesis are square root transformed values

2. Sprouted bulbs

The effect of topping, curing and days of storage shows a significant difference with respect to the sprouting percentage of 'Agrifound Dark Red'. Both dry matter and water from the edible fleshy scales transfer from bulbs to sprouts during the sprouting of onion bulbs, resulting in loss of market quality of such bulbs and increased shriveling. (Kukanoor, 2005) [6] reported that, sprouting is one of the major causes of qualitative as well as quantitative deterioration of stored onion bulbs. Curing of onion bulbs for 15 days, no sprouting of bulbs was recorded upto 30 days of storage. With the advancement of the storage period (60 to 90 days), the bulbs start sprouting.

Bulbs without leaves T_0 (topping) showed the maximum percentage of sprouting i.e. 15.00% and 21.67% at storage periods of 60 and 90 days, respectively while the bulbs were not cured at all and after 15 days of curing it is 5.00% and 9.67% at storage periods of 60 and 90 days, respectively. Though bulbs with leaves cured for 15 days showed a minimum percentage of sprouting, i.e. 0.67% and 2.33% at storage periods of 60 and 90 days respectively. The data clearly indicate that bulbs without leaves (T_0) experience significantly higher sprouting percentage compared to those with leaves (T_1). This suggests that the presence of leaves may play a critical role in reducing the incidence of sprouting, likely due to the residual physiological activity or protective barrier against sprout initiation.

Table 2: Effect of topping and curing on sprouting (%) at different storage intervals in kharif onion

Topping	Curing time (days)	Sprouting (%) at different storage intervals	
		60	90
T_0 (without leaves)	0	15.00 (3.99)	21.67 (4.76)
	5	10.67 (3.41)	18.67 (4.43)
	10	8.33 (3.05)	12.67 (3.69)
	15	5.00 (2.45)	9.67 (3.26)
T_1 (with leaves)	0	7.33 (2.89)	11.33 (3.51)
	5	3.33 (2.08)	6.67 (2.77)
	10	2.67 (1.91)	5.00 (2.45)
	15	0.67 (1.28)	2.33 (1.82)
S.E(m) ±		0.90	1.00
CD at 5%		2.77	3.08

*Values within parenthesis are square root transformed values

3. Rotted Bulbs

The analysis of rotting of bulbs reveals that the presence of leaves increases the susceptibility of bulbs to rotting over time. Without leaves, the percentage of rotting rises to 30% at 90 days of storage, while with leaves, it reaches upto 35% when the bulbs were not cured at all.

Curing of onion bulbs protects the bulbs against microbial infection. It heals wounds and strengthens general skin condition of the bulbs. It involves in the suberisation of outer tissues followed by the development of wound periderm which acts as an effective barrier against infection. (Booth, 1974) [3]

Moreover, curing plays a significant role in mitigating rotting losses. Curing for 15 days results in the lowest percent loss, reducing it to 12.33% without leaves, where as 16.33% with leaves when bulbs were stored for 90 days.

Table 3: Effect of topping and curing on rotting (%) at different storage intervals in kharif onion

Topping	Curing time (days)	Rotting (%) at different storage intervals	
		60	90
T_0 (without leaves)	0	30.33 (5.60)	35.00 (6.04)
	5	29.67 (5.54)	32.33 (5.77)
	10	21.33 (5.05)	25.33 (5.13)
	15	14.00 (3.88)	16.33 (4.16)
T_1 (with leaves)	0	28.33 (5.41)	30.00 (5.57)
	5	24.00 (5.01)	26.67 (5.26)
	10	17.67 (4.32)	19.33 (4.51)
	15	10.00 (3.32)	12.33 (3.65)
S.E(m) ±		N/A	N/A
CD at 5%		1.14	1.17

*Values within parenthesis are square root transformed values

4. Total soluble solids (TSS)

The analysis of total soluble solids (^{0}B) across different treatments and curing durations showed significant differences for TSS. Curing of bulbs for 15 days with leaves shows maximum TSS 15.37 ^{0}B for 90 days. This might be due to proper drying of the bulbs and conversion of polysaccharides into soluble form of sugars (Satodiya and Singh,1993) [10].

Table 4: Effect of topping, curing and storage time on TSS (^{0}Brix) content in kharif onion

Topping	Curing time (days)	TSS (^{0}Brix)			
		0	30	60	90
T_0 (without leaves)	0	13.38	13.43	13.73	14.87
	5	13.57	13.64	14.27	14.90
	10	13.18	13.49	14.67	15.04
	15	13.40	14.44	15.05	15.13
T_1 (with leaves)	0	13.62	13.67	14.10	14.92
	5	13.31	13.50	14.75	15.04
	10	14.78	14.93	15.04	15.07
	15	14.91	14.91	15.13	15.37
S.E(m) ±		0.12	0.03	0.04	0.05
CD at 5%		0.38	0.10	0.13	0.14

5. Pyruvic acid (μmol/g)

Pyruvic acid plays significant role in onion's Pungency, higher the pyruvic acid content more is pungency (Pal and Singh, 1987) [8]. This is because pyruvic acid is formed as a byproduct when the onion's flavor precursor compounds are broken down by the enzyme alliinase. Combinations of topping, curing and storage find a significant difference in pyruvic acid value. Among different treatments the highest value of pyruvic acid 2.94 μmol/g was recorded in bulbs without leaves and not cured at all and lowest value of pyruvic acid was recorded in bulbs with leaves (2.24 μmol/g) cured for 15days and stored for 90 days. There was gradual decrease of pyruvic acid content throughout the curing period, which may be attributed to the entry of pyruvic acid into oxidative pathway by pyruvate dehydrogenase

Table 5: Effect of topping, curing and storage time on pyruvic acid (μmol/g) content in kharif onion

Topping	Curing time (days)	Pyruvic acid (μmol/g)			
		0	30	60	90
T_0 (without leaves)	0	2.94	2.83	2.76	2.61
	5	2.72	2.62	2.52	2.49
	10	2.69	2.56	2.54	2.43
	15	2.56	2.44	2.34	2.25
T_1 (with leaves)	0	2.82	2.75	2.63	2.60
	5	2.68	2.53	2.47	2.50
	10	2.59	2.46	2.41	2.37
	15	2.47	2.33	2.28	2.24
S.E(m) ±		0.028	0.026	0.024	0.021
CD at 5%		0.087	0.080	0.074	0.065

Conclusion

The combined analysis of experiment reveals the critical influence of leaf presence and curing duration on post-harvest quality and shelf life of onion bulbs. Curing effectively reduces both rotting and sprouting, with curing duration of 15 days being the most beneficial across all the parameters. The presence of leaves, while minimizing rotting, appears to provide a protective effect against sprouting. They also help in reducing moisture loss and sprout initiation. The result highlights the importance of leaf presence and adequate curing, to retain more bulb weight, to minimize rotting, and sprouting, thereby preserving bulb quality and enhancing marketability. Adopting these practices can significantly extend the storage life of kharif onion thereby ensuring better economic returns for growers.

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