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INFLUENCE OF CURING METHODS AND STORAGE CONDITIONS ON THE POST-HARVEST QUALITY OF ONION BULBS

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Abstract

Influence of curing methods, storage conditions and duration on the post harvest quality of onion bulbs was studied at Agriculture Research Institute Tarnab, Peshawar, during 2006-07. Onion bulbs were cured with and without foliages and stored under different conditions e.g., cold store, cemented room and mud room for four months and evaluated for different quality attributes. Results indicated that the quality of onion bulbs was significantly affected by curing methods, storage conditions and duration. The maximum dry matter (17.5%) and TSS (11.5%) was recorded in bulbs cured with foliage as compared to 15.7% DM and 9.36% TSS with curing without foliage accordingly. The DM (21.2%) and TSS (14.9%) recorded in cold stored bulbs was followed by 15.65 and 13% DM with 9.44 and 6.65% TSS in mud and cemented room storage accordingly. Curing with foliage resulted in significantly lower weight loss, sprouting and rotting. The rate per month weight loss (1.95%), sprouting (2.4%) and rotting (0.4%) were the lowest in cold stored bulbs, while maximum 59.3, 59.5 and 31.3% accordingly were observed in bulbs stored cemented room. Weight loss, sprouting and rotting percentage increased with increasing storage duration. The lowest weight loss, sprouting and rotting (0 % each) obtained in cold store during the 1st month storage duration and highest percentage (13, 2.5 and 1.67 respectively) recorded with cemented room. After four months storage, the minimum percentage of weight loss (6%), sprouting (9.6%) and rotting (1.7%) was recorded in cold stored bulbs while the maximum weight loss (98%), sprouting (100%) and rotting (70%) was observed in bulbs stored cemented room.

Introduction

Onion (*Allium cepa* L.) is cultivated as vegetable throughout the world. In the sandy zone of Pakistan, wild onion (*A. tenuifolius* Cav.) is found as the most aggressive weed of chickpea (Khan *et al*., 2011). In Pakistan, the onion (*Allium cepa* L.) is grown over an area of 0.153 million hectares with a total production of 2.015 million tons, is an important vegetable crop in Pakistan (Nabi *et al*., 2011). It is cross pollinated and cool season vegetable crop. Onion is the oldest known vegetable, as it is mentioned in the Holy Quran and also in Bible (Shah *et al*., 2012). The onion is used as a condiment either as green leaves or mature bulb in salad and preparation of other dishes (Khan *et al*., 2005). The onion is a rich source of phosphorous, calcium sodium and fiber with no fat and is an important component of folk medicine (Nayerabi *et al*., 2001; Marwat *et al.,* 2011). The onion is low perishable crop, yet considerable deterioration may occur during storage due to rotting, sprouting, and physiological weight loss and storage losses could be as high as 66% (Biswas *et al*., 2010). Hence considerable losses during marketing leading post harvest diseases (Fatima *et al.,* 2009). The production of onion in Pakistan is generally surplus and the growers temporarily store their produce in field, under shelters, sheds and rooms under ambient conditions (Ahmad & Khan, 2005), which increase post harvest rots and decrease quality (Milenkovic *et al*., 2009). Rotting and re-growth increase the rate of respiration, heat generation and consequently enhance moisture loss and reduce the shelf life are the major factors of deterioration in onion bulbs during storage (Trevisan *et al*., 1999). Cold storage of onion is rare and the growers generally store onions with traditional techniques (Tariq *et al*., 2005). The quality of onion bulbs are better retained at low temperature (0°C), which inhibit sprouting and decay, thus ensure longer storage life (Doug, 2004). By contrast storage at high temperature (18-21°C) results in increased total storage losses (Krawiec, 2002). The retention of onion bulb quality during storage depends on the bulb maturity and variety. Generally, the more pungent the onion (i.e., yellows and reds), the longer is the storage potential (Doug, 2004). Storage of onion for extended period to catch the high prices in off season can result in more profit (Jahanzab & Nabi 2005). Traditionally onion growers cure onion bulbs for 2 or 3 days in ambient field condition and covered them with Typha dried leaves and polythene sheet. Provision of optimum curing and storage condition may enhance the storage performance of onion bulbs (Maw *et al*., 1997). Keeping in view the previous findings, it was necessary to evaluate the influence of curing methods and storage conditions on the post harvest quality of onion bulbs. However, the experiences gained in the previous experiments should also be kept as the base line of this trial.

Materials and Methods

The experiment "Influence of curing methods and storage conditions on the post harvest quality of onion bulbs" was conducted at Agriculture Research Institute Tarnab, Peshawar, during 2006-07. The bulbs were procured by growing transplanting seedlings of Swat-1 variety of onion; at plant to plant distance 10 cm and row to row 25 cm (Khan & Khan (1990). Urea, K_2SO_4 and Di-ammonium Phosphate were applied as a constant dose at the rate of 100kg, 100kg and 196 kg DAP ha-1 respectively during land preparation, while remaining 95 kg Urea ha-1 was applied 30 days after transplantation (Khan & Khan, 1990). Onions were harvested (on 3rd

June), when more than 40% of tops of leaves were bend down (Khokhar & Jilani, 2000).

Two statistical designs i.e., two factors RCB design and three factor RCBD were used for data analysis. Dry matter and TSS parameters (Factor 1- curing methods (curing of bulbs with and without foliage) and Factor 2- different storage conditions i.e., Cold store (0-1°C, RH >75%), Cemented room (34 to 38°C & RH 50-60%, and. Mud (mud made) room (27 to 31°C & RH 60-70%) with three replications. The ambient temperature was 42 to 47°C. There were three replications. The design of experiment was two factors RCB in accordance with Steel & Torrie (1980) statistical analysis procedure. While three factors RCBD was used for weight loss, sprouting and rotting of bulbs parameters, comprising factor-1 bulbs cured with and without foliage, factor 2- different storages (Cemented room, Mud room and Cold store) and factor 3- storage periods (1, 2 , 3 and 4 months).

The bulbs were cured with or without foliage for 14 days under partial shade. Uniformed medium size onion healthy bulbs (100 nos. each) were in stored under different storage conditions and data were recorded for 4 months on dry matter, TSS, weight loss, sprouting and rotting percentage of bulbs.

Total soluble solids were recorded with a hand refractometer. The scale leaf from the middle of onion was smashed and a few drops of juice were added to the on prism of absolutely dry refractometer for TSS determination. The dry matter was assessed by recording the weight of the bulb and then oven drying at 56°C for 48 hours to determine the dry weight and conversion to dry matter content. Weight loss was approximated by taking the initial bulb weight and then weighing after respective storage interval and expression as percent weight loss.

Results and Discussion

Bulb dry matter (%): There were significant differences among the different storage conditions ($p \leq 0.001$) and curing methods ($p \leq 0.01$), However, the interaction between storage conditions and curing methods was non significant. The maximum dry matter (21.15%) was recorded in bulbs stored in cold storage, while lowest (13.05%) was in cemented room storage (Table 1). According to Tariq *et al*., (2005) sugars are the major component of dry matter and are consumed due to respiration. Low temperature decreases the rate of respiration and subsequent decline in dry matter. Al-Jebori *et al*., (1988) recommended 0°C as the best temperature for keeping bulbs in a sound dormant state because it significantly decreased sprouting, rooting, decay and weight loss. By contrast high storage temperature (10 and 20°C) significantly increased sprouting, decay and weight losses and increase storage losses (Krawiec, 2002; Ko Sweesuak *et al*., 2002). The higher dry matter content (17.53%) recorded in bulbs cured with foliage in contrast to bulbs cured without foliage (15.7%) in line with the earlier reports (Pandey *et al*., 1992; Pandey *et al*., 1993).

Total soluble solids (%): The Total Soluble Solids (TSS) content of bulbs was significantly affected by storage conditions ($p \leq 0.001$), curing methods ($p \leq 0.01$), but their interaction was not significant. The maximum TSS (14.85° brix) recorded in bulbs kept in cold storage, while lowest (6.64 obrix) were in Cemented room condition (Table 1).The TSS is an important constituent of onion bulb quality. It includes sugars, salts and proteins etc, but sugar being predominant. The TSS contents generally decrease with increase in storage duration due to breakdown of sugars in respiration that causes the reduction in TSS during storage (Weichmann, 1987, Benkeblia & Shiomi, 2004). The rate of decline is correlated with decline in sugars ((Weichmann, 1987 & Krawiec, 2002) and depends on the storage temperature. The higher TSS (11.27%) recorded in bulbs cured with foliage as compared to bulbs cured without foliage (9.36%) is in agreement with Kaynas *et al*., (1995).

Bulb weight loss (%): Significant differences in weight loss were observed for storage conditions ($p \leq 0.001$), curing methods ($p \leq 0.001$), storage duration and the interaction of storage conditions and curing method ($p \leq 0.001$) as well as the interaction between storage conditions and duration ($p \leq 0.001$). The highest weight loss (59.31%) was in bulbs stored in cemented room, while weight loss was the lowest (1.95%) in cold stored bulbs (Table 3). Al-Jebori *et al*., (1988) reported storage temperature of 0^{o}C as the best for keeping bulbs in a sound dormant state and decreasing weight loss while high storage temperature tend to increase weight loss by increasing the rate of respiration and water loss from the bulbs (Biswas *et al*., 2010). Weight loss increased during storage from the minimum of 7.98 to the maximum of 65.62 with storage for four months (Table 2). The interaction of curing method, storage conditions and duration revealed the highest weight loss (96.26 and 100%) was recorded with bulbs cured with or without foliage and stored for 4 months in cemented room as compared to 1.64 and 2.67% for curing with or without foliage but stored cold storage (Table 2). Weight loss in onion bulbs during storage due to moisture loss in respiration (Ward, 1976) and hence depends on temperature. Therefore, the weight loss decrease significantly with storage at low temperature (Krawiec, 2002).

Bulb sprouting (%): There were significant differences ($p \leq 0.001$) among the different storage conditions, curing methods ($p \leq 0.001$), storage duration, the interaction between type of storage conditions and curing method ($p \leq 0.001$), the interaction between storage conditions and storage period ($p \leq 0.001$) and the interaction between curing method and storage period ($p \leq 0.001$). The maximum sprouting (59.50%) was recorded in bulbs stored in cemented room, while lowest sprouting (2.40%) found in cold stored bulbs (Table 4). The sprouting of bulbs increased from the minimum of 0.83% after one month storage to the 67.01% with increasing storage to four months (Table 4). The increase in sprouting was observed in both curing methods but after 3 months storage in cemented rooms, it was significantly higher (100%) with curing without foliage as compared to 80% with curing with foliage. The interaction of storage period and curing methods showed that the higher sprouting (35.69%) of bulbs occurred in without foliage bulbs as compared to 30.1% in bulbs cured with foliage (Table 5). Similarly the interaction of curing methods and storage period revealed that the highest sprouting (70.11%) was

recorded when bulbs were cured without foliage and stored for 4 months period in contrast to 0 or 1.67%) for curing with or without foliage and storage for one month (Table 5). The interaction of storage conditions and duration showed that the maximum sprouting (59.50%) occurred in cemented room and lowest (2.40%) was in cold stored bulbs. The highest sprouting (100%) found in bulbs stored for longer period (4 months) in cemented room (Table 5), while minimum or no sprouting was found in cold store and mud room bulbs stored for shorter period (both 1 or 2 moths). Sprouting and rooting are the main factors that cause the deterioration of onion during long term storage Adamicki (2005). The storage temperature has a significant effect on all biological processes and the bulbs stored at high temperature tend to sprout earlier (Ko Sweesuak *et al*., 2002; Krawiec, 2002). The enhanced rate of respiration may be due to the increased need of energy metabolism for sprouting bulbs (Al-Jebori *et al*., 1988). Thus, the lowest sprouting percentage in cold storage could be attributed to lower rates of respiration and other metabolic processes required for sprouting (Doug, 2004).

Table 1. Dry matter (%) of bulbs cured with or with out foliage after 4 months storage.

Storage conditions	Dry matter (%)			Total soluble solids (%)		
	Curing methods		Mean	Curing methods		Mean
	With foliage	Without foliage		With foliage	Without foliage	
Cold store	22.9	19.4	21.15 a	16.6	13.09	14.85 a
Mud room	16.27	15.03	15.65 b	10.05	8.83	9.44 b
Cemented room	13.43	12.67	13.05 c	7.15	6.14	6.65 c
Mean	17.53 a	15.7 b		11.27 a	9.36 b	

Table 2. Influence of curing methods, storage conditions and duration on the weight loss (%) of onion bulbs.

Storage conditions	Curing methods	Storage duration (months)				Mean curing method	Mean storage types
		1	2	3	4		
Cold store	With foliage	On	0.31 n	1.67 mn	4.57 1m	1.64 d	1.95 c
	Without foliage	On	On	1.56 mn	7.52 k1	2.27 d	
Mud room	With foliage	9.87 jk	36.18 i	62.49 f	88.81 c	49.34 c	52.11 b
	Without foliage	11.18 jk	40.99 gh	70.8 e	95.58 a	54.89 b	
Cemented room	With foliage	132.25 j	38.81 hi	76.44 d	96.26 ab	56.19 b	59.31 a
	Without foliage	13.56 j	43.88 g	92.31 bc	100 a	62.44 a	
Mean		7.98 d	26.7 c	50.88 b	65.62 a		

Table 3. Effect of curing methods and storage types and duration on weight loss (%) of onion bulbs.

Curing method	Storage duration (months)				Mean
	1	2	3	4	
With foliage	7.707 g	25.1 f	46.87 d	63.21 b	35.72 b
Without foliage	8.247 g	28.29 e	54.89 c	68.03 a	39.86 a
Mean	7.977 d	26.695 c	50.88 b	65.62 a	
Cold store	0 h	0.16 h	1.61 h	6.05 g	1.95 c
Mud room	10.52 f	38.58 e	66.65 d	92.69 b	52.11 b
Cemented room	13.41 f	41.35 e	84.38 c	98.13 a	59.32 a
Mean	7.977 d	26.69 c	50.88 b	65.62 a	

Table 4. Influence of bulbs curing with or with out foliage under different storage conditions in different duration of storage on the bulbs sprouting (%).

Storage conditions	Curing methods	Storage duration (months)				Mean curing methods	Mean storage conditions
		1	2	3	4		
Cold store	With foliage	On	0.31 n	1.67 mn	4.57 1m	1.64 d	1.95 c
	Without foliage	On	On	1.56 mn	7.52 k1	2.27 d	
Mud room	With foliage	9.87 jk	36.18 i	62.49 f	88.81 c	49.34 c	52.11 b
	Without foliage	11.18 jk	40.99 gh	70.8 e	95.58 a	54.89 b	
Cemented room	With foliage	132.25 j	38.81 hi	76.44 d	96.26 ab	56.19 b	59.31 a
	Without foliage	13.56 j	43.88 g	92.31 bc	100 a	62.44 a	
Mean		7.98 d	26.7 c	50.88 b	65.62 a		

Table 5. Effect of curing method, storage conditions and duration on sprouting (%) of onion bulbs.

Curing methods	Storage duration (months)				Mean
	1	2	3	4	
With foliage	0 f	16.22e	40.28d	63.9 b	30.1 b
Without foliage	1.67f	18.22e	52.77c	70.11a	35.69a
Mean	0.83d	17.22c	46.52b	67.01a	Mean
Cold store	0 g	0 g	0 g	9.6 e	2.4 c
Mud room	0.g	6.17f	49.57c	91.42b	36.79b
Cemented room	2.5 g	45.5 d	90 b	100 a	59.5 a
Mean	0.8 d	17.2 c	46.5 b	67.0 a	

Table 6. Influence of bulbs curing with or without foliage under different storage conditions in different duration of storage on the bulbs rotting (%).

Storage conditions	Curing methods	Storage duration (months)				Mean curing methods	Mean storage conditions
		1	2	3	4		
Cold store	With foliage	0 j	0 j	0 j	0 j	0 e	0.4 c
	Without foliage	0 j	0 j	0 j	3.3 i	0.8 e	
Mud room	With foliage	0 j	3.3 i	16.67 f	23.3 e	10.8 d	12.9 b
	Without foliage	0 j	6.67 h	23.3 e	30 c	15 c	
Cemented room	With foliage	0 j	10 g	26.67 d	40 b	19.2 b	31.3 a
	Without foliage	3.3 i	30 c	40 b	100 a	43.3 a	
Mean		0.56 d	8.3 c	17.78b	32.78 a		

Bulb rotting (%): Rotting of bulbs was significantly affected by storage conditions ($p \leq 0.001$), curing methods ($p \leq 0.001$), storage duration and the interaction between storage conditions and curing methods ($p \leq 0.001$). The interaction between storage conditions and duration ($p \leq 0.001$) and the interaction between curing methods and storage duration ($p \leq 0.001$) was also significant. The highest rotting (31.30%) was observed in bulbs stored in cemented room, followed by 12.9% in mud room and the lowest rotting (0.40%) in cold stored bulbs (Table 6). Bulb rotting was the minimum in both curing conditions but cold storage conditions, while highest rotting of bulbs noted in curing without foliage bulbs and storage in cemented room. Increasing storage duration resulted in increased rotting with the highest rotting (32.78%) recorded in bulbs stored for 4 months followed by 17.78, 8.3, and 0.56% with 3, 2 and 1 month storage accordingly. The interaction of curing methods, storage conditions and duration revealed that the highest rotting (100%) was recorded in curing bulbs without foliage and stored in cemented rooms for 4 months (Table 6). A positive correlation R^2= 0.99** and 0.9**) was noticed between storage duration and percentage of rotten bulbs cured with or without foliage. No rotting (0%) was observed in bulbs stored at all storage conditions for 1 month or 3 months in cold storage condition (Table 6). While rotting percentage increased in both curing methods with increasing storage duration, the increase was higher (44.44%) in bulbs cured without foliage, it was almost half in bulbs cured with foliage (21.11%). The storage conditions also showed significant interaction with storage duration. The rotting percentage of 70 and 33.34% after 3and 4 months storage respectively in cemented room was significantly higher than 26.66% and 1.67% rotting in bulbs stored in mud rooms or cold storage (Table 7). Since rotting is a biological activity resulting from the degradation of the bulbs (Ko Sweesuak *et al*., 2002; Krawiec, 2002, Khan *et al*., 2004), it is reasonable to get lower and delayed rotting at low temperature (Nabi, *et al*., 2010).

Table 7. Influence of curing method, storage conditions and duration on onion bulbs rotting (%).

Curing method	Storage duration (months)				Mean
	1	2	3	4	
With foliage	0.00f	4.44e	14.45c	21.11b	10.00b
Without foliage	1.11f	12.22d	21.11b	44.44a	19.72a
Mean	0.56d	8.33c	17.78b	32.78a	
Cold store	0.00f	0.00f	0.00f	1.67f	0.42c
Mud room	0.00f	5.00e	20.00d	26.66c	12.91b
Cemented room	1.67f	20.00d	33.34b	70.00a	31.25a
Mean	0.56d	8.33c	17.78b	32.78a	

Conclusions

The onion bulb quality can be maintained longer by curing with foliage intact and stored in cold storages. Significant retention of quality and storage life can also be achieved by using mud rooms for storing onion, when cold storage facility can not be availed. The use of cemented room for storage of onion bulbs is however, detrimental to the quality and storage life and hence must be avoided for storing onion bulbs.

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