ANALYSIS OF STORABILITY OF GUAVA IN DIFFERENT STORAGE CONDITIONS

Commented [p1]: Modified the title to:
Effect of different storage methods on the shelf life of guava fruits and some quality indicators

ABSTRACT: Guava is fifth most important fruit crop of India in production after banana, mango, citrus and papaya. Guava fruits are widely used by consumers as a fresh or are processed into a variety of value-added products in the food industries such as jam, jelly, cheese, nectar, paste. Guava fruits without any treatment and wrapper (1000g) were placed over perforated plastic round basket and stored under Room storage, Refrigeration and zero energy cool chamber (ZECC) up to 5 days with thrice replication. The moisture loss (%), mass loss (g), physiological loss in weight (PLW), shrinkage (%) and colour of guava was evaluated. It is clear from that the shelf life of guava were increased considerable by keeping them in room storage, Refrigeration and ZECC. Low PLW and shrinkage was noticed under refrigeration and ZECC throughout the period of storage. Lowest decrement in PLW and shrinkage was observed in Zero energy cool chamber, refrigeration as compared to room storage condition.

Commented [p2]: Add the place of implementation of the manuscript and the time period.

Commented [p3]: Delete.

Commented [p4]: was

Commented [p5]: The researcher is requested to rewrite the abstract to include the different storage conditions for guava fruits, and some of the results reached in this manuscript.

Key words: Room storage, Refrigeration, zero energy cool chamber, physiological loss in weight, guava.

Abbreviation

PLW: Physiological loss in weight

ZECC: Zero energy cool chamber

Introduction

India's total fruits and vegetables production is lost during harvest, storage, grading, transport, packaging and distribution in a year which reduces the growers share. Between 20 and 30% of total fruit production goes to waste owing to spoilage at various steps of the postharvest chain, reducing per capita availability of fruits to around 80 g per day which is almost half the requirement for a balanced diet. The fruit processing sector has grown at a rate of about 20% per annum [**1**]. Hence, there is a need for maximum commercial utilization of fruits and vegetables. Hence, preserving these types of foods in their fresh form demands that the chemical, bio-chemical and physiological changes are restricted to a minimum by close control of space temperature and humidity [**2**].

Due to their highly perishable nature, about 20-30% of total fruit production and 30- 35% of total vegetable production go waste during various steps of the post-harvest chain the lack of sufficient cool storage space at farm level and refrigerated storage at market level further enhances loss of fruits and vegetables [**3**]. Reducing the losses in postharvest fruit and vegetable operations is a worldwide goal [**4**]. The zero energy cool chambers working on the principle of evaporative cooling was though developed earlier, the effort to popularize this low-cost storage structure for on farm storage of perishables is snowballing only now. This could be easily

UNDER PEER REVIEW

constructed by the farmers themselves using locally available materials and could help in retaining the freshness of vegetables for a short period so that the farmers can store their produce for few days and can send the bulk of their commodity to the wholesale market avoiding distress local sale through middlemen. Temperature and humidity play major role in storage of fruits and vegetables. Temperature is the single most important factor affecting the deterioration rate of freshly harvested commodities also, proper relative humidity is required to be maintained during storage [**5**].

The storage life of fruits and vegetables can be extended greatly by removing the field heat and applying cooling as soon as possible after harvesting. The optimum storage temperature of most fruits and vegetables is above their freezing point [**6**]. Proper storage is an important for marketing and distribution of horticultural commodities. Storage also balances the daily fluctuations of supply and demand [**7**].

Storage of horticultural products inside the cool chamber has showed reduction in physiological loss in weight, optimum color, better firmness and extended shelf life by 1–2 weeks in other parts of the country. Cool chambers are effective in maintaining the fruit acceptability for a longer period and minimizing the weight loss during storage [**8**]. Relatively lower weight loss of fruits and vegetables under evaporative cooler than that of ambient has been reported by many researchers. The least deterioration in quality parameters of tomato such as TSS, acidity and ascorbic acid content when stored in zero energy cool chamber reported by [**9**].

Guava is one of the popular fruit crops and its fruits generally takes about 17-20 weeks from fruit set to maturity. Guava is fifth most important fruit crop of India in production after banana, mango, citrus and papaya. Guava fruits are widely used by consumers as a fresh or are processed into a variety of value-added products in the food industries such as jam, jelly, cheese, nectar, paste and other similar items because of high pectin content of fruits [**10**]. The fruits of guava show climacteric type of pattern in ripening and its shelf-life period ranges from 4-5 days at room temperature and ripen rapidly after harvesting because of having high moisture content. The different storage techniques and postharvest treatments are available to increase the shelf-life of guava fruits [**11**].

Commented [p6]: crops,

Commented [p7]: Rephrase the sentence in a simpler way.

Slower rate of change of physicochemical constituents in fruits stored in cool chamber reported by [**12**]. Weight loss of fresh tomato has been reported to be primarily due to

UNDER PEER REVIEW

transportation and respiration, and limited shelf-life and losses in quality have been identified as the major problems faced in the marketing of fresh tomatoes [**13**]. Zero energy cool chambers along with packaging materials, ventilation and antifungal treatments can help in minimizing the losses of ascorbic acid in the stored lemon fruits to some extent compared to the storage under ambient conditions of storage [**14**].

Materials and Methods

Commented [p8]: The researcher should add the objectives and justification for the manuscript before the materials and methods.

Commented [p9]: Fig 1

Bricks, cement mortar (1:10), rivered sand, brick batts, gunny bags were used for development of zero energy cool chamber (ZECC). Digital electronic balance, thermometer, hydrometer and water supply system were used during experiments. The development of ZECC was done with some modifications of the design of ZECC recommended by [**15, 16**].

Picture 1: Zero Energy Cool Chamber

The Zero-Energy Cool Chamber is developed under RKVY funded project entitled “Establishment of Agro Processing Centre” in 2021. Zero energy cool chamber (2 nos.) having outer dimension 210×210×50 cm and inner size 110×110×40 cm was constructed with double brick walls using cement mortar (1:10) leaving a 25 cm spacing them. Photographic view of ZECC is shown in Fig. 1. The cavity of between brick walls was filled with riverbed sand. Out of two structures, the first made of without cement mortar and second with plaster inner and outer side of structure. In present study with plaster ZECC was used for experiment of guava fruit. The inner flour of structure was made with brick and plastered with cement mortar. The top of the storage space was covered with plastic sheet. All two structure were covered with tin shade. Water supply was made through 1 inch diameter plastic pipe spread all side in cavity with small holes which is connected to rooftop water tank. The sand used in cavity were completely moistened till they got saturated. It was ensured that before actual recording of temperature and relative humidity data, the cool chamber was thoroughly wet. Water was supplied carefully in order to prevent flowing out of sand from the cavity of the walls. The whole experiment was conducted

Commented [p10]: was

UNDER PEER REVIEW

during month of April. The temperature and relative humidity of the ZECC and ambient under shed were recorded one time at 1.00pm each day with the help of liquid-in-glass thermometer and hygrometer made of India with least count of 0.5^0C and ±1%, respectively.

Freshly harvested guava of uniform shape and size, firm texture and properly mature were brought from local market of Meerut and sorted out for elimination of brushed, punctured and damaged materials generally occur during transport. Soon after sorting, the fruits were washed thoroughly in running water, drained and wiped out with tissue papers. Guava fruits without any treatment and wrapper (1000g) were placed over perforated plastic round basket and stored under Room storage, Refrigeration and zero energy cool chamber (ZECC) up to 5 days with thrice replication. The moisture loss (%), mass loss (g), physiological loss in weight (PLW), shrinkage (%) and colour of guava were evaluated. Data were noted every day at 4.00 pm in the evening and the weighing of guava was done with help of electronic balance with least count of 0.1 g while color of fruits by lightness meter made of India. The shelf life and marketability of stored guava was evaluated on the basis of all the observation data.

Commented [p11]: What type is used in this study? What quantities of guava were used in this study?

Commented [p12]: How were moisture loss (%), mass loss (g), physiological loss in weight (PLW), shrinkage (%) and color in guava evaluated, please clearly detail it with scientific references.

Results and Discussion

Commented [p13]: Discuss the results in comparison with the results of previous studies.

Guava fruits without treatment & wrapper (1000g) were placed over perforated plastic round basket and stored under Room storage, Refrigeration and zero energy cool chamber upto 5 days with thrice replication. The moisture (%), mass (g), physiological loss in weight (PLW), shrinkage (%) and colour of guava were evaluated. Data were noted each day at 4.00 pm in the evening and the weighing of guava was done with help of electronic balance while color of fruits by lightness meter (Scale: lightness '0' and darkness '100').

Variation in quality parameters like moisture (%), mass (g), physiological loss in weight (PLW), shrinkage (%) and colour of guava as affected by different storage systems are reported in Table 1. From the Fig. 1, It reported that the mass of guava was lose higher in room storage (1000 to 910.8 g) followed ZECC (1000 to 957.4 g) and lowest in refrigeration (1000 to 964.2 g) and similarly in case of moisture (%) was lose higher in room storage (502.40 to 448.67%) followed ZECC (502.40 to 476.74%) and lowest in refrigeration (502.40 to 480.84 %) (Fig. 2).

It is clear from that the shelf life of guava were increased considerable by keeping them in room storage, Refrigeration and ZECC. Low PLW and shrinkage was noticed under refrigeration

Commented [p14]: was

UNDER PEER REVIEW

and ZECC throughout the period of storage (Fig. 3). PLW was observed lower on second day of storage and there after suddenly increased on third day. It appears that high humid condition (78 to 84 %) and comparatively low temperature (23.4 to 26.9^{0}C) under zero energy cool chamber retarded the metabolic activities through respiration and transpiration, which resulted the longer shelf life and smaller physiological loss in weight (PLW) during storage period (Khan and Samsher, 2001). Similarly, lowest moisture and mass loss was observed at refrigeration and followed by ZECC and highest was at room storage due to higher temperature of ambient (33.0 to 37.8^{0}C). The loss in PLW is an indication of moisture loss from the fruits which renders fruits unmarketable as they not only lose colour, freshness and crispiness but also the palatability. Thus, the moisture loss from guava cannot be taken as mere loss in weight of produce but also it also results in loss in appearance, taste and nutrients, leading to greater economic loss **[17].** The higher relative humidity retains the moisture content of post-harvest sample. Because of water is an important factor in maintaining post-harvest quality **[18]**. Shrinkage in guava is depend on geometric dimension of guava which affected by temperature, relative humidity and type of storage conditions. Lowest shrinkage (Fig. 4) was reported in ZECC (0 to 6.54%), followed by Refrigeration (0 to 7.88 %) and highest at room temperature (0 to 15.19%). It is clear that higher temperature and low humidity affect the dimension of fruits which responsible for shrinkage of the tissue during storage. Sensory parameter like colour of guava was observed by lightness meter at each day and noticed that score of colour decreased with increasing the days of storage. Initial colour score was recorded for room storage (14.70), Refrigeration (15.95) and ZECC (15.60) whereas mean score for the last four days of storage as room storage (15.85), Refrigeration (14.52) and ZECC (14.30). The study revealed that the colour of the guava (Fig. 5) was increased in room storage as decreased in refrigeration and ZECC. Low temperature and high relative humidity decreased the colour intensity in guava while high temperature and low humidity increased color intensity Table (1-2). From Table 1, It is clear that the lowest value of coefficient of determination was found best indication of lowest Physiological loss in weight in guava during storage in ZECC.

Table 1: Effect of Quality of Guava fruits in different storages

Commented [p15]: Effect of different storage conditions on some quality indicators of guava fruits

Day of storage	Moisture, %	Mass, g	PLW, %	Shrinkage, %	Colour
Room storage					

UNDER PEER REVIEW

1	502.40	1000.0	0	0	14.70	
2	490.12	979.6	2.04	2.18	19.00	15.85
3	477.83	959.2	4.08	5.75	16.10	
4	465.84	939.3	6.07	14.45	14.80	
5	448.67	910.8	8.92	15.19	13.50	
R^2	**0.9945**	**0.9945**	**0.9945**	**0.9326**	**0.4941**	
Reg. Eq.	**y = -13.174x + 516.49**	**y = -21.87x + 1023.4**	**y = 2.187x - 2.339**	**y = 4.265x - 5.281**	**y = -0.7524x + 17.986**	
Refrigeration						
1	502.40	1000.0	0	0	15.95	
2	494.75	987.3	1.27	1.28	15.10	14.52
3	489.21	978.1	2.19	1.88	15.20	
4	488.55	977.0	2.30	2.18	13.90	
5	480.84	964.2	3.58	7.88	13.90	
R^2	**0.9489**	**0.949**	**0.9490**	**0.7488**	**0.6651**	
Reg. Eq.	**y = -4.932x + 505.95**	**y = -8.19x + 1005.9**	**y = 0.819x - 0.589**	**y = 1.666x - 2.354**	**y = -0.267x + 15.743**	
Zero Energy Cool Chamber (ZECC)						
1	502.40	1000.0	0	0	15.60	
2	496.50	990.2	0.98	0.98	13.80	14.30
3	493.43	985.1	1.49	4.08	13.80	
4	489.15	978.0	2.20	6.21	14.30	
5	476.74	957.4	4.26	6.54	15.30	
R^2	**0.9283**	**0.9283**	**0.9283**	**0.9443**	**0.0004**	
Reg. Eq.	**y = -5.867x + 509.25**	**y = -9.74x + 1011.4**	**y = 0.974x - 1.136**	**y = 1.831x - 1.931**	**y = -0.01x + 14.59**	

Table 2: Temperature and RH data of Room and ZECC storage.

Days of storage	**Room storage**		**ZECC**	
	Temp (^{0}C)	**RH (%)**	**Temp (^{0}C)**	**RH (%)**
1	37.8	39	26.9	84
2	33.0	25	25.5	78
3	36.0	25	25.4	79
4	34.3	17	25.4	79
5	33.0	20	23.4	81

UNDER PEER REVIEW

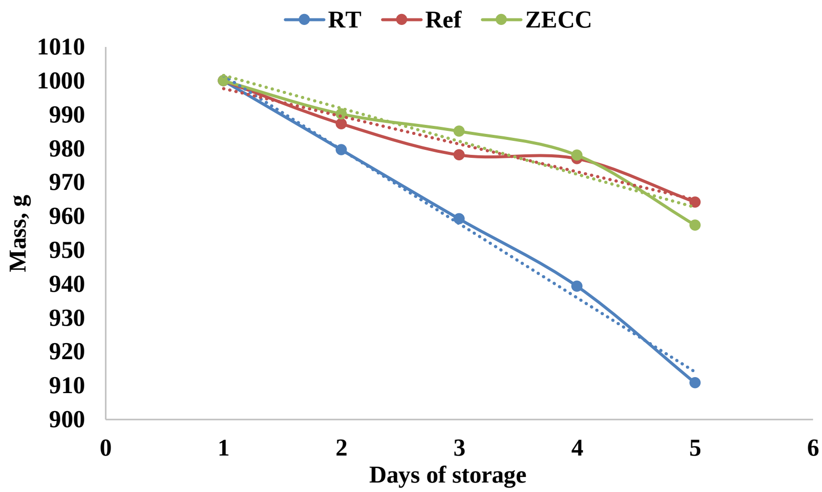

Fig. 1: Effect of different storages on mass (g) in Guava Fruits

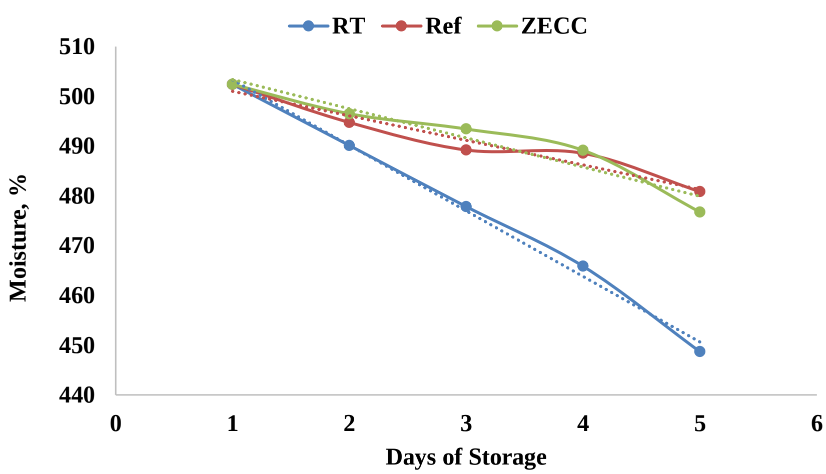

Fig. 2: Effect of different storages on moisture (%) in Guava Fruits

Commented [p16]: guava fruits

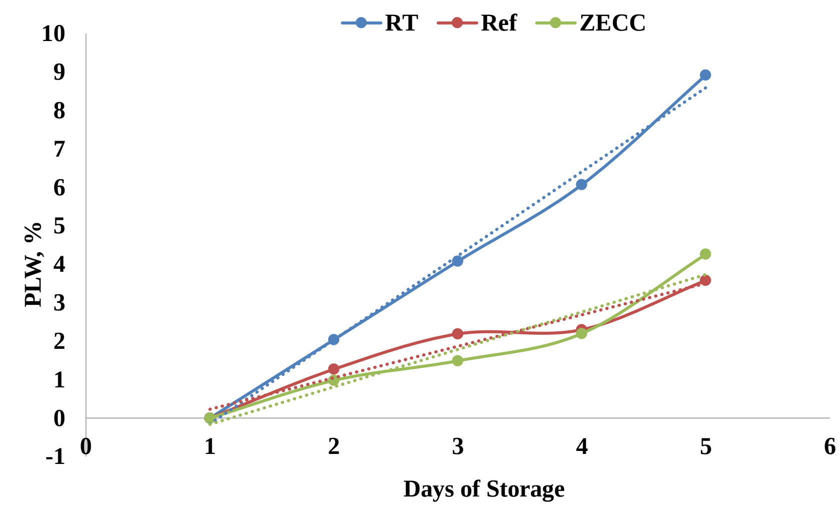

Fig. 3: Effect of different storages on Physiological Loss in Weight (%) in Guava Fruits

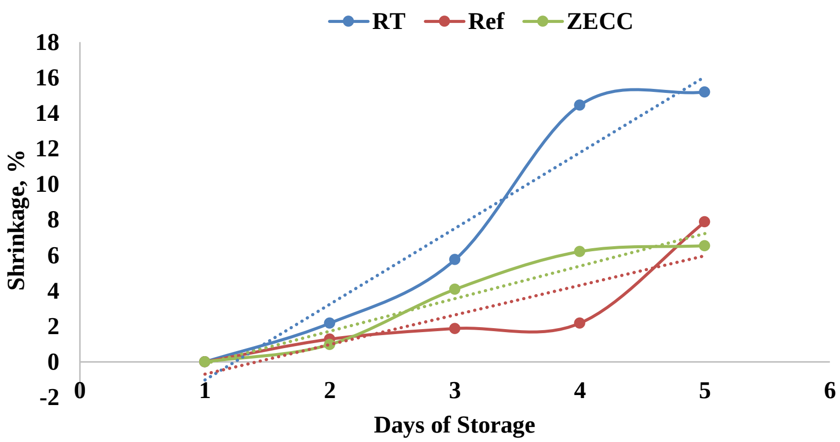

Fig. 4: Effect of different storages on Shrinkage (%) in Guava Fruits

Commented [p17]: Effect of different storages on physiological loss in weight (%) in guava fruits

Commented [p18]: shrinkage (%) in guava fruits

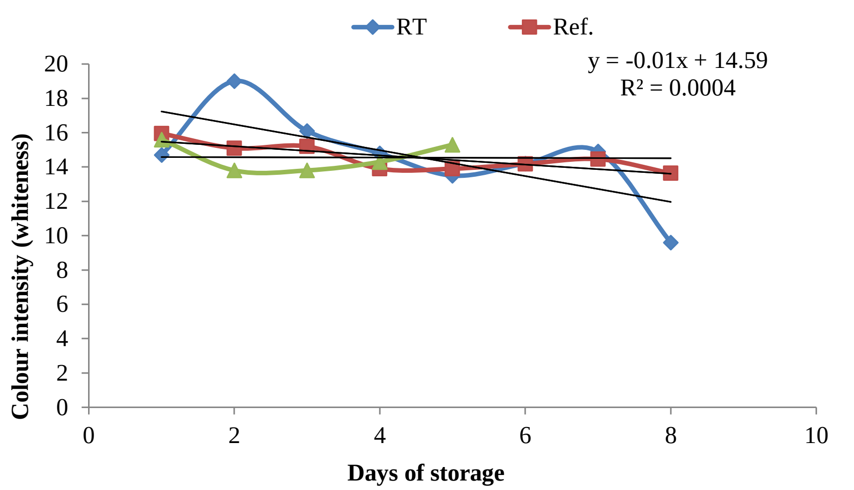

Fig. 5: Effect of different stoarge on the colour of the Guava fruits

Commented [p19]: The same.

Conclusion

The initial moisture content in Guava were evaluated 83.4 % (502.40 %, db). In case of Guava fruits, the moisture content and mass of guava was decreased while Physiological loss in weight (%) and shrinkage (%) was increased with increasing days of storage in all types of storage. Lowest decrement in PLW and shrinkage was observed in Zero energy cool chamber as compared to other storage condition. Freshness was calculated according the colour intensity (Whiteness) of fruits. Zero energy cool chambers (ZECC) are also observed the lowest rate of decrement in PLW and shrinkage. ZECC was found suitable for fruits of guava as per present study and some human errors also taken during experiments. Temperature was observed best suitable viz. 24.3 to 26.9 ^{0}C and RH 79 to 84 % in ZECC as compared to ambient storage i.e. Temperature ranged 33.0 - 37.8^{0}C and RH (17 - 39 %).

Commented [p20]: was

Recommendations

The evaporative cooled storage structure has proved to be useful for short term, on-farm storage of fruits and vegetables in hot and dry regions. Evaporative cooling is an efficient and economical means for reducing temperature and increasing the relative humidity of an enclosure,

UNDER PEER REVIEW

and has been extensively tried for enhancing the shelf life of horticultural produce which is essential for maintaining the freshness of the commodities. Evaporative cooling is an environmentally friendly air conditioning system that operates using induced processes of heat and mass transfer where water and air are working fluids. Such a system provides an inexpensive, energy efficient, environmentally benign (not requiring ozone-damaging gas as in active systems) and potentially attractive cooling system. The semi-perishable fruit and vegetables, milk and some products, cooked food, mushroom, meat, fish, flowers and that have a short shelf life can be stored inside the zero-energy cool chamber.

References

Commented [p21]: Write references in a uniform manner in accordance with the publishing instructions approved in the journal.
Use more recent references.

1. Rahul SN, Khilari K, Sagar S. Chaudhary. Challenges in Postharvest Management of Fungal Diseases in Fruits and Vegetables – A review. South Asian Journal Food Technology and Environment. 2015; 1(2):126-130.
2. Chandra P, Shrivastava R, Dash SK. Thermal behaviour of a fruits and vegetables storage structure. Journal of the Institute of Engineers (AG-1). 1999; 80(1):5.
3. FAO. Postharvest Management of Fruit and Vegetables in the Asia-Pacific. 2006.
4. Clément V, James TSW. Postharvest Technologies for Horticultural Crops California, USA. 2009; 2:25-47.
5. Kadar AA. Postharvest technology of horticultural crops, Cooperative extension. Univ. of California. Special Publication No. 331. 1992; 35-43.
6. FAO. Fruit and Vegetables processing, FAO. Agricultural Service Bulletin 119, Rome. 1995.
7. Chakraverty A, Mujumdar AS, Raghvan GS, Ramaswamy HS. Handbook of postharvest technology. Cereals, fruits, vegetables, tea and spices. Marcel Dekker, Inc, New York. 2003.
8. Bhatnagar DK, Pandita ML, Shrivastava VK. Effect of packaging materials and storage conditions on fruit acceptability and weight loss of tomato. National Workshop on Post Harvest Management of Fruits and Vegetables, March 14-16, Nagpur, India. 1990.

UNDER PEER REVIEW

9. Sandooja JK, Sharma RK, Pandit ML, Batra BR. Storage studies to tomato in zero-energy cool chamber in relation to storage of maturity and packaging material used. Haryana Agriculture University Journal of Research. 1987; 17(3): 216-217.
10. Boora RS. Improvement in guava (*Psidium guajava* L.)-a review. Agricultural Reviews. 2012; 33(4): 341-349.
11. Singh P, Singh N, Singh SN. Studies on Improving Storability and Quality of Harvested Guava Fruits using Chemicals. Biological Forum – An International Journal. 2023; 15(2): 1124-1133.
12. Wasker DP, Nikam SK, Garande VK. Effect of different packaging materials on storage behaviour of sapota under room temperature and cool chamber. Indian Journal of Agricultural Research. 1999; 33:240-244.
13. Bhowmic SR, Pan PC. Shelf life of mature green tomatoes stored in controlled atmosphere and high humidity. Journal of Food Science. 1992; 4:948-953.
14. Prabha A, Sharma HR, Goel AK, Ranjana V. Changes in ascorbic acid content of lemon fruits stored in zero energy cool chamber and under ambient atmosphere. Journal of Dairying, Foods and Home Sciences. 2006; 25(1):73-75.
15. Khan IA and Samsher. Study of the performance of zero energy cool chamber vis-à-vis room temperature storage of vegetables. Proceeding of the XXXV Annual Convention of ISAE January 22-24, College of Agril Engg and Technology, Orissa University of Agriculture and Technology, Bhubaneswar. Paper no. FP-2K-II-12. 2001.
16. Khan IA and Samsher. Studies on Physiological loss in weight (PLW) and shelf life of vegetables during storage under evaporative cool chamber. Proceeding of the 89th session of the Indian Science Congress (Engineering Section) January 3-7, Lucknow University, Lucknow, p-11. 2002.
17. Sundaram V. Studies on storability of vegetables in zero energy cool chamber. Agriculture Science Digest. 2016; 36(3): 244-246. DOI: 10.18805/asd.v36i3.11453.
18. Murugan AM, Ranjith Singh AJA, Vidhya S. Evaluation of self-life and organoleptic aspects of fruits stored in a modified traditional earthen pot cool chamber. Indian Journal of Traditional Knowledge. 2011; 10(2): 375-379.

UNDER PEER REVIEW