The Pharma Innovation Journal 2023; 12(4): 1915-1922

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(4): 1915-1922

www.thepharmajournal.com
Received: 09-02-2023
Accepted: 12-03-2023

Prajakta Phadtare
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

Sumit Inamdar
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

Vinayak Jadhav
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

AN Yadav
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

Corresponding Author:
Prajakta Phadtare
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

Development of rat trap bond storage structure using natural dehumidifier

Prajakta Phadtare, Sumit Inamdar, Vinayak Jadhav and AN Yadav

Abstract
Onion storage is widely practiced worldwide in accordance to their cultural and economic practice. In India, method of storage adopted mostly depends on the traditional knowledge and commonly practiced methods are bag, pucca room, tat storage, bamboo, chawl structure and the losses associated are quite higher. Sprouting, desiccation and microbial spoilage are often observed in storage and it compels to choose advanced techniques like modified ventilated structures, modified atmospheric (MA) and controlled atmospheric (CA) storage. The CA and MA storage reduces the application of chemicals for sprout inhibition by manipulating the gas composition to extend the storage period of the onions. The onion bulbs are generally stored from May to November for a period of four to six months. However, 50-90 per cent storage losses are recorded depending upon genotype and storage conditions. The total storage losses are comprised of physiological loss in weight (PLW) i.e. moisture loss and shrinkage (30-40%), rotting (20-30%) and sprouting (20-40%). The PLW can be minimized by harvesting at right time, proper curing of onion bulbs and subsequent storage at desired temperature and humidity conditions. Generally, the rotting losses are at peak in initial months of storage, particularly in June and July, when high temperature coupled with high humidity result the losses. However, proper grading and selection of quality bulbs and good ventilation conditions can reduce the rotting losses. Application of post-harvest fungicidal sprays can also reduce the rotting. But this is not a practice in India. Sprouting losses are usually recorded at the end of storage period or when exposed to high temperature of humid air. Noticeable sprouting losses are observed because of storage of poor-quality bulbs having less rest and dormant period and also having thick neck. Comparatively, more sprouting losses are recorded in dark red and white onion cultivars than the light red onion cultivars. Hence the present investigation on, "Effect of different thicknesses of cooling pad of evaporative cooling chamber on inside environment and shelf-life of perishable commodities" Was under taken at research and development field of Farm Structure department Dr. Budhajirao Mulik college of Agricultural engineering and Technology, Mandaki-Palvan, Tal. Chiplun, Dist. Ratnagiri. To find out best suitable thickness of rap trap bond for storage onions. The rap trap bond of thicknesses 75mm (T_1), 100mm (T_2), 125mm (T_3) and one room temperature storage structure (T_0) were constructed. Depending on quality parameters *viz*. color index, Softness index, Physiological loss of weight, Moisture Content, Total soluble solids and acidity, present investigation were indicated that Treatment T_3 shows better results followed by treatment T_2, treatment T_1, and treatment T0. The shelf-life of onions in T_3 treatment was up to 14 days followed by treatment T_2 (12 to 13 days), treatment T_1 (10 to 12 days) and treatment T_0 (6 days). Thus shelf-life of onion was increased by eight days in treatment T_3 as compared to treatment T_0. Depending on inside temperature and relative humidity, treatment T_3 was shows better results followed by treatments T_2, treatment T_1, and treatment T0. Minimum temperature and maximum relative humidity shown by T3 treatment was 17 ºc and 90.4% respectively. Hence treatment T_3 is considered as best suited for storage onions with good temperature and relative humidity conditions.

Keywords: Onion storage structure, dehumidifier, rat trap bond storage.

1. Introduction

Onion is cultivated in large number of countries in the world. The area under onion in the world increased continuously and during the last one and half decade it has almost doubled (Tripathi *et al*. 2005) [75]. India, China, and Turkey are the three major onion-growing countries in the world. The major Onion producing states are Maharashtra, Madhya Pradesh, Karnataka, Gujarat, Bihar, Rajasthan, Andhra Pradesh, Haryana, West Bengal, and Uttar Pradesh in the country. These States account for almost 90% of the total onion production of the country. (Monthly Report Onion 2018). At present, Maharashtra is the largest producer of onion in the country. Maharashtra accounts for around 55-60% of the country's Kharif production and 36- 40% of country's Rabi production. Storage of onion, especially in the long gap between the Rabi crop and next Kharif crop, can save tears both for farmers and consumers by evening out the supply and demand position. Onion is an essential ingredient of Indian food. Seasonality of onion production introduces volatility in its prices and often leads to major consumer resentment, when it goes up and proves disastrous for farmers when the due to over-production price crashes. Onion, with appropriate scientific storage, can be stored for up to six months. Food preservation is most important post-harvest operation (Phadtare *et al*., 2019) [58].

Planting of Kharif onion starts in June and it arrives in market during Sept – November. The late Kharif onion planted in August arrives in the market during December- January. Onions of both these crops are not very suitable for storage. It is the main Rabi crop which arrives in March-June which, besides being the largest crop (about 25 lakh tons), is also most suitable for storage. Since the bulk of Rabi Onion is harvested during April – May, just before the onset of the monsoon, the prices of onion decline during this period while the same shoots up during the January to March. Sell of produce immediately after the harvest to save further deterioration during rains leads to most depressed prices and the middlemen in the trade get the advantage of volatility of prices of this essential commodity. The prices of onion are as low as Rs 500-600 per quintal during May while they are over Rs 1200 per quintal during July. The situation is much worse due to insignificant storage structures at village level. If only the farmers will have enough storage facilities to store and release the onion to the market evenly, the prices would have been less volatile and benefits would have accrued to both farmers and consumers.

Conventional storage of onion at the farm level had many pit falls. These temporary structures could not protect the produce from seepage of humidity and lacked aeration leading to high levels of sprouting and rotting of bulbs, thus resulting in high losses, neutralizing the advantages of higher price realization during off season. It was, therefore, realized that it would be essential to provide proper storage facility for this important food item to reduce the post-harvest losses. Government of Maharashtra took the initiative to encourage farmers to construct their own storage structures by providing subsidy for Scientific Onion Storage. Thus a permanent structure of brick masonry which must be cost effective, thermally insulated should be needed. In brick masonry, rat trap bond masonry is a cost effective application of brick masonry that has been popularized in India by the Architect Laurie Baker in the last 20-30 years. A "Rat-Trap Bond" is a type of wall brick masonry bond in which bricks are laid on (i.e. The height of each course of a brick size 230×110×75 mm, will be 110 mm plus mortar thickness) such that the shiner and rowlock are visible on the face of masonry. Thus in rat trap wall, the bricks are placed on edge, thereby leaving a cavity of 4" between the two leaves in case of a 10" thick wall. The bricks are placed alternate headers and stretchers as in Flemish bond.

The rat trap bond masonry reduces cost by reducing the consumption of bricks and cement mortar for the same cubic meter of brickwork. This is the major reason where virgin materials like brick clay and cement can be considerably saved. By adopting this method of masonry, you can save on approx. 20-35% less bricks and 30-50% less mortar; also this reduces the cost of a 9 inch wall by 20-30% and productivity of work enhances. For 1 m3 of Rat trap bond, 470 bricks are required compared to conventional brick wall where a total of 550 bricks are required. It will also help reduce the Embodied Energy of virgin materials and save the production of Green House Gases into the atmosphere. This adds this technology to the list of Green building technologies and sustainability for an appropriate option as against conventional solid brick wall masonry. This cavity adds an added advantage as it adds a green building feature of help maintain improved thermal comfort and keep the interiors colder than outside and vice versa. Inside environment of storage structure is related to temperature and humidity. The storage life of perishible commodity like onion, potato, garlic etc. is directly affected by these parameters. The humidity can be reduced by using natural dehumidifiers like coal, rock salt, baking soda etc. It is not enough to improve the ventilation of storage structure in order to reduce humidity but use of natural dehumidifiers should be essential to reduce the humidity. The substances which naturally absorb moisture are called as natural dehumidifier. Rock salt, charcoal, baking soda etc. are the natural dehumidifies which are used to reduce the humidity. Rock salt is one of the most effective materials for dehumidification. Highly absorbent and good value for money, salt is a hygroscopic material. What this means is that it draws and stores water molecules from its surrounding environment, pulling excess moisture out of the air in a similar way to that of an electric dehumidifier. Other hygroscopic substances include sugar, honey, ethanol and methamphetamine, although none of those would be as effective and the latter is likely to be very expensive. Rock salt is descent makeshift solution if you have got short term issue that is likely to be resolved within a few days. Charcoal is also a very effective natural dehumidifier. It is very easily available in every region. Charcoal in a container helps to remove the humidity from the area but it should replaced like rock salt for effective use. So in the view of above a permanent storage structure of rat trap bond brick masonry based on scientific background will be decided to test under a project title "Development of Rat Trap Bond Storage Structure Using Natural Dehumidifier" for the produce like onion, garlic and potato with following objectives,

- To develop the rat bond storage structure with natural dehumidifier
- To test the shelf life of Onion
- To determine the cost of storage structure

2. Material and Methods

2.1 Study Area

The Present investigation entitled "Development of Rat Trap Bond Storage Structure Using Natural Dehumidifier'' was conducted at the research and development laboratory of Farm structure department of Dr. Budhajirao Mulik College of Agricultural Engineering and Technology, Mandki-Palvan, Taluka-Chiplun, District- Ratnagiri (M.S.).

2.2 Climatic Conditions

The study area is located in Konkan region which is the tropical zone of Maharashtra with hot and humid climatic conditions. The average annual rainfall of the region is in between 3188 mm. Maximum relative humidity in rainy season is about 99%. Minimum relative humidity in summer season is about 50%. Maximum temperature in summer season is about 41˚C. Minimum temperature in winter season is about 19.5 ˚C.

2.3 Material

2.3.1 Bricks

For construction of Rat trap bond locally available bricks were used. The dimension of the available brick was 9 X 4 X 3 inch.

2.3.2 Weighing balance
Average weight loss of onion in rat trap bond was determined with the help of weighing balance of capacity 3kg and having least count 0.10gm.

2.3.3 Tray for storage
Perforated plastic trays are used to store the onions inside the Rat trap bond brick masonry structure.

2.3.4 Covering material
Wooden frame cover with ventilated holes was used as lid of Rat trap bond brick masonry structure which covers the structure from top.

2.3.5 Thermometer
Temperature inside the Rat trap bond brick masonry structure and outside environment was measured by using thermometer.

2.3.6 Digital Hygrometer
Digital hygrometer is used to measure relative humidity inside and outside of the Rat trap bond brick masonry structure.

2.3.7 Onions
20 onions for inside storage & 10 onions are taken.

2.3.8 Charcoal & Salt
Fully dried charcoal 15kg & salt 30 kg is used as dehumidifier.

2.3.9 Planning
Following points should be considered while selecting the site for keeping the constructed of rat trap bond.
1. There should be dry place.
2. The location should be such that there must be ample shade and free movement of air.

2.3.10 Erection of Rat trap bond brick masonry structure
1. Site was selected for construction of Rat trap bond storage structure and one room temperature storage.
2. Site selected was cleaned properly and some amount of water was applied to floor of the site.
3. For Rat Trap Bond, dimension of 1049mm × 1049mm were marked on the floor in row with proper diagonal check and by leaving 75mm brick thickness from marked row, another row was marked on outer side.
4. Brick wall was constructed on marked floor using cement and sand mortar up to height of 820mm.
5. Outer brick wall was constructed on marked floor using cement and sand mortar up to height of 800mm.
6. Room temperature storage structure with single wall was constructed by bricks, cement and sand mortar with an inner dimension of 550mm × 550mm and height up to 800mm.
7. Constructed chambers were watered continuously for 7 days in order to set the concrete to attain the strength and stability of base of structure.

2.3.11 Storage
For this purpose it was decided to bring fresh onions. So 3 kg on onions was made available from Sawarde market.

20 onions were selected and stalked in plastic trays by taking initial observations.
Then these plastic trays were placed in respective structure and closed with help of lid.

2.4 Methodology
The quality parameters such as physical and chemical parameters.

2.4.1 Quality Parameters
2.4.1.1 Colour Index
The color of onions is changed from red to dark brown during storage. The color of onion is an important feature of quality assessment. The score for color index was given on the basis visual observation. The rating of color index is defined as,
1. Dislike extremely
2. Dislike very much
3. Dislike moderately
4. Dislike slightly
5. Neither like nor dislike
6. like slightly
7. Like moderately
8. Like very much
9. Like extremely

Where,
Red indicates just harvested, edible and good condition
Light brown indicates just ripen, not edible and good condition.
Brown indicates ripen, edible and good condition.
Dark brown indicates not edible, over ripen and rotten.
For present study the observations were recorded at four day of interval for each treatment of colour index taking fifteen fruit at a time.

2.4.1.2 Softness Index
The onions should undergo from firm to slightly softened, moderately softened, advanced softened and fully softened stages during storage. The softness index was given on the basis of sensory observation.
1. Dislike extremely
2. Dislike very much
3. Dislike moderately
4. Dislike slightly
5. Neither like nor dislike
6. like slightly
7. Like moderately
8. Like very much
9. Like extremely

Where,
Firm indicates just harvested, not edible and good condition.
Slightly softened indicates just ripen, not edible and good condition.
Moderately softened indicates ripen, edible and good condition.
Advanced softened indicates not edible, over ripen.
Fully soften indicates not edible and rotten.
For present study the observations were recorded at four day of interval for each treatment for softness index taking 20 onions at a time.

2.4.1.3 Physiological loss in weight
Physiological loss in weight is given in percent by following

formula by weighing the onion before &after the storage.

Percent physiological loss in weight = $\{(W_1 - W_2) \div W_1\} \times 100$

Where
W_1 = Weight of onions before storage.
W_2 = Weight of onions after storage

The observation was recorded at one day of interval for each treatment and for physiological loss in weight ten onions were taken from stature which were kept aside for physiological loss in weight only.

2.5 Cost of Rat trap bond

It was also decided to find the construction cost of rat trap bond. The cost of each material required and labour charge were considered to determine the total cost of rat trap bond.

3. Result and Discussion

Plate 1: Construction Rat Trap Bond Masonary Onion Storage Structure

Plate 2: Onion storage inside and outside the structure

The storage of fruits is done to provide suitable environment that will permit to store the onions as long as possible without deterioration of quality. The quality of the fruits is depends upon its physiological and chemical properties *viz.* color index, softness index, physiological loss in weight. The present investigation entitled "Development of Rat Trap Bond Storage Structure Using Natural Dehumidifier" for the storage of onion conducted at research and development field of farm of farm structure department of Dr. Budhajirao Mulik college of Agricultural Engineering and Technology, Mandki-Palvan, Tal. Chiplun, Dist. Ratnagiri. The objectives were

1. To study the effect of temperature and humidity in the rap trap bond on onion and okra.
2. To study the effect of dehumidifier on inside humidity of the chamber.
3. Physical properties of onion

3.1 Firmness
3.2 Appearance
3.3 Smell
3.4 Colour
3.5 Physiological loss in weight

The results obtained were tabulated and discussed in this chapter.

3.1 Environmental Parameter

Following environmental parameters were observed during project work.

3.1.1 Inside and Outside Temperature

The temperature was recorded four times in a day as per mentioned in the methodology. The average values were worked out and tabulated. A graph was plotted between no. of days of storage and temperature inside and outside.

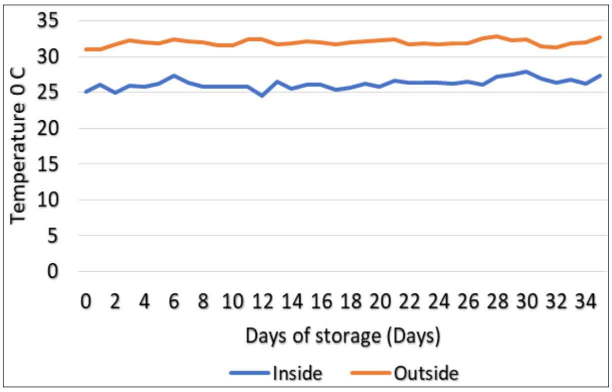

Fig 1: Variation in temperature inside rat trap bond and outside during storage

Referring to the Figure 1, it was observed that the temperature inside the rat trap bond was dropped down than that of ambient during storage period. Minimum temperature of 24.55 °C was observed on the 12th day of storage inside the rat trap bond when the outside temperature was observed 31.02 °C on 2nd day. Maximum temperature of 27.32 °C was observed on the 6th day of storage inside the rat trap bond when the outside temperature was observed 32.8 °C. Average temperature drop down of 4.68 °C was observed during storage period inside the rat trap bond.

3.1.2 Inside and Outside Relative Humidity

The relative humidity was recorded four times in day as per mentioned in the methodology.

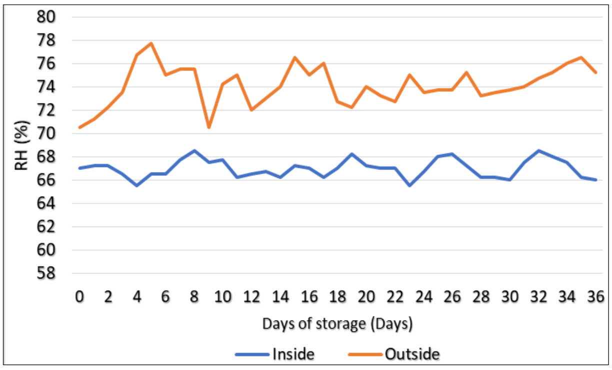

Fig 2: Variation in relative humidity inside earthen pot and outside during storage

Referring to the Figure 2 it was observed that the relative humidity inside the rat trap bond was pulled down than that of ambient during storage period. Minimum relative humidity of 66$^{\%}$ was observed during over all period of storage inside the rat trap bond when the outside relative humidity was observed in between 70.50% and 77.75%. Maximum relative humidity of 68.25% was observed during over all period of storage inside the rat trap bond when the outside relative humidity was observed in between 70.50 and 77.75%. Average relative humidity difference between inside and outside was observed 14.70% during storage period. The relative humidity was observed less inside the rat trap bond by 14.70% than outside.

3.2 Quality Parameters
Following quality parameters were observed during project work.

3.2.1 Physical Quality Parameters
Physical quality parameters like physiological loss in weight (PLW) was determined for stored onion as per methodology.

3.2.1.1 Physiological loss in weight (PLW)
The data for physiological loss in weight of onion were shown in graph were plotted.

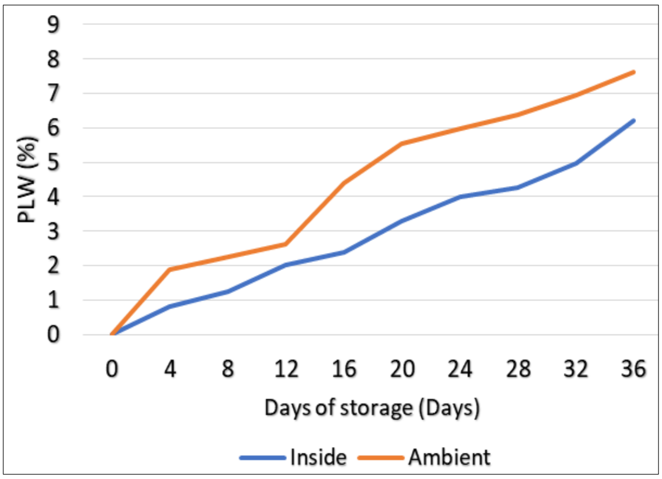

Fig 3: Variation in physiological loss in weight of onion during storage

Referring to Fig. 3 It was observed that physiological loss in weight was found maximum in outside storage of onion than that of inside storage in rat trap bond. The physiological loss in weight was ranged from 0% to 7.63% in outside storage of onion and that was ranged from 0% to 6.23% in inside storage i.e. storage in rat trap bond. Average difference between physiological loss in weight of the outside and inside storage was observed 1.40% up to 36th day for onion. That means the physiological loss in weight was observed maximum in ambient storage of onion by 1.40%.

Table 1: Firmness index, Appearance index, Colour Index and Smell index inside and outside of the structure

S. N.	Days of storage	Parameters (Inside)			
		Firmness	Appearance	Smell	Colour
1	0	9	9	9	9
2	4	9	9	9	9
3	8	9	8.66	8.66	9
4	12	8.66	8.66	8.33	8.66
5	16	8.33	8.33	8	8.33
6	20	7.66	7.66	7.33	8
7	24	7.33	7.66	7	7.66
8	28	7.33	7.33	6.66	7.66
9	32	7	7.33	6	6.66
10	36	6.33	6.66	5.66	6.33

Table 2: Firmness index, Appearance index, Colour Index and Smell index inside and outside of the structure

S. N.	Days of storage	Parameters (Outside)			
		Firmness	Appearance	Smell	Colour
1	0	9	9	9	9
2	4	8.66	8.66	8.66	8.66
3	8	8.66	8	8.66	8
4	12	7.66	7.33	7.66	7.33
5	16	7.33	7.33	7.66	6.66
6	20	7	6.33	6	5.66
7	24	6.33	5.33	5.33	4.33
8	28	6	4.66	4.33	3.33
9	32	5	4	3.33	2
10	36	3.66	2.33	2.33	1.33

3.3 Cost of Rat Trap Bond
The overall cost of rat trap bond was Rs. 15,000/-

4. Summary and Conclusion
In tropical areas like Konkan region, there is one of the most serious problems of storage of perishable commodities like fruits, vegetables and root crops after harvesting. Storage of perishable commodities is essential, because these commodities undergo physiological changes after harvesting and there is long time lag between harvesting and marketing. Storage increases the shelf life of products and helps to maintain the quality of the products. Generally storage of perishable commodities is done in cold storage but cold storage is uneconomical for small farmers. Rather than cold storage, evaporative cooling chamber is much effective and economical and affordable to small farmers and require small space. Hence the present investigation, "Effect of different thicknesses of cooling pad of evaporative cooling chamber on inside environment and shelf-life of perishable commodities" Was under taken at research and development field of Farm Structure department Dr. Budhajirao Mulik college of Agricultural engineering and Technology, Mandaki-Palvan, Tal. Chiplun, Dist. Ratnagiri. To find out best suitable thickness of cooling pad of evaporative cooling chamber for storage onion. To study the storage of onion in rat trap bond, we constructed rat trap bond with thicknesses as 22.5mm respectively and one room temperature storage structure with storage space of 550mm X 550mm and height of 800mm. We kept the onion in rat trap bond structure for storage period of 20 days. We measured temperature and relative humidity inside the rat trap bond structure for 20 days of storage. We also measured colour index, softness index, and physiological loss of weight, total soluble solids, and acidity of onion from rat trap bond structure at a four day of interval.

4.1 Summary
By comparative study of rat trap bond thicknesses of 22.5mm, we concluded that quality parameters of onion like color index, softness index, physiological loss of weight, were increased and acidity was decreased in all treatments up to 20 days of storage period. Colour was changed from dark red to dark brown in treatment T_1 up to 20 days depending upon colour index marks between 1to9. The softness was changed from firm to fully soft in T_1 treatment for 1 to 20 days depending upon marks of softness index treatment T_0 (6 days). The physiological loss of weight was increased up to 14 days with physiological loss in weight of 21.0%, treatment T_1 for 14 to 36 days (20 to 24.5%). As far as comparative study of Rat trap bond depending upon temperature and relative humidity inside the structure was concerned, inside

temperature was recorded minimum and relative humidity was recorded minimum in treatment T_1. As far as inside temperature minimum up to 17ºc and relative humidity maximum up to 94.4% and treatment T_0 (29.8 ºc and 64%).

4.2 Conclusions
1. Rat trap bond with 22.5mm thick brick has physical and chemical parameters of onion followed by room temperature storage structure.
2. The shelf-life of onion was 20 days in treatment T_1, and treatment T_0 (6 days). From above we concluded that shelf-life of onion in treatment T_1 was increase by eight days than that of room temperature storage.
3. Rat trap bond with 22.5mm thick brick (T_1 treatment) was better depending upon inside temperature and relative humidity of structure followed by chamber and room temperature storage structure.
4. As far as inside temperature and relative humidity was concerned treatment T_1 should be use full for domestic purpose for the storage of fruits and vegetables.

5. References

1. Abbey I. Effect of poultry manure and post production application of fungicide on the shelf life of onion cv. Bawku Red. Crop Research. 2000;20(1):87-92.
2. Adamicki F. Przechowywanie warzyw w kontrolowanejatmosferze. Biuletyn Warzywniczy Supplement. 1989;1:107-113.
3. Adamicki F. Effects of pre-harvest treatments and storage conditions on quality and shelf-life of onions. Acta Hortic. 2004;688:26-33.
4. Adamicki F, Kepka AK. Storage of onions in controlled atmospheres. Acta Horticulturae. 1974;38:53-73.
5. Adamicki F, Dyki B, Malewski W. Effects of carbon dioxide on the physiological disorders observed in onion bulbs during CA storage. Qualitas Plantarum. 1977;27:239-248.
6. Ali Zulfikar, Ashish Yadav, Tsering Stobdan, Shashi Bala Singh. Indian Journal of Traditional Knowledge. 2012;11(2):351-353.
7. Arora SK, Randhawa KS, Mohan S, Gupta AK. Influence of different chemicals on the storage of onion (*Allium cepa* L.). Maharashtra Journal of Horticulture. 1993;7(2):93-99.
8. Babu N, Srivastava SK, Suman Agarwal. Indian Journal of Traditional Knowledge. Bag storage. 2013;12(3):518-523. www.thebatavian.com. Date accessed on 28.02.2014
9. Bhagachandani PM, Pal N, Singh N, Chaudhary B. White onion for dehydration. Indian Horticulture. 1980;24(4):7-9.
10. Bhatnagar AK, Tyagi RPS, Bansode PC. Handling, storage and marketing of onion. Dr. Panjabrao Deshmukh Krishi Vidyapeeth Research Journal. 1989;13(2):135-139.
11. Bhor SE. Economics of production, storage and marketing of rabionion in Pune district. M.Sc. (Agri.) Thesis, Mahatma Phule Krishi Vidyapeeth, Rahuri. Biochemical characteristics of onion cv. SS1 bulbs during storage. Postharvest. Biol Technol. 2003;44:131-140
12. Bishop DJ. Controlled atmosphere storage. In Dellino, C.J.V. Editor. Cold and Chilled Storage Technology; c1996. p. 53-92.
13. Bufler G. Exogenous ethylene inhibits sprout growth in onion bulbs. Ann Bot (Lond). 2009;103:23-28.
14. Chavan VB, Dsouza TF, Kokate SB, Sawant DM. Efficacy of storage methods for minimising the bulb rots of onion. Maharashtra Journal of Horticulture. 1992;6(1):73-75.
15. Chawan T, Pflug IJ. Controlled atmosphere storage of onion. Michigan Agricultural Station Quarterly Bulletin. 1968;50:449-475.
16. Chengappa PG, Manjunatha AV, Vikas Dimble, Khalil Shah. Competitive Assessment of Onion Markets in India. Institute for Social and Economic Change. Competition commission of India; c2012. p. 1-86.
17. Chope GA, Terry LA, White PJ. The effect of 1-methylcyclopropene (1-MCP) on the physical and Controlled atmospheric storage of onions; c2007. http://omegaexports.tradeindia.com/storage-godown-1166672.html. Date accessed on 21.1.2013
18. Cools K, Gemma A, Chope GA, John P Hammond, Andrew J Thompson, Leon A Terry. Plant Physiology. 2011;156:1639-1652.
19. Cultivars under different storage methods. Haryana Journal of Horticultural Science, 24(3-4):245-250.
20. Datar VV, Mulekar VG. Investigation on post-harvest decay of onion (*Allium cepa* L.) in India. Onion Newsletter for the Tropics; c1989. November-December: 27-30. Date accessed on 01.07.13
21. Deka BC, Sarma DN, Shadeque A, Bora GC, Baruah JN. Storage behaviour of few onion; c1995.
22. Directorate of onion and garlic research. Indian council of agricultural research; c2013. http://www.dogr.res.in/ index.php?option= com content&view= article&id= 97 & Date accessed on 01.05.2013
23. FAOSTAT. Production database of onions; c2012. http://faostat.fao.org/site/339/default.aspx.
24. Fellows PJ. Food Processing Technology. Ellis Horwood, London, New York Toronto, Sydney, Tokyo and Singapore; c1988.
25. Gadalla SO. Inhibition of sprouting of onions during storage and marketing. PhD thesis, Cranfield University, UK. Hanging storage of onions; c1997. http://sallygardens.typepad.com/sallygardens. Date accessed on 04.03.2014
26. Hardenburg RE. Ventilation of packaged produce. Onions are typical of items requiring effective perforation of film bags. Modern Packaging. 1955;28(140):199-200.
27. Hardenburg RE, Watada AE, Wang CY. The commercial storage of fruits, vegetables and florist and nursery stocks. United States Department of Agriculture, Agricultural Research Service, Agriculture Handbook. 1990, 66.
28. Iordachescu CS, Nihailescu N. Studies on the improvement of technology of onion storage in large stores. Journal of Fructerlor. 1979;10(1):31-37.
29. http://www.actahort.org
30. https://agricoop.nic.in/sites/default/files/Monthly%20Report%20on%20Onion%20for%20May%2C%202018.pdf
31. Iordachescu CS, Nihailescu N. Studies on the improvement of technology of onion storage in large stores. Journal of Fructerl. 1983;10(1):31-37.
32. Iordachescu CS, Fuel N, Nihailescu V, Turbo. Studies on the possibilities of storing onions with reduced energy consumption. Agricultural Engineering Abstract. 1983;8:3.
33. Isenberg FMR. The use of maleic hydrazide on onion.

Proc. Amer. Soc. Hort. Sci. 1956;68:343-350.
34. Isenberg FMR. Controlled atmosphere storage of vegetables. Horticultural Review. 1979;1:337-394.
35. Johnson J. Onion storage revolution?. The Vegetable Farmer. 2006;2:25-26.
36. Kader AA. Modified atmosphere and low-pressure systems during transport and storage. In Kader, A.A; c1985.
37. Kader AA. A summary of CA requirements and recommendations for fruit other than pome fruits. Proceedings of the Fifth International Controlled Atmosphere Research Conference, Wenatchee, Washington, USA. 1989 June 14-16;2:303-328.
38. Karmarkar DV, Joshi MB. Investigations on the storage of onions. Indian Journal of Agricultural Sciences. 1941;11:82-89.
39. Karthikeyan C, Veeraragavathatham D, Karpagam D, AyishaFirdous S. Indian Journal of Traditional Knowledge. 2009;8(2):225-229.
40. Kasmire RF, Mitchell FG, Reid MS, Sommer NF, Thompson JF. Editors. Postharvest Technology of Horticultural Crops. Cooperative Extension, University of California, Division of Agriculture and Natural Resources, 59-60.
41. Kepka A, Adamicki F, Perlowska M. The application of a new technique for onion storage. Biuletyn Warzywniczy. 1989;1:97-105.
42. Khurana SC, Singh CB. A note on loss in weight during storage of onion bulbs. Haryana Journal of Horticultural Science. 1984;13(3-4):186-188.
43. Krishnamurthy KC, Viswanath AP, Babu CK, Subramany S. Bulletin on harvest and post-harvest Technology of onion. University of Agricultural Sciences Research Bulletin, No. UAS/HPST/87/5. 1987.
44. Kukanoor. Post – harvest studies in onion Cv. N-53. Ph.D. Thesis. University of Agricultural Sciences, Dharwad; c2005.
45. Mahadevaswamy KL. Studies on the simple storage techniques for onion cv. Ballary red with pre-harvest treatment of maleic hydrazide. M.Sc. Thesis, University of Agricultural Sciences, Bangalore; c1984.
46. Maini SB, Chakrabarti AK. Post-harvest management of onions and garlic. Souvenir, National Symposium on Onion and Garlic Production and Postharvest Management: Challenges and Strategies, 19-21 November 2000, National Research Centre for Onion and Garlic, Rajgurunagar, Nasik; c2000 p. 25-32.
47. Maini SB, Diwan B, Anand JC. Storage behaviour and drying characteristics of commercial cultivars of onion. Journal of Food Science and Technology. 1984;21(6):417.
48. Maini SB, Sagar UR, Chandan SS, Rajeshkumar. Evaluation of different structures for storage of onions. Vegetable Science. 1997;24(1):73-74.
49. Market Intelligence system. Baseline data for potato and onion; c2012. http://sfacindia.com/Docs/Onion%20&%20Potato%20Baseline%20Report.pdf.Date accessed on 01.08.2013
50. Medlicott A, Brice T, Salgado T, Ramirez D. Forced ambient air storage of different onion cultivars. Horticulture Technology. 1995;5(1):52-57.
51. Modified ventilated storage for onions. http://www.msamb.com/schemes/onionstorage.htm. Date accessed on 21.02.2014
52. Monzini A, Gorini FL. Controlled atmosphere in the storage of vegetables and flowers. Annalidell 'Istituto Sperimentale per la Valorizzazione Tecnologicadei Prodotti Agricoli. 1974;5:277–291.
53. Mukeshkumar, Kumar M. Effect of maleic hydrazide and curing on quality of kharif onion (*Allium cepa* L.) during storage. Journal of Interacademicia. 1991;4(3):382-385.
54. Murthy KC, Vishwanath AP, Babu CK, Ramakumar MV. Onion storage in Nasik type structure. Current Research. 1988;17(11):149-151.
55. National Horticultural Research and Development Board; c2012. www.nhrdf.com. Date accessed on 01.03.14
56. Pedeliski AV. Extension of onion blub dormancy by plant growth regulators and its importance in water permeability determinations. Hortic. Sci. 1973;8:416.
57. Phadtare PD, Karpe OS, Mohod AG. Application of renewable energy sources: Agriculture and agro-based industry [online]. Pucca Storage; 2019. http://www.themalaysianinsider.com/business/article/india. Date accessed on 06.03.2014
58. Rajkumar R, Lalouette JA, Bachraz DY, Sukudeep, Seebaluck BD. Selection of onion cultivars for yield, early maturity and storage potential in Mauritius. Proceedings of the Second Annual Meeting of Agricultural Scientist Reduit, 12-13 August, Mauritius; c1998.
59. Ranpise SA, Birade RM, Patil BT, Sawant SV. Factors affecting the storage of onion: A Review. The Orissa Journal of Horticulture. 2001;29(1):1-12.
60. Robinson JE, Brown KM, Burton WG. Storage characteristics of some vegetables and soft fruits. Annals of Applied Biology. 1975;81:339-408.
61. Saltveit ME. A summary of requirements and recommendations for the controlled and modified atmosphere storage of harvested vegetables. Proceedings of the Fifth International Controlled Atmosphere Research Conference, Wenatchee, Washington, USA. 1989 June 14-16;2:329-352.
62. Sea Land. Shipping Guide to Perishables. Sea Land Services Inc., Iselim, New Jersey, USA; c1991.
63. Selvaraj S. Onion: Queen of the kitchen. Kisan World. 1976;3(12):32-34.
64. Shukla BD, Gupta RK, Midmore DJ. Development and evaluation of concentric type storage structure for onions. Acta Horticulturae. 1994;358:389-394.
65. Singh K, Singh D. Effects of various methods of storage on the keeping quality of onion bulbs. Haryana Journal of Horticultural Science. 1973;2(3-4):116-122.
66. Sitton JW, Fellman JK, Patterson ME. Effects of low-oxygen and high-carbon dioxide atmospheres on postharvest quality, storage and decay of 'Walla Walla' sweet onions. Seventh International Controlled Atmosphere Research Conference, 13–18 July, University of California, Davis, California 95616, USA [abstract], 1997, 60.
67. Smittle DA. Evaluation of storage methods for 'Granex' onions. Journal of the American Society for Horticultural Science. 1988;113:877–880.
68. Smittle DA. Controlled atmosphere storage of Vidalia onions. Proceedings of the Fifth International Controlled Atmosphere Research Conference, Wenatchee, Washington, USA. 1989 June 14-16;2:171-177.
69. Stoll K. Storage of vegetables in modified atmospheres. Acta Horticulturae. 1974;38:13–23.

70. Subbaram M, Singaravelu T, Thangaraj, Irulappan I. Ventilated bamboo structure for onion storage. Onion Newsletter for the Tropics. 1990;2:38-41.
71. Thomas P, Padwal Desai SR, Srirangarajan AN, Joshi MR, Janave MT, Bhonde SR, *et al*. Pilot scale storage tests on the efficacy of gamma irradiation for sprout inhibition of onion under commercial storage conditions. Journal of Food Science and Technology. 1986;23(2):79-84.
72. Thomas TH. The role of growth substance in the regulation of onion bulb dormancy. Journal of Experimental Botany. 1969;20:124-137.
73. Tripathi PC, Lawande KE. Onion storage structure for small and marginal farmers. ICAR News, A Science and Technoogy Newsletter. 2003;9(4):18-19.
74. Tripathi PC, Dhumal SS, Jadhav HM, Lawande KE, NRCOG R. Onion storage in India-A survey Report. NRC for onion and Garlic, Rajgurunagar; c2005. p. 32.
75. Warade SD, Desale SB, Shinde KG. Effect of different recommended practices of storability of onion bulbs cultivars N-2-4-1 under modified storage structure with bottom ventilation. Vegetable Science. 1995;22(2):122-125.
76. Warade SD, Desale SB, Shinde KG. Effect of different storage recommendation on storability of onion bulbs. Journal of Maharashtra Agricultural Universities. 1997;22(3):283-285.
77. Warade SD, Desale SB, Shinde KG. Studies on storage of onion bulbs. Journal of Maharashtra Agricultural Universities. 1997;22(3):336.
78. Wittwer SH, Sharma RC, Weller LE, Sell HM. The effect of pre-harvest foliage sprays of certain growth regulators on sprout inhibition and storage quality of carrots and onions. Plant Physiology. 1950;25:539-549.
79. www.directindustry.com
80. www.searchomepro.com
81. Yamashita Koichiro, Wataru Sasaki, Kazuo Fujisaki, Hiroshi Haga. Effects of controlled atmosphere storage on storage life and shelf-life of the Japanese onion cultivar Super-Kitamomiji. 10th International Controlled & Modified Atmosphere Research Conference; c2009.