The Pharma Innovation Journal 2021; 10(11): 686-691

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(11): 686-691

www.thepharmajournal.com
Received: 10-08-2021
Accepted: 24-10-2021

C Indhupriya
Research Scholar, Department of Vegetable Science, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam, Tamil Nadu, India

V Premalakshmi
Assistant Professor, Department of Fruit Science, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam, Tamil Nadu, India

J Prem Joshua
Professor and Head, Department of Post-Harvest Technology, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam, Tamil Nadu, India

GJ Janavi
Professor and Head, Department of Vegetable Science, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam, Tamil Nadu, India

V Vani
Assistant Professor, Department of Post-Harvest Technology, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam, Tamil Nadu, India

Corresponding Author:
C Indhupriya
Research Scholar, Department of Vegetable Science, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam, Tamil Nadu, India

Quality of okra (*Abelmoschus esculentus* L. Moench) influenced by different postharvest treatments and storage conditions

C Indhupriya, V Premalakshmi, J Prem Joshua, GJ Janavi and V Vani

Abstract
An experiment was carried out to assess the postharvest quality of okra by dipping fresh okra fruits of *cv.* Bhendi Hybrid CO 4 in 500ppm citric acid (T_1), 0.5% ascorbic acid (T_2), 0.5% cysteine (T_3) and distilled water (T_4) for three minutes. The treated fruits were packed in HDPE 50 micron polyethylene bags and then stored at ambient and cold storage conditions. The fruits treated with 0.5% cysteine (T_5) and stored at cold storage was found to be the best treatment with minimum weight loss (7.87%), had maximum firmness (5 kg/cm^2), ascorbic acid content (14.28mg/100g), less total color change (7.88), less reduction in hue angle (118.78) and maximum shelf life of 18 days compared to control fruits stored in ambient condition with the shelf life of 3.5 days.

Keywords: Okra, citric acid, ascorbic acid, cysteine, shelf life, quality

1. Introduction
Okra (*Abelmoschus esculentus* L.) is an annual vegetable crop, belongs to the Malvaceae family. It is widely known as 'Gumbo' in the United States, 'Lady's finger' in the United Kingdom, and 'Bhindi' in India. Fruits in the green and tender stages are utilised as a vegetable in soups, curries, and stewed with meat. Mature fruits contain crude fibre, which is utilised in the paper industry. The fruits are long (10-30 cm), ridged, more or less oblong hairy capsules that dehiscing longitudinally. Okra fruit (100g) approximately contains; 89.6% moisture, 7.45g carbohydrates, 1.93g protein, 3.2g total dietary fibre, 0.19g fat and 0.86g ash in 100g of edible portion (USDA, 2019). The ripen seeds contain approximately 20% edible oil. Okra is a good source of vitamin A, B, C and minerals, especially iodine. It also has several therapeutic properties which aids in the treatment of human ailments like diabetes, goiter, heart problems, *etc.* Fruits and vegetables have high moisture content, ranging from 70% to 95%. They wilt and shrivel under ambient condition due to a lack of firmness and cell shrinkage. Postharvest losses in okra are mostly caused by poor storage, handling and transportation, which causes discolouration due to loss of chlorophyll, damage of fruits and loss of firmness finally leading to decay. The loss is mainly because of high respiration rate that leads to rapid deterioration of fresh produce. Okra has a very short postharvest life of about ten days when stored at temperature ranging from 1to10ºC due to its high respiration rate of more than 120 mg CO_2/kg/hr at 10 °C (Piloo and Kabir, 2015) [17]. Under room temperature conditions, okra fruits lose quality in two days due to blackening, shrivelling, and rotting, resulting in significant post-harvest losses (Ngure, 2009) [13].
Orgnanic acids and preservatives such as citric acid, ascorbic acid, cysteine, calcium chloride, potassium metabisulphite (KMS) and sodium benzoate are widely employed in postharvest treatment of fruits and vegetables (Saleh *et al.*, 2013 and Niketa *et al.*, 2016) [18, 14] which are now found to be a better alternative to synthetic chemicals used conventionally. They are organic compounds that have been shown to have little residual effects and were generally regarded as safe for use. Ascorbic acid, citric acid and cysteine have antioxidant properties and were found to be effective in delaying the oxidation process that causes undesirable changes in nutritive value, color and quality of stored fruits and vegetables (Taain *et al.*, 2014) [21]. The present study has been carried out to examine the effects of post-harvest treatment, and storage conditions on the shelf life and quality of okra.

2. Materials and Methods
The Bhendi Hybrid CO 4 crop was raised in Western Farm, Department of Vegetable

Science, Horticultural College and Research institute, TNAU, Periyakulam. The experiment was carried out at Postharvest Technology Laboratory, Horticultural College and Research institute, TNAU, Periyakulam. The fresh okra fruits were harvested with pedicel using sharp blade or knife, sorted with uniform size, color and maturity. The fruits were then treated with amino acids and organic acids at various concentrations *viz.,* T_1 – citric acid @ 500 ppm, T_2 – ascorbic acid @ 0.5%,T_3 – cysteine @ 0.5% and T_4 – water dip for three minutes. The treated fruits were allowed to dry to remove excess moisture and then packed in HDPE 50 µ with 2% vents. The packed fruits were stored at two different storage conditions *viz,* ambient condition (A_1) at 27±2ºC temperature with 60±10% RH and cold storage condition (A_2) at 13±2ºC temperature with 85±10% RH. The okra fruits were divided equally for each replication and the experiment was carried out by Factorial Completely Randomized Design with three replications. The fruit quality parameters analyzed were Physiological Loss in Weight (PLW), firmness, ascorbic acid, color value and shelf life. Changes in physiological and biochemical parameters were examined once in four days.

2.1. Physiological Loss in Weight (%)

Physiological Loss in Weight was calculated using the methodology given by Abound (1974) and expressed in

$$\text{Physiological loss in weight (PLW)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \text{ X } 100$$

2.2. Fruit firmness (kg/cm^2)

Fruit firmness was measured by using the instrument Fruits Hardness Tester, model: FR-5120 and expressed in kg/cm^2.

2.3. Ascorbic acid (mg/100g)

Ascorbic acid content in okra fruits was estimated by AOAC method (A.O.A.C, 2001). The ascorbic acid content is expressed in mg/100g.

2.4. Color

Color changes during storage of okra was measured by using portable digital colorimeter with direct reading of L coordinates (luminosity/luminance that varies from lightness (50-100) or darkness (0-50)), chromatic coordinate 'a' which varies from green (−a) or red (+a), chromatic coordinate 'b' which varies from blue (−b) or yellow (+b) (Paulus *et al.*, 2021) [16] and the results were expressed as h^o (hue angle) and ΔE (Total color change) (Kanwal *et al.*, 2020) [10]. The total color change and hue angle were calculated by the following formula.

$$\Delta E = \sqrt{(Lf - Li)2 + (af - ai)2 + (bf - bi)2}$$

$$h^o = 180^o + \tan^{-1}\left(\frac{bf}{af}\right)$$

where, L_i, a_i, b_i are the initial values and L_f, a_f, and b_f are the final values.

2.5. Shelf life

The shelf life was recorded from the day of harvest to a stage at which the fibre content increased, seeds become hard and yellowish and the spoilage was obvious (Niketa *et al.*, 2016) [14].

2.6. Statistical analysis

The results obtained were analyzed statistically at $p < 0.05$ level of significance by methods described by Panse and Sukhatme (1954) [15] using AGRESS software.

3. Results and Discussion

3.1. Physiological Loss in Weight (%)

Temperature and relative humidity are the major factors that influence moisture loss from the stored produce (Kumar *et al.*, 2021) [11]. A gradual increase in weight loss was observed throughout the storage period. Weight loss of okra was significantly influenced by postharvest treatments, storage conditions and their interactions. Between the storage conditions, minimum weight loss (5.77%) was observed in cold storage condition (A_2) compared to ambient condition (7.67%) (A_1). Among the postharvest treatments, T_3 recorded the lowest mean weight loss (4.20%) compared to control with a mean weight loss of about 10.44 per cent. In cold storage condition, minimum weight loss was observed in T_3A_2 (7.87%), followed by T_2A_2 (9.47%) and the maximum weight loss was observed in T_4A_2 (21.16%) at 18th day of storage, whereas in ambient condition minimum weight loss was observed in T_3A_1 (4.79%), followed by T_2A_1 (5.08%) and the maximum weight loss was observed in T_4A_1 (11.40%) at the eighth day of storage (Table 1). The steady increase in weight loss is in accordance with Saleh *et al* (2013) [18] in which the weight loss of fresh cut okra was lower in treated okra samples compared to untreated samples. The weight loss is generally due to loss of dry matter contents by respiration and loss of moisture by transpiration (Adetuyi *et al.*, 2008) [2]. Similar results were observed by Awad *et al.* (2021) [5] that postharvest treatments of ethanol, peppermint oil and ascorbic acid @ 0.5% reduced weight loss compared to control in french bean. Microcracks in pericarp tissues are the most common source of moisture loss. Reduced moisture loss in cysteine treated fruits may be owing to suppression of pericarp microcracks (Ali *et al.*, 2016).

3.2. Firmness (kg/cm^2)

Freshness of fruits is also assessed by firmness because loss in firmness is considered to be an indication of senescence (Kanwal *et al.*, 2020) [10]. Loss of firmness results in softening of the fruits during storage which causes reduction in quality and acceptance of the fruits. Loss of firmness could be possibly due to loss of moisture from the fruits (Niketa *et al.*, 2016) [14]. Significant differences were observed among the postharvest treatments, storage conditions and their interaction effects with regard to fruit firmness. Firmness was decreased from 5.27 kg/cm^2 to 4.59 kg/cm^2 throughout the storage period. Loss of firmness was maximum in okra fruits stored at ambient condition compared to cold storage. Among the treatments, T_3 recorded the highest firmness. Among the interactions, the treatment T_3A_2 recorded the highest firmness (5.00 kg/cm^2), followed by T_2A_2 (4.94 kg/cm^2) and the lowest firmness was observed in T_4A_2 (4.78 kg/cm^2) at 18th day of storage, whereas at ambient condition the highest firmness was recorded in T_3A_1 (4.87 kg/cm^2), followed by T_2A_1 (4.86 kg/cm^2) and the lowest firmness was observed in T_4A_1 (4.60 kg/cm^2) at the eighth day of storage (Figure 1). Similar findings were reported by Kanwal *et al.*, (2020) [10] in okra. The lesser reduction of firmness in treated okra fruits would be due to decreased activity of enzymes responsible for fruit softening. In addition to postharvest treatments, storage

temperature also influences the fruits firmness (Bashir, 2003 and Cheng *et al.*, 2018) [7]. The drastic decrease in firmness of okra fruits stored at ambient condition might be due to increase in loss of moisture from the fruits compared to cold storage condition (Indore *et al.*, 2016) [9]. Cysteine treatment reduced the production of EGase, which is linked to cell wall breakdown, which in turn prevented the loss of fruit firmness (Li *et al.*, 2018) [12].

3.3. Ascorbic acid (mg/100g)

Ascorbic acid is an important antioxidant that usually decreases with the advancement of storage period. The solubility in water, heat degradation, and enzymatic oxidation during storage were the main causes of ascorbic acid loss (Selmon, 1994) [19]. The ascorbic acid content of stored okra fruits were significantly influenced by postharvest treatments, storage temperature and their interaction. The loss in ascorbic acid content in okra ranged from 21.05 mg/100g to 7.82 mg/100g over the storage period. Decrease in ascorbic acid content was maximum in ambient storage compared to cold storage condition. The treatment T_3 recorded the highest ascorbic content (16.84mg/100g) compared to other treatments. Among the interactions, the highest ascorbic content was recorded in T_3A_2 (14.28 mg/100g) followed by T_2A_2 (12.85 mg/100g) and the lowest was observed in T_4A_2 (8.63 mg/100g) at 18th day of storage in cold storage condition, whereas in ambient condition highest ascorbic acid content was recorded in T_3A_1 (13.76 mg/100g) followed by T_2A_1 (13.04 mg/100g) and the lowest ascorbic acid content was observed in T_4A_1 (10.76 mg/100g) at the eighth day of storage (Table 2). The ability of cysteine to inhibit oxidative-degradation of ascorbic acid may account to the delayed reduction in ascorbic acid concentration with prolonged storage duration of fruit (Ali *et al.*, 2016) [3]. Similarly in okra, 1-MCP treatment with MAP was effective in retaining ascorbic acid content compared to control (Kanwal *et al.*, 2020) [10]. Similar findings were also reported in french bean were the samples treated with 0.5% ascorbic acid contained higher ascorbic acid compared to untreated samples (Awad *et al.*, 2021) [5].

3.4. Color

The ability to retain a bright green colour is a key criterion for evaluating the quality of okra on the market (Dhall *et al.*, 2014). The darkening or browning of okra fruit ridges during storage is a serious issue that affects its appearance. Lesser change in color and hue angle was observed in okra fruits stored in cold storage compared to ambient condition. Color change of okra increased constantly throughout storage. Less intensive color change was observed in T_3A_2 (7.88), followed by T_2A_2 (9.47) and the maximum was observed in T_4A_2 (21.16) at 18th day of storage in cold storage condition (Figure 2). In ambient condition, ΔE (Total color change) was recorded minimum in T_3A_1 (4.80) followed by T_2A_1 (5.08) and the maximum ΔE was recorded in T_4A_1 (11.40) at the eighth day of storage. The results are in accordance with Kanwal *et al.* (2020) [10] and Paulus *et al.* (2021) [16].

Hue angle also decreased with increase in storage period. Less decline in hue angle from the initial hue angle (124.56) was observed in T_3A_2 (118.78), followed by T_2A_2 (118.20) and the decline was maximum in T_4A_2 (116.65) at 18th day of storage in cold storage condition. In ambient condition the hue angle decline was recorded minimum in T_3A_1 (114.56) followed by T_2A_1 (114.28) and the maximum was recorded in T_4A_1 (112.56) at the eighth day of storage (Figure. 3). The results are similar with those obtained by Kanwal *et al.*, (2020) [10] where okra fruits treated with 1-MCP along with MAP showed less reduction in hue angle of stored okra fruits. The results are in agreement with Saleh *et al.*, (2013) [18] that the fresh cut okra treated with cysteine and ascorbic acid recorded less reduction in hue angle compared to control.

3.5. Shelf life (days)

Shelf life of fruits and vegetables was determined till the produce remains in marketable condition without much decrease in quality parameters. The postharvest treatments and storage along with their interaction significantly influenced shelf life of okra fruits. Between the storage conditions, maximum mean shelf life (15 days) was recorded in cold storage condition (A_2) and minimum mean shelf life (7 days) was recorded ambient condition (A_1). Among the postharvest treatments, T_3 recorded the highest mean shelf life (13.50 days) compared to control (6.50 days). Among the interaction effect of postharvest treatments and storage conditions, the maximum shelf life of 18 days was recorded in T_3A_2, followed by T_2A_2 (17 days) and minimum shelf life was recorded in T_4A_1 (3.5 days) (Table 3). The results are in agreement with Sohail *et al.*, (2021) [20], that the postharvest treatment of leafy vegetables significantly increased the green life of leafy vegetables.

Table 1: Effect of postharvest treatments and storage conditions on physiological loss in weight (%) of okra

Treatments	Day 4		Day 8		Day 12		Day 16		Day 18		Mean
	A_1	A_2	A_1	A_2	A_1	A_2	A_1	A_2	A_1	A_2	
T_1	3.99	1.55	5.86	3.12	11.21	4.96	-	6.85	-	12.55	6.27
T_2	3.05	0.87	5.08	1.98	10.03	3.87	-	5.85	-	9.47	5.03
T_3	2.85	0.50	4.79	1.36	9.12	2.86	-	4.22	-	7.86	4.20
T_4	5.05	2.34	11.39	4.01	19.55	7.05	-	12.95	-	21.15	10.44
Mean	3.74	1.32	6.78	2.62	12.48	4.69	-	7.47	-	12.76	
Mean	A_1 = 7.67					A_2 = 5.77					

Source	Day 4		Day 8		Day 12		Day 16		Day 18	
	SEd	CD(0.05)	SEd	CD(0.05)	SEd	CD(0.05)	SEd	CD(0.05)	SEd	CD(0.05)
A	0.0348	0.0739**	0.0519	0.1101**	0.1019	0.2161**	0.0393	0.0833**	0.0806	0.1710**
T	0.0493	0.1045**	0.0734	0.1558**	0.1442	0.3057**	0.0555	0.1178**	0.1141	0.2419**
A×T	0.0690	0.1470**	0.1039	0.2203**	0.2039	0.4323**	0.0786	0.1666**	0.1614	0.3421**

* The means are highly significant at $p \leq 0.05$; ** The means are highly significant at $p \leq 0.01$

'-' The fruits were not available for analysis due to termination of shelf life.

Table 2: Effect of postharvest treatments and storage conditions on ascorbic acid content (mg/100g) of okra

Treatments	Day 4		Day 8		Day 12		Day 16		Day 18		Mean
	A_1	A_2	A_1	A_2	A_1	A_2	A_1	A_2	A_1	A_2	
T_1	15.94	18.93	12.32	16.89	-	14.84	-	12.16	-	10.65	14.53
T_2	16.87	20.03	13.04	17.95	-	16.88	-	15.36	-	12.85	16.14
T_3	17.01	20.58	13.76	18.78	-	17.35	-	16.13	-	14.28	16.84
T_4	14.58	17.89	10.76	15.54	-	13.06	-	10.71	-	8.63	13.02
Mean	16.10	19.35	12.47	17.29	-	15.53	-	13.59	-	11.60	
Mean	A_1 = 14.29				A_2 = 15.47						
Source	Day 4		Day 8		Day 12		Day 16		Day 18		
	SEd	CD(0.05)	SEd	CD(0.05)	SEd	CD(0.05)	SEd	CD(0.05)	SEd	CD(0.05)	
A	0.0116	0.0246**	0.0061	0.0129**	0.1197	0.2539**	0.0854	0.1811**	0.1043	0.2212**	
T	0.0164	0.0348**	0.0086	0.0183**	0.1693	0.3590**	0.1208	0.2562**	0.1475	0.3128**	
A×T	0.0232	0.0493**	0.0122	0.0259**	0.2395	0.5078**	0.1709	0.3623**	0.2086	0.4424**	

* The means are highly significant at $p \leq 0.05$; ** The means are highly significant at $p \leq 0.01$

'-' The fruits were not available for analysis due to termination of shelf life.

Table 3: Effect of postharvest treatments and storage conditions on shelf life (days) of okra

Treatments	Shelf life(days)		Mean (days)
	A_1	A_2	
T_1	7.00	15.50	11.25
T_2	8.50	17.00	12.75
T_3	9.00	18.00	13.50
T_4	3.50	9.50	6.50
Mean	7.00	15.00	
Source	**S.Ed**	**CD (0.05)**	
A	0.0958	0.2032**	
T	0.1356	0.2874**	
AXT	0.1917	0.4065**	

* The means are significant at $p \leq 0.05$; ** The means are significant at $p \leq 0.01$

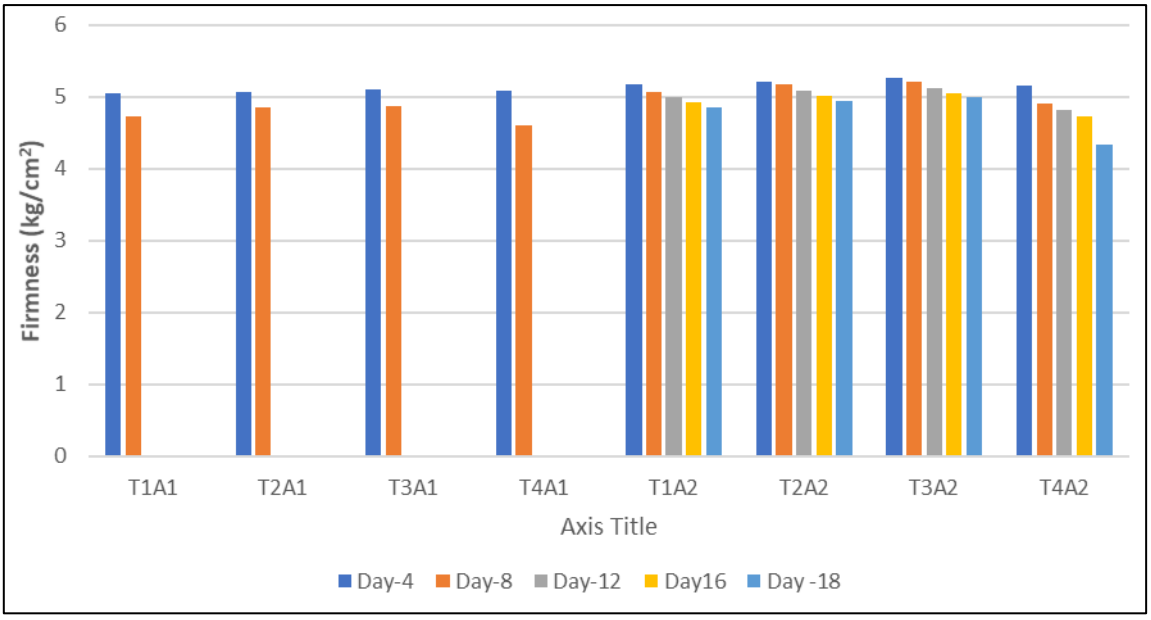

Fig 1: Effect of postharvest treatments and storage conditions on firmness (kg/cm^2) of okra

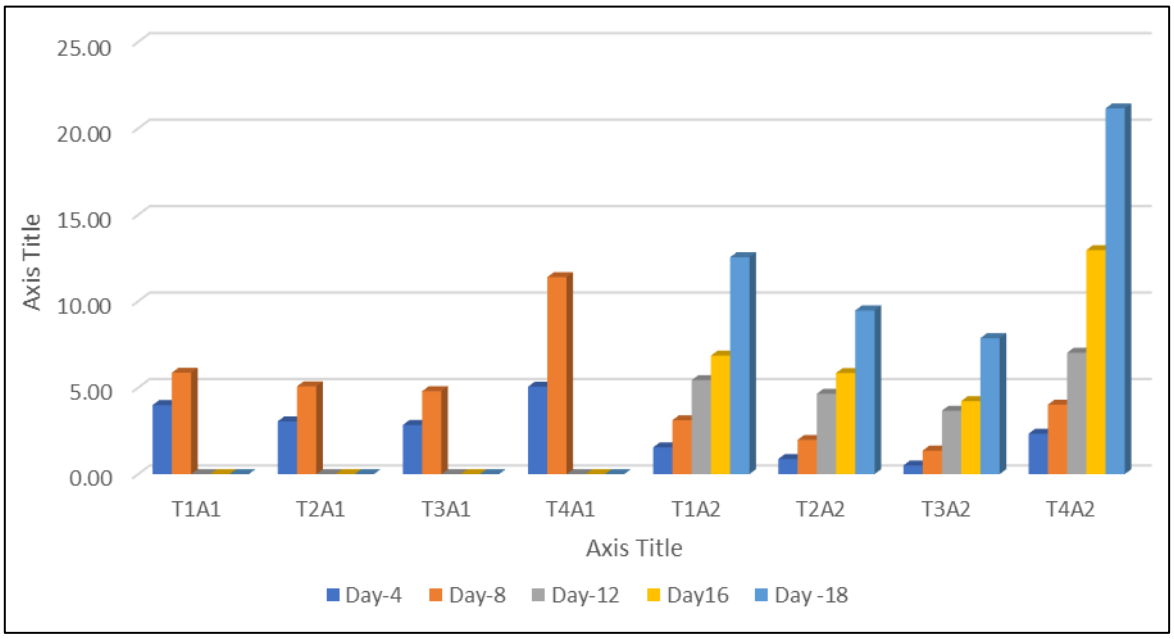

Fig 2: Effect of postharvest treatments and storage conditions on change in color (ΔE) of okra

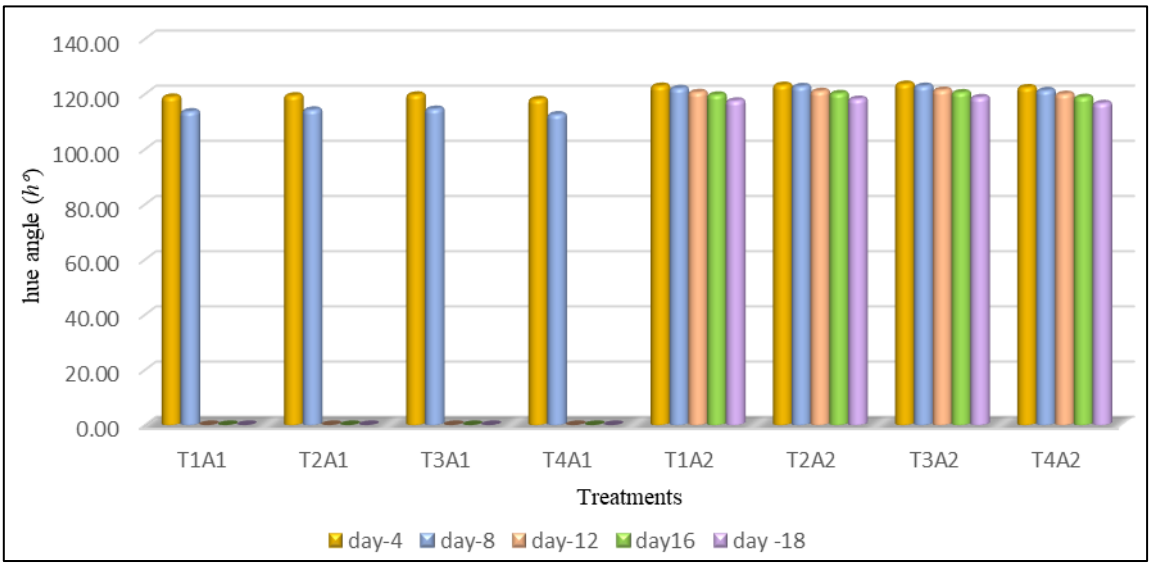

Fig 3: Effect of postharvest treatments and storage conditions on hue angle (*h*°) of okra

4. Conclusion

From the experiment it can be concluded that the postharvest treatments were effective in maintaining quality of okra fruits during storage. The unfavourable changes that primarily occured during storage were weight loss, decrease in firmness, blackening and finally leading to decay of fruits. Postharvest treatment of okra with 0.5% cysteine was effective in reducing quality losses and extending the shelf life to about 18 days at low temperature storage compared to ambient storage condition.

5. References

1. Abound HA. A study of physical and chemical changes observed in six commercial cultivars of six field grown vine riped tomatoes in the fresh state and after storage. Diss. Abstr 1974;B-34:50-52
2. Adetuyi FO, Osagie AU, Adekunle AT. Effect of postharvest storage techniques on the nutritional properties of benin indigenous okra (Abelmoschus esculentus. L Moench.). Pakistan Journal of Nutrition 2008;7(5):625-657.
3. Ali S, Khan AS, Malik AU. Postharvest L-cysteine application delayed pericarp browning, suppressed lipid peroxidation and maintained antioxidative activities of litchi fruit. Postharvest Biology and Technology 2016;121:135-142
4. AOAC. Official methods of analysis.1984. Washington DC,USA.
5. Awad AHR, Parmar A, Ali MR, El-Mogy MM, Abdelgawad KF. Extending the Shelf-Life of Fresh-Cut Green Bean Pods by Ethanol, Ascorbic Acid, and Essential Oils. Foods 2021;10:1103.
6. Bashir HA, Abu- Bakr A, Abu-Goukh. Compositional changes during guava fruit ripening. Food Chem 2003;80:557-563
7. Cheng Z, Gong X, Jing W, Peng Z, Li J. Quality Change of Postharvest Okra at Different Storage Temperatures. Journal of Food Engineering and Technology 2018;7:1.
8. Dhall RK, Sharma SR, Mahajan BVC. Development of post-harvest protocol of okra for export marketing. J. Food Sci. Technol 2014;51:1622-1625.
9. Indore HD, Garande VK, Dhumal SS, Patgaonkar DR,

Patil VS, Sonawane PN. Effect of packaging materials and storage conditions on shelf life and quality of okra. Int. J Adv. Res 2016;4(11):257-265
10. Kanwal R, Ashraf H, Sultan M, Babu I, Yasmin Z, Nadeem M *et al*. Effect of 1-Methyl Cyclopropane and Modified Atmosphere Packaging on the Storage of Okra (*Abelmoschus esculentus* L.): Theory and Experiments Sustainability 2020;12:7547.
11. Kumar R, Bhargava P, Karn M, Kumar A, Pathak S. Postharvest pathogenic behaviour of different litchi varieties. The Pharma Innovation Journal 2021;10(6):655-659
12. Li T, Wua Q, Zhoua Y, Yuna Z, Duana X, Jianga Y. L-Cysteine hydrochloride delays senescence of harvested longan fruit in relation to modification of redox status. Postharvest Biology and Technology 2018;143:35-42.
13. Ngure JC, Aguyoh JN, Gaoquiong L. Interactive effects of packaging and storage temperatures on the shelf-life of okra. Arpn J Agric. and Biol. Sci 2009;4(3):44-49.
14. Niketa P, Patel NL, Sangani SL. Effect of Post Harvest Treatments, Packaging Materials and Storage Conditions on Shelf Life and Quality of Okra. International Journal of Agriculture Sciences 2016;8(52):2601-2605.
15. Panse VG, Sukhatme PV Statistical methods of Agriculture workers. 2nd edn. ICAR, New Delhi 1954, 381.
16. Paulus D, Ferreira SB, Becker D. Preservation and post-harvest quality of okra using low density polyethylene. AIMS Agriculture and Food 2021;6(1):321-336.
17. Piloo N, Kabir J. Efficacy of different storage conditions of okra *(Abelmoschus esculentus* L. Moench*)* The Asian Journal of Horticulture 2015;10(1):134-138.
18. Saleh MA, El-Gizawy AM, El-Bassiouny REL, Ali HM. Effects of anti-coloring agents on blackening inhibition and maintaining physical and chemical quality of fresh-cut okra during storage. Annals of Agricultural Science 2013;58(2):239-245.
19. Selmon ID. Vitamin retention during blanching of vegetables. Food Chemistry 1994;49:137-147.
20. Sohail M, Wills RBH, Bowyer MC, Pristijono P. Impact of exogenous arginine, cysteine and methionine on the postharvest senescence of six green leafy vegetables Journal of Horticulture and Postharvest Research 2021;4(3):253-262.
21. Taain DA, Jasim AM, Al-Hij JHH. A study of storage behavior of okra fruits. Int. J. Farming Allied Sci 2014;3: 760-766.
22. United States Department of Agriculture 2019 (Available at https://fdc.nal.usda.gov/).