RESEARCH PAPER | International Journal of Agricultural Engineering | Volume 6 | Issue 1 | April, 2013 | 121–127

Effect on physico-chemical characteristics of cucumber and kinnow stored in evaporative cool chambers using rice husk ash as alternative material

■ YOGENDER SINGH AND Y. K. YADAV

Received : 16.10.2012; **Revised :** 16.01.2013; **Accepted :** 28.02.2013

See end of the Paper for authors' affiliation

Correspondence to:

Y. K. YADAV
Department of Processing and Food Engineering,College of Agricultural Engineering and Technology, C.C.S. Haryana Agricultural University, HISAR (HARYANA) INDIA
Email:profykyadav@yahoo.co.in

■ **ABSTRACT :** The physico-chemical characteristics of cucumber and kinnow stored in evaporative cool chambers were analyzed. The two evaporative cool chambers were developed based on the principle of evaporative cooling using alternative materials as river bed sand and rice husk ash. The average temperature drop of 8.6 °C and 10.7 °C was obtained in evaporative cool chamber with river bed sand (ECC RBS) and evaporative cool chamber with rice husk ash (ECC RHA) and average relative humidity increase of 53 per cent and 57 per cent to the ambient, respectively. These structures extended the shelf-life of commodity by 2 to 3 times. The cucumbers were stored in evaporative cool chambers in summer while kinnow were stored in winter season. The temperature and relative humidity were recorded inside the cool chambers and ambient condition on regular interval. Observations were recorded on different physico-chemical parameters to judge the shelf-life of cucumber and kinnow under all storage conditions. The rate of change of physico-chemical constituents in cucumber and kinnow stored in cool chamber with rice husk ash as cavity fill material was found slower than other storage conditions.

■ **KEY WORDS :** Physico-chemical characteristics, Evaporative cool chamber, Storage, cucumber, Kinnow, Rice husk ash

■ **HOW TO CITE THIS PAPER :** Singh, Yogender and Yadav, Y.K. (2013). Effect on physico-chemical characteristics of cucumber and kinnow stored in evaporative cool chambers using rice husk ash as alternative material. *Internat. J. Agric. Engg.*, **6**(1) : 121-127.

Post harvested losses of fruits and vegetables can be greatly minimized by storing them at low temperature and high humidity (Wills *et al.*, 1998). Naturally, fresh produce needs low temperature and high relative humidity during storage and transportation. Loss of moisture from fresh fruits and vegetables coupled with loss of nutritional components is of significant importance towards nutritional security of harvested produce. Low temperature decreases physiological, biochemical and microbiological activities which are the main cause of quality deterioration. The respiration of fresh fruits and vegetables can be reduced by many preservation techniques like low temperature, canning, dehydration, freeze-drying, controlled atmosphere, and hypobaric and modified atmosphere (Alique *et al.*, 2003).

Refrigeration and cold storage systems often used in advanced countries for fresh produce storage may not be suitable for use in India due to their high cost and energy requirement. The low cost evaporative cool chambers maintains high relative humidity and relatively low temperature and are useful for orderly marketing and quality assurance of fresh fruits and vegetables for short term holding (Roy and Pal, 1991). Fresh fruits and vegetables harvested seasonally in large amounts from different areas are mostly stored in suitable environments until marketed and consumed. Hence, development of postharvest technologies is believed to make great contribution to improve quality and use of these crops (Singh and Yadav, 2012a).

Fresh fruits and vegetables can be preserved in various ways but evaporative cool chamber storage is an environment friendly and also low energy consuming method (Singh *et al.*, 2010). This is the cheapest and simplest method for extending shelf-life of fruits and vegetables in fresh form, because it requires least amount of energy to operate and like most of cold stores it does not need chlorofluorocarbon (Jha, 2008). The evaporatively cooled environment is suggested to be a good alternative for the small-scale peasant farmers, retailers, and wholesalers, as it require low initial and running cost compared to other cooling methods (Tigist *et al.*, 2011).

It is essential to control storage temperature and relative humidity during storage as they are the main causes of fruit and vegetable deterioration during ripening and storage. The experiment was laid out with the objective to study the storage performance of cucumber and kinnow in evaporative cool chamber with river bed sand and rice husk ash as alternative material and the quality of stored produce was assessed on the basis of physico-chemical parameters in different storage conditions.

METHODOLOGY

Experimental tests were carried out at Department of Processing and Food Engineering, Chaudhary Charan Singh Haryana Agricultural University, Hisar (India) during the year 2009-2010 and the geographical location is located at 29°10/N latitude and 75°46/E longitudes with an altitude of 215 meters above mean sea level in semi arid region of North Western India. Two evaporative cool chambers were constructed with the help of baked bricks to store the commodity with the specifications described by Singh and Yadav (2012b). The performance of both the evaporative cool chambers was compared on the basis of cooling efficiency.

Performance parameters of evaporative cool chamber :

The dry bulb temperature and relative humidity were recorded throughout the storage period using digital psychrometer units. The readings were made at one hour interval during the daytime over the study period.

Cooling efficiency (CE) :

$$CE\,(\%) = \frac{Ta - Ts}{Ta - Tw} \times 100$$

Ta = dry bulb temperature of ambient air, ºC
Ts = dry bulb temperature of the cooled space air, ºC
Tw = wet bulb temperature of ambient air, ºC

Sample preparation :

For the determination of postharvest physico-chemical characteristics studies, cucumber and kinnow fruits were procured from local market of Hisar, Haryana (India). Uniform, unblemished cucumber and kinnow having similar size and color were then selected and hand washed with tap water to remove soil particles and to reduce microbes on the surface. Then, air dried and stored in different storage conditions in three replications.

The storage experiment was done by combining cucumber and kinnow with three storage conditions (ECC RBS, ECC RHA and Ambient storage). The experiment was done in randomized block design with three replications. Observations were recorded on physico-chemical parameters like physiological loss in weight (PLW)(%), firmness (kg/cm^2) of samples were recorded with the help of a pressure tester made by Ogawa Seiki Company Ltd., Japan fitted with cylindrical plunger. It was measured on equatorial region of each commodity, total soluble solids (%) by Abbe hand refractometer. The pH, acidity (%) and ascorbic acid content (mg/100g) were determined by Ranganna (2000) and overall acceptability by 9-point Hedonic rating scale was estimated at regular intervals. All the chemicals used during the present course of investigations were of analytical grade and obtained from Himedia Laboratories Limited, Bombay and Sisco Research Laboratories Pvt. Ltd., Bombay (India).

Statistical analysis :

The periodical observations on various physico-chemical parameters were made and data were analyzed by using ANOVA technique in a randomized block design using the SPSS 16.0 software. The commodities at different treatments and different storage period were studied replicating each observation thrice. The critical difference of treatments, storage period and interactions was calculated at $P \leq 0.05$.

RESULTS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in following heads:

Thermal performance of evaporative cool chambers during storage of cucumber :

During storage period of cucumber the thermal performance of the evaporative cool chamber was evaluated on the basis of the parameters *i.e.* dry bulb temperature, relative humidity, cooling efficiency etc. The ambient dry bulb temperature varied from 30.1ºC to 37.8ºC, in ECC RBS from 25.8ºC to 30.2ºC and in ECC RHA from 24.8ºC to 29.0ºC, respectively (Fig. 1). The average difference in dry bulb air temperature between ambient and ECC RBS was 6.3ºC whereas and between ambient and ECC RHA was 7.4ºC. The relative humidity (Fig. 2) indicates the variation of ambient conditions from 41per cent to 55 per cent, in ECC RBS 82 per cent to 90 per cent and in ECC RHA 89 per cent to 96 per cent,

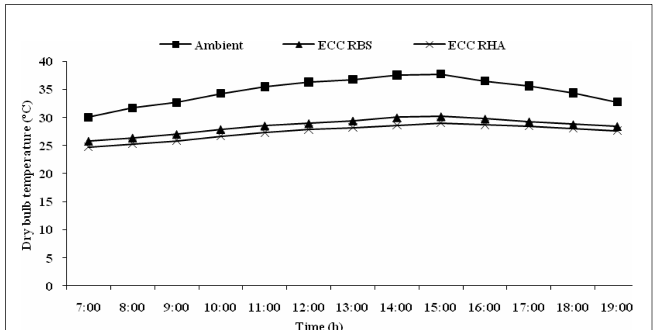

Fig. 1: Effect of day time on average dry bulb temperature of ambient environment and evaporative cool chamers during storage of cucumber in summer

respectively. The average difference in relation humidity between ambient and ECC RBS was 41 per cent and between ambient and ECC RHA was 46 per cent, respectively. The cooling efficiency (Fig. 3) during storage of cucumber of ECC RBS and ECC RHA was 52 per cent to 71 per cent and 64 per cent to 82 per cent, respectively. The average difference the cooling efficiency between ECC RBS and ECC RHA was 11 per cent.

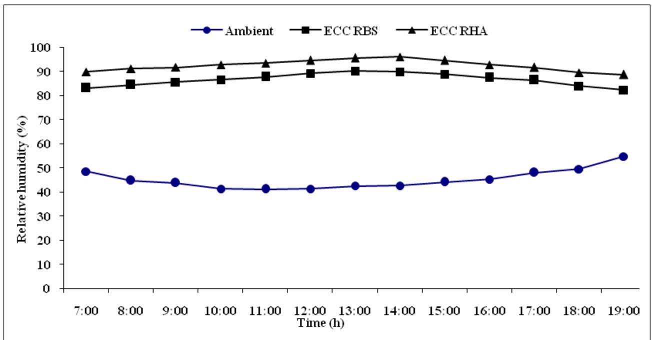

Fig. 2 : Effect of day time on average relative humidity of ambient environment and evaporative cool chambers during storage of cucumber in summer

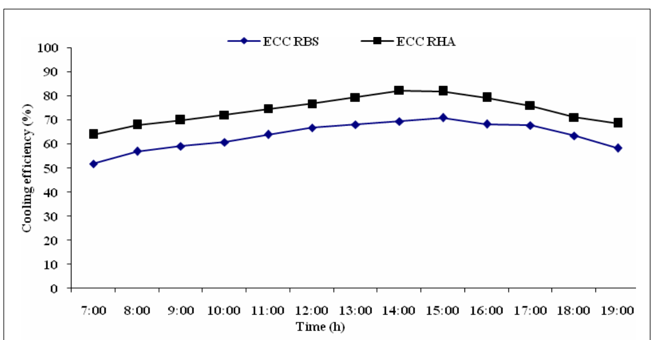

Fig. 3: Effect of day time on average cooling efficiency of evaporative cool chamers during storage of cucumber in summer

The evaporative cool chamber with risk husk ash as alterative material was found most effective in reduction of dry bulb temperature and elevation in relative humidity with higher cooling efficiency compared to evaporative cool chamber with river bed sand. Similar trend was described by Babarinsa (2006) in evaporative cool chamber using river bed sand. The evaporative cooler was effective in minimizing the extremes of temperature and RH which is in agreement with the previous reports by Getenit *et al.* (2008) and Singh and Yadav (2012b). Thus, this could have a better implication for knowing the shelf life and quality maintenance of fruits and vegetables stored under cooler areas of the country because most of warm season fruits are produced in warmer area of the country and sold in cooler areas.

Thermal performance of evaporative cool chambers during storage of kinnow :

The storage of kinnow in evaporative cool chambers the thermal performance of the storage structures was evaluated. The ambient dry bulb air temperature varied from 11.4°C to 17.1°C, in ECC RBS from 10.8°C to 15.2°C and in ECC RHA from 10.3°C to 14.8°C, respectively (Fig. 4). The average difference in dry bulb air temperature between ambient and ECC RBS was 1.5°C and between ambient and ECC RHA was 2.0°C. The relative humidity (Fig. 5) states that the variation in ambient conditions was 67 per cent to 81 per cent, in ECC RBS 96 per cent to 98 per cent and in ECC RHA 98 per cent to 99 per cent, respectively. The average difference in relative humidity between ambient and ECC RBS was 22 per cent and between ambient and ECC RHA was 23 per cent, respectively. The cooling efficiency (Fig. 6) during storage of kinnow of ECC RBS and ECC RHA was 24 per cent to 68 per cent and 44 per cent to 86 per cent, respectively. The average difference in the cooling efficiency between ECC RBS and ECC RHA was 15 per cent.

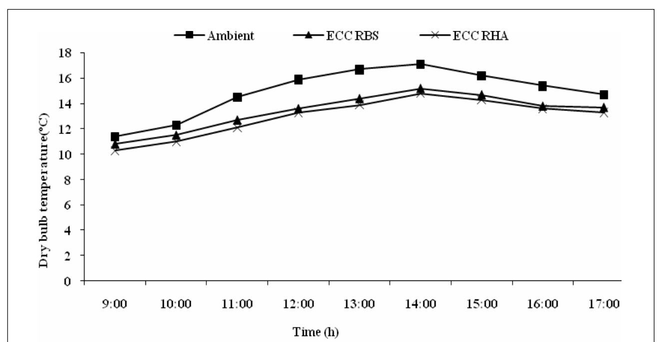

Fig. 4: Effect of day time on average dry bulb temperature of ambient environment and evaporative cool chamers during storage of kinnow in winter

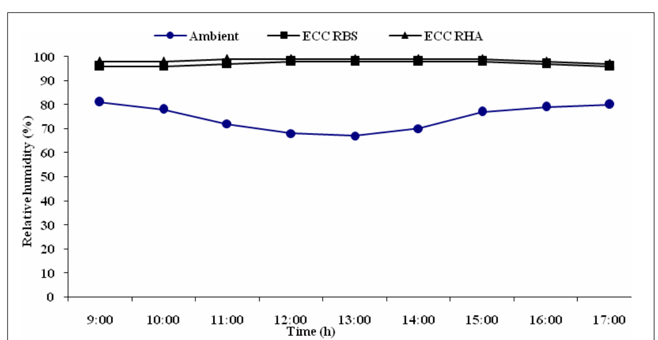

Fig. 5: Effect of day time on average relative humidity of ambient environment and evaporative cool chamers during storage of kinnow in winter

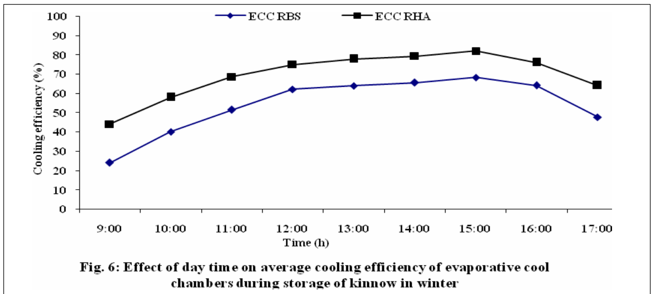

Fig. 6: Effect of day time on average cooling efficiency of evaporative cool chamers during storage of kinnow in winter

Kinnow were stored in evaporative cool chamber in winter season. The average difference in dry bulb temperature during storage of kinnow between ambient and ECC RBS was 1.5ºC and in ambient and ECC RHA was 2.0ºC whereas relative humidity was 22 per cent and 23 per cent, respectively. Similar results were described by Dzivama *et al*. (2006).

Physico-chemical constraints during storage of cucumber and kinnow :

Physiological loss in weight (%) :

Physiological loss in weight (PLW) was recorded daily during storage of cucumber and kinnow and data are presented in Table 1 and Table 2, respectively. It is clear from the data that PLW increased progressively with increase in storage period during different storage conditions. Fruits and vegetables are the living entities, all the physiological activities continue in them even after their harvest till it is fully deteriorated. Respiration and transpiration are the main processes which are responsible for loss in weight. The minimum physiological loss in weight was recorded for the produce stored in evaporative cool chamber with rice husk ash. This might be due to delayed production of ethylene in fruit and vegetable as pointed out by Venkatesha and Reddy (1994). Significant difference in weight loss of tomato and

Table 1: Changes in physico-chemical parameters of cucumber during different storage conditions in summer

Treatments (T)	Storage period (S) days								C.D. at 5%		
	0	1	2	3	4	5	6	7			
Physiological loss in weight, %											
Ambient	0.00	7.83	15.37	23.10	29.53	35.93	43.07	49.60	T	-	0.165
ECC RBS*	0.00	4.17	9.07	12.97	16.03	19.50	23.20	26.83	S	-	0.253
ECC RHA**	0.00	2.43	5.23	7.47	9.60	12.10	14.63	17.93	S×T	-	0.438
Firmness, kg/cm²											
Ambient	7.27	6.17	5.27	4.63	3.50	3.13	2.93	2.60	T	-	0.073
ECC RBS*	7.27	6.90	6.67	5.70	4.73	4.17	3.43	3.10	S	-	0.112
ECC RHA**	7.27	7.13	6.97	6.60	5.87	5.13	4.47	4.00	S×T	-	0.194
Total soluble solids, %											
Ambient	2.83	2.73	2.67	2.63	2.33	2.23	2.00	1.73	T	-	0.036
ECC RBS*	2.83	2.83	2.77	2.70	2.60	2.50	2.37	2.17	S	-	0.056
ECC RHA**	2.83	2.83	2.80	2.77	2.70	2.57	2.47	2.33	S×T	-	0.098
Acidity, %											
Ambient	0.15	0.14	0.11	0.09	0.08	0.08	0.07	0.06	T	-	0.003
ECC RBS*	0.15	0.14	0.12	0.11	0.10	0.10	0.09	0.09	S	-	0.005
ECC RHA**	0.15	0.15	0.13	0.12	0.11	0.11	0.11	0.10	S×T	-	0.009
Ascorbic acid, mg/100g											
Ambient	3.83	3.47	3.13	2.77	2.47	1.97	1.60	1.23	T	-	0.040
ECC RBS*	3.83	3.57	3.23	2.90	2.63	2.20	1.90	1.87	S	-	0.061
ECC RHA**	3.83	3.80	3.40	3.10	2.80	2.30	2.20	2.10	S×T	-	0.106
Overall acceptability, 9-point hedonic scale											
Ambient	9.00	5.37	3.10	1.00	1.00	1.00	1.00	1.00	T	-	0.086
ECC RBS*	9.00	7.07	5.10	4.00	3.93	3.07	1.00	1.00	S	-	0.132
ECC RHA**	9.00	7.67	6.97	6.07	5.10	3.57	2.80	1.00	S×T	-	0.229

*Evaporative cool chamber with river bed sand, **Evaporative cool chamber with rice husk ash kinnow fruits was observed due to the interaction effect of storage period and storage environment.

Firmness (kg/cm^2) :

Critical perusal of the data (Table 1) reveals that firmness of cucumber goes on decreasing with the increase in storage period. Dzivama *et al*. (2006) also explain the significant change in firmness for the fruits stored under ambient conditions which is at higher temperatures than that of evaporative cooler. Table 2 revealed that the firmness of the kinnow fruits decreased gradually during the storage. The firmness of fruits is an indicator for better keeping quality. Generally, there was softening of fruits as the storage time progressed which could be due to texture modification through degradation of polysaccharides such as pectins, cellulose and hemicellulose that take place during ripening.

Total soluble solids (TSS) (%) :

Results on TSS in cucumber during storage as affected by different storage conditions are presented in Table 1. Data clearly indicates that cucumber at initial stage of storage period TSS was 2.83 per cent. TSS content decreased continuously during the storage period in all the storage conditions. The decrease in TSS could be due to utilization of sugars as respiratory substrate or its conversion on condensation with other metabolites. Total soluble solids (%) during storage in kinnow as affected by different treatments are presented in Table 2. The increase in TSS content might be due to loss of water from the fruits through transpiration and might also be due to breakdown of complex polymers into simpler substances by hydrolytic enzymes. These results are similar to those described by Getenit *et al.* (2008) for tomato.

Acidity (%) :

Acidity (Table 1) of cucumber decreased significantly for entire period of storage in all storage conditions. This might have been due to reason that various acids present in fruits were utilized as a substrate during respiration process.

Table 2: Changes in physico-chemical parameters of kinnow during different storage conditions in winter

Treatments (T)	Storage period (S) days								C.D. at 5%		
	0	4	8	12	16	20	24	28			
Physiological loss in weight, %											
Ambient	0.00	3.44	6.56	9.33	12.32	15.64	18.23	22.65	T	-	0.174
ECC RBS*	0.00	1.18	2.17	3.14	4.36	5.24	6.48	6.91	S	-	0.266
ECC RHA**	0.00	0.44	1.00	1.52	2.12	2.67	3.64	4.41	S×T	-	0.462
Firmness, kg/cm^2											
Ambient	5.27	4.95	4.87	4.64	4.53	4.34	4.22	4.04	T	-	0.025
ECC RBS*	5.27	5.00	4.90	4.82	4.74	4.62	4.52	4.44	S	-	0.039
ECC RHA**	5.27	5.10	5.07	4.96	4.88	4.79	4.74	4.72	S×T	-	0.069
Total soluble solids, %											
Ambient	11.99	12.25	12.53	12.78	13.01	13.16	13.33	13.52	T	-	0.024
ECC RBS*	11.99	12.21	12.33	12.51	12.91	12.97	12.80	12.72	S	-	0.038
ECC RHA**	11.99	12.14	12.24	12.31	12.42	12.51	12.56	12.61	S×T	-	0.066
Acidity, %											
Ambient	0.98	0.92	0.87	0.84	0.79	0.74	0.68	0.62	T	-	0.005
ECC RBS*	0.98	0.94	0.90	0.86	0.83	0.79	0.75	0.71	S	-	0.008
ECC RHA**	0.98	0.95	0.91	0.89	0.88	0.82	0.81	0.79	S×T	-	0.014
Ascorbic acid, mg/100g											
Ambient	24.80	25.47	25.87	26.40	26.53	24.77	23.30	22.33	T	-	0.065
ECC RBS*	24.80	25.33	25.77	26.20	26.43	26.63	25.33	24.57	S	-	0.100
ECC RHA**	24.80	25.03	25.57	25.93	26.23	26.43	26.73	25.63	S×T	-	0.174
Overall acceptability, 9-point hedonic scale											
Ambient	8.93	8.10	7.47	6.33	5.33	4.70	3.33	2.67	T	-	0.066
ECC RBS*	8.93	8.33	7.70	7.07	6.53	6.10	5.53	4.93	S	-	0.101
ECC RHA**	8.93	8.67	8.23	7.83	7.30	6.93	6.53	6.03	S×T	-	0.176

*Evaporative cool chamber with river bed sand, **Evaporative cool chamber with rice husk ash

Results of acidity during storage in kinnow as affected by different storage are presented in Table 2. A decreased acidity may be attributed to the conversion of acid to sugar or may result from the utilization of acid during respiration. Furthermore, slow respiration as well as transpiration rate may contribute for higher retention of water in fruits (Mathooko, 2003). The greater change in acidity obtained for the produce stored under ambient condition could, therefore, be attributed to the high temperature of the ambient condition, which accelerated the metabolic activity (Dzivama *et al*., 2006).

Ascorbic acid (mg/100g) :

Data pertaining to ascorbic acid content of cucumber (Table 1) estimated during storage period revealed that the ascorbic acid content of cucumbers decreased continuously in all the storage conditions. Decrease in ascorbic acid content might be due to oxidation of ascorbic acid, which might have taken place after some time of storage. Data pertaining to ascorbic acid content of kinnow (Table 2) reveals that ascorbic acid content decreased as the storage period increased in all the storage conditions. It is an important organic acid which the plant parts synthesize themselves for unknown metabolism. The ascorbic acid content of kinnow increased up to middle of storage period and thereafter it is decreased till the end of storage period. The increase in ascorbic acid with the storage period is correlated with transpiration loss. Decrease in ascorbic acid content might be due to oxidation of ascorbic acid, which might have taken place after some time of storage. This trend is in agreement with the previous report by Bron and Jacomino (2006).

Overall acceptability (9 points hedonic rating scale) :

The observation on organoleptic rating during storage in cucumber as affected by different storage conditions is presented in Table 1. Overall acceptability was based on the organoleptic rating. This might be due to reason that in this storage condition the cucumber had slow deterioration in quality parameters. The observation on organoleptic rating during storage in kinnow was affected in different storage conditions are presented in Table 2. Fruits stored in the evaporative cool chamber with rice husk ash had better rating for all fruits stored as compared to other storage condition. This might be due to reason that in this storage condition the fruits had slow deterioration in quality parameters. These results are in conformity with findings of Singh and Yadav (2011) in guava.

Conclusion :

Evaporative cool chambers were more effective in summer than in winter. The evaporative cool chamber storage helps to maintenance of firmness by lowering the physiological loss in weight (PLW) and other metabolic processes. As the storage time advanced, produce stored in the evaporative cool chambers had shown better results in terms of total soluble solids, acidity and ascorbic acid values. The evaporative cool chamber with rice husk ash as cavity fill material was found most effective as it maintained the quality of the commodity in terms of biochemical and physiological changes during the storage and almost doubled the shelf life of the commodity stored in it.

Acknowledgement :

The authors would like to acknowledge Sh. Vijay Setia, President, All India Rice Exporters Association for their timely support in the present work.

Authors' affiliations:

YOGENDER SINGH, Department of Processing and Food Engineering, College of Agricultural Engineering and Technology, C.C.S. Haryana Agricultural University, HISAR (HARYANA) INDIA

■ REFERENCES

Alique, R., Martinez, M. A. and Alonso, J. (2003). Influence of the modified atmosphere packaging on shelf-life and quality of Navalinda sweet cherry. *European Food Res. Technol.,* **217**(5): 416–420.

Babarinsa, F.A. (2006). Performance evaluation of an evaporative cooling system for fruits and vegetable storage in tropics. *Agric. Mechanization Asia, Africa Latin America,* **37**(4): 60-65.

Bron, H.V. and Jacomino, A.P. (2006). Ripening and quality of Golden papaya fruit harvested at different maturity stages. *Brazilian J. Plant Physiol*., **18**: 389–396.

Dzivama, A.U., Igbeka, J.C. and Audu, I. (2006). Performance efficiency of an active evaporative cooling system for the storage of fruits and vegetables in a semi arid environment. *Agric. Mechanization Asia, Africa Latin America*, **37**(4): 36-41.

Getenit, H., Seyoum, T.W. and Woldetsadik, K. (2008). The effect of cultivar, maturity stage and storage environment on quality of tomatoes. *J. Food Engg*., **87**(4): 467–478.

Jha, S.N. (2008). Development of a pilot scale evaporative cooled storage structure for fruits and vegetables for hot and dry region. *J. Food Sci. Technol.,* **45**(2): 148-151.

Mathooko, F.M. (2003). A comparison of modified atmosphere packaging under ambient conditions and low temperatures storage on quality of tomato fruit. *African J. Food Agric. Nutr. Devel*., **3**: 20–27.

Ranganna, S. (2000). *Handbook of analysis and quality control of fruits and vegetables products.* Tata McGraw Hill Publ. Co. Ltd., NEW DELHI. INDIA.

Roy, S.K. and Pal, R.K. (1991). A low-cost zero energy cool chamber for short term storage of mango. *Acta Hort.,* **219**: 519-522.

Singh, Y. and Yadav, Y. K. (2011). Evaporative cool chambers using alternative materials for storage of horticultural produce. *J. Dairying Foods Home Sci.,* **30**(4): 302-306.

Singh, Y. and Yadav, Y.K. (2012a). Storage behaviour of guava fruits in evaporative cool chambers during winter Season. *J. Agric. Engg.,* **49**(3): 19-24.

Singh, Y. and Yadav, Y.K. (2012b). Performance evaluation of evaporative cool chambers using alternative materials for safe storage of fruits and vegetables. *Agril. Mechanization Asia, Africa Latin America,* **43**(2): 75-78.

Singh, Y., Yadav, Y. K. and Garg, M.K. (2010). Storage behavior of tomato in evaporative cool chambers with alternative materials. *Environ & Ecol.,* **28**(4A): 2649-2653.

Tigist, M., Workneh, T. S. and Woldetsadik, K. (2011). Effects of variety on the quality of tomato stored under ambient conditions. *J. Food Sci. Technol*., doi:10.1007/s13197-011-0378-0

Venkatesha, M. and Reddy, T.V. (1994). Use of polyethylene bags to extend the shelf life of guava (*Psidium guajava* L.) fruits. *Indian Food Packer*, **48**: 5-10.

Wills, R., Glasson, M., Graham, D.and Joyce, D.(1998). *Postharvest: An introduction to the physiology and handling of fruits, vegetables and ornamentals*. South Wales University Press, 4th edn. UNSW Press, NEW YORK, U.S.A.

***