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Research Article

EFFECT OF POST HARVEST TREATMENTS, PACKAGING MATERIALS AND STORAGE CONDITIONS ON SHELF LIFE AND QUALITY OF OKRA

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Abstract- The present experiment was conducted at Department of Post-Harvest Technology, ASPEE College of Horticulture and Forestry, N.A.U., Navsari, Gujarat. The whole course of study was divided in two experiments. The first experiment was conducted by using different post-harvest dipping chemicals and the second experiment consisted of three packaging materials and three storage conditions. The results of first experiment revealed that the okra fruits dipped in citric acid 500 ppm + sodium benzoate 100 ppm (T8) proved to be the best with respect to maximum shelf life, higher marketable fruits with excellent general appearance of fruits. This treatment was used for experiment second. The second experiment indicated that when the okra fruits packed in LDPE bags of 50 micron thickness with 5% vents and stored at 12^{0}C temperature with 95% RH individually as well as in combination had extended the shelf life up to 16 days with maximum ascorbic acid and moisture content also with minimum TSS and lesser disease incidence. This was followed by the okra fruits packed in same packaging and kept in zero energy cool chambers, which had extended the shelf life of okra fruits up to 12 days

Keywords- Okra, Packaging materials, Post-harvest treatment, Storage conditions, Shelf life

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Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] is an annual vegetable crop belongs to family Malvaceae. It is popularly known as 'Gumbo' in United States of America, 'Lady's finger' in United Kingdom and 'Bhindi' in India. Its green and tender stages fruits are used for cooking as vegetable, soups, curries and stewed with meat. Mature fruits contain crude fibre used in paper industry. Ripened seeds are roasted, grounded and used as a substitute for coffee as in Mehta [1]. Okra is said to be very useful against genitourinary disorder, spermatorrhoea and chronic dysentery as in Bose and Som [2]. Fruits and vegetables contain high moisture, ranging from 70 to 95 per cent. Under normal atmospheric conditions they dry rapidly, which causes wilting and shrivelling as a result of loss in rigidity and shrinkage of cells. This enormous wastage, which results in product scarcity and higher prices, is attributed mainly to improper handling methods, poor packaging, and inadequate transportation facilities by Chakravarty et al. [3]. Losses in okra mainly occur in the form of discoloration, broken fingers and injury to pods due to improper storage, handling and transportation. Okra pods lose quality through blackening, shrivelling, and decaying within two days under room temperature condition leading to heavy post-harvest losses. Citric acid, Potassium metabisulphite (KMS) and sodium benzoate are commonly used chemicals for preservation. They are organic chemicals which are safe and found negligible residual effects testimony by Koley et al. [4]. Use of polyethylene film for packaging seems to be ideal, since it is transparent, moisture proof and facilitates easy sealing and printing. Further, it also provides a modified atmosphere to a certain extent and thus helps in postponing the senescence process in produce. Packaging of fruits and vegetables is to protect them during storage, transportation and distribution from deterioration, which may be physical, chemical or biological. It still plays an important role in delivering the contents safely to the end consumers. Therefore, the present work was done to find the effect of post-harvest treatments, packaging materials and storage conditions on shelf life and quality of okra.

MaterialsandMethods

The present experiment was carried out at Post Harvest Technology Laboratory, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, during the year 2013-14 to 2014-15. The N.A.U. Campus is situated on the coast of Arabian Sea at 72^0-54' E longitudes, 20^0-58' N latitude with an altitude of 10-12 meters above sea level. Freshly harvested, tender but optimum mature and marketable fruits of okra var. 'Shakti' from the well maintained field at Kantasvel village immediately brought in the morning to the laboratory of department of Post-Harvest Technology were used to carry out the experiment first. Fruits of uniform shape, size and colour were selected for the study i.e., bright green in colour and 7-9 cm in length. The fruits were divided in to 15 batches to dip them in 15 different dipping solutions. These 15 batches of okra fruits were dipped in different dipping treatments for 5 minutes subsequently air dried. About 500 g okra fruits kept in tray for taking observations and recording data. The following dipping chemical treatments were applied: T1: Control (Dip in water); T2: CA (Citric acid) 500 ppm; T3: CA 1000 ppm; T4: NaB (Sodium benzoate) 100 ppm; T5: NaB 200 ppm; T6: KMS (Potassium metabisulphite) 250 ppm; T7: KMS 500 ppm; T8: CA 500 ppm + NaB 100 ppm; T9: CA 500 ppm + NaB 200 ppm; T10: CA 1000 ppm + NaB 100 ppm; T11: CA 1000 ppm + NaB 200 ppm; T12: CA 500 ppm + KMS 250 ppm; T13: CA 500 ppm + KMS 500 ppm; T14: CA 1000 ppm + KMS 250 ppm; T15: CA 1000 ppm + KMS 500 ppm. The best dipping treatment was derived from experiment first and taken for the further investigation entitled effect of different packaging materials and storage conditions on shelf life and quality of okra in experiment second. The following packaging

materials and storage conditions treatments were applied: T1: P0S0: Control (CFB box 5 ply + ambient temperature); T2: P0S1: Control (CFB box 5 ply + zero energy cool chamber); T3: P0S2: Control (CFB box 5 ply + 12^{0}C with 95% R.H); T4: P1S0: LDPE (*50*micron) without vents + ambient temperature; T5: P1S1: LDPE (*50*micron) without vents + zero energy cool chamber; T6: P1S2: LDPE (*50* micron) without vents + 12^{0}C with 95% R.H; T7: P2S0: LDPE (50micron) with 5% vents + ambient temperature; T8: P2S1: LDPE (50 micron) with 5% vents + zero energy cool chamber; T9: P2S2: LDPE (*50*micron) with 5% vents + 12^{0}C with 95% R.H; T10: P3S0: LDPE (*50*micron) with 10% vents + ambient temperature; T11: P3S1: LDPE (*50*micron) with 10% vents + zero energy cool chamber; T12: P3S2: LDPE (*50*micron) with 10% vents + 12^{0}C with 95% R.H; T13: P4S0: LDPE (*50*micron) with 15% vents + ambient temperature ; T14: P4S1: LDPE (*50* micron) with 15% vents +zero energy cool chamber; T15: P4S2:LDPE (*50*micron) with 15% vents + 12^{0}C with 95% R.H ; T16: P5S0: HDPE (*50*micron) without vents + ambient temperature; T17: P5S1: HDPE (*50*micron) without vents +zero energy cool chamber; T18: P5S2: HDPE (*50*micron) without vents + 12^{0}C with 95% R.H ; T19: P6S0: HDPE (*50*micron) with 5% vents + ambient temperature; T20: P6S1: HDPE (*50*micron) with 5% vents + zero energy cool chamber; T21: P6S2: HDPE (*50*micron) with 5% vents + 12^{0}C with 95% R.H ; T22: P7S0: HDPE (*50*micron) with 10% vents + ambient temperature; T23: P7S1: HDPE (*50*micron) with 10% vents + zero energy cool chamber; T24: P7S2: HDPE (*50*micron) with 10% vents + 12^{0}C with 95% R.H; T25: P8S0: HDPE (*50*micron) with 15% vents + ambient temperature; T26: P8S1: HDPE (*50*micron) with 15% vents + zero energy cool chamber; T27: P8S2: HDPE (*50*micron) with 15% vents 12^{0}C with 95% R.H. For experiment first observations were recorded on shelf life of okra fruit at alternate day during the storage period, whereas, For experiment second, observations were recorded on TSS, ascorbic acid content and disease incidence of okra fruit at alternate day during the storage period. The shelf-life was recorded at the day from harvest to a stage at which fibre content increased, seeds become hard and yellowish and spoilage was inevitable. The total soluble solids (TSS) were determined with the help of hand refractometer and expressed as ^{0}Brix at 20^{0}C using reference table for temperature, Ascorbic acid was estimated by 2, 6-dichlorophenol-indophenol dye as reported by Ranganna [5] and expressed as mg/100g. Disease incidence (DI) was calculated based on number of fruits showing symptoms of diseases (D) to the total number of fruits per bag (TF). DI (%) = [(DF/TF) x 100].

Results and Discussion

The two years mean data on shelf life of okra fruits [Table-1] revealed that significantly the maximum shelf life (6.18 days) was recorded in okra fruits dipped in treatment T11 (Citric acid 1000 ppm + sodium benzoate 200 ppm) which was at par with treatment T9, T10 and T8, whereas, the minimum shelf life (1. 65 days) was observed in treatment T1. This maximum shelf life may be due to citric acid and sodium benzoate which are organic chemicals and act as an antimicrobial agent, citric acid act as antioxidants, decreasing the tissue permeability thereby reducing the rate of moisture loss, disease incidence, degradation of green color, blackening of ridges and shriveling. Mixture of organic acids could exert a wider antimicrobial activity than a single organic acid. All of these collectively resulted in higher shelf life of okra fruits.

Table-1 *Effect of post-harvest treatments on shelf life (Days) of okra fruits var. 'Shakti' on the 6th day of storages (Two years pooled data)*

Treatments	Shelf life of okra fruits (Days)		
	Year 1	Year 2	Pooled
T1	1.62	1.63	1.65
T2	1.95	1.97	1.93
T3	2.28	2.30	2.32
T4	3.25	3.31	3.28
T5	3.57	3.64	3.62
T6	2.60	2.63	2.63
T7	2.93	2.97	2.95
T8	6.06	5.31	5.88
T9	6.09	5.98	6.06
T10	6.13	5.64	5.94
T11	6.17	6.31	6.18
T12	3.90	3.97	3.97
T13	4.22	4.64	4.45
T14	4.55	4.31	4.43
T15	4.87	4.97	4.92
S.Em. ±	0.04	0.35	0.34
C.D. at 5%	0.12	1.02	0.31
S.Em.± (Y xT)	-	-	0.044
C.D. (Y xT)	-	-	0.125
C.V. %	1.79	1.91	1.92

The two years mean data indicated significant differences in TSS per cent due to packaging materials [Table-2]. The TSS was significantly the lowest in LDPE bags of 50 micron thickness with 5% vents (P2) on the 4th (7.10 ^{0}Brix) and 8th (7.12 ^{0}Brix) day of storage, which was at par with treatment P6, P1, P5, P3, P7, P4 and P8, whereas, CFB Box (P0) registered the highest TSS (7.41 and 7.43 ^{0}Brix) on the 4th and 8th day, respectively. After 8th day of storage treatments P0, P1, P3, P4, P5, P7 and P8 were discarded due to poor quality and spoilage. TSS in okra fruits was significantly affected by polyethylene packaging. There was a gradual increase in per cent total soluble solids with packaging. The lowest total soluble solid was recorded in okra fruits when packed in LDPE bags of 50 micron thickness with 5% vents as compared to other packaging. This could be due to the development of modified atmosphere in the package, which slowed down respiration and transpiration. These changes may have slowed down ripening.

Table-2 *Effect of packaging and storage conditions on TSS (^{0}Brix) of okra fruits var. 'Shakti' (4th and 8th day) (Two years pooled data*)

Treatment	Okra TSS (^{0}Brix)							
	4th day				8th day			
	S0	S1	S2	Mean	S0	S1	S2	Mean
P0	7.47	7.39	7.38	7.41	7.48	7.40	7.40	7.43
P1	7.26	7.17	7.12	7.18	7.27	7.19	7.14	7.20
P2	7.28	7.02	6.99	7.10	7.30	7.04	7.01	7.12
P3	7.33	7.14	7.11	7.19	7.35	7.16	7.13	7.21
P4	7.36	7.22	7.20	7.26	7.37	7.24	7.22	7.27
P5	7.27	7.18	7.13	7.19	7.29	7.19	7.15	7.21
P6	7.30	7.04	7.00	7.12	7.32	7.06	7.03	7.13
P7	7.34	7.16	7.11	7.20	7.36	7.18	7.13	7.22
P8	7.37	7.24	7.21	7.28	7.39	7.25	7.23	7.29
Mean	7.33	7.17	7.14		7.35	7.19	7.16	
Factors	P	S	P x S	Y x P x S	P	S	P x S	Y x P x S
S.Em. ±	0.059	0.035	0.099	0.150	0.058	0.035	0.098	0.148
C.D. at 5%	0.18	0.11	NS	NS	0.17	0.11	NS	NS

P= Packaging material; S= Storage condition

The two years pooled data also showed significant differences in TSS due to storage conditions. The TSS (^{0}Brix) was significantly lowest in okra fruits kept in cold storage at 12 ^{0}C with 95% RH (S2) on the 4th (7.14 ^{0}Brix) and 8th (7.16 ^{0}Brix) day of storage, which was followed by treatment S1 (okra fruits stored in zero energy cool chamber) i.e., 7.17 and 7.19 ^{0}Brix, respectively. However, higher TSS was noted in okra fruits kept at ambient temperature throughout the storage period

(S0). Accumulation of total soluble solids is a function of starch metabolism, which is slower in okra fruits stored at lower temperature. Similar observations were recorded by Anandaswamy et al. [6] in okra, Tandel [7] and Patel et al. [8] in sapota. Okra fruits stored in zero energy cool chamber also showed lower total soluble solids than those stored at ambient temperature. This might be due to low temperature and high humidity in zero energy cool chamber, which could be slowed down the conversion of starch into sugars. Similar results have also been reported by Wasker et al. [9] in bottle gourd, Pal and Roy [10] in carrot, Sandooja et al. [11] in tomato. Two years pooled data pertaining to ascorbic acid content (mg/100g) under various packaging materials and storage conditions are presented in [Table-3]. Pooled data indicated significant differences in ascorbic acid content due to packaging materials. The ascorbic acid content was significantly the highest in treatment P2 on the 4th (15.82 mg/100g) and 8th (12.43 mg/100g) day of storage, which was at par with P6 treatment (15.66 and 12.31 mg/100g, respectively). CFB Box (P0) registered the lowest ascorbic acid content (12.93 and 10.35 mg/100g) on the 4th and 8th day, respectively. After 8th day of storage treatments P0, P1, P3, P4, P5, P7 and P8 were discarded due to poor quality and spoilage. Preservation of ascorbic acid content is a difficult task as it undergoes oxidation and also because vitamin C is water soluble and may have been easily lost by leaching. However, in the present investigation, the highest ascorbic acid content was recorded in okra fruits packed in LDPE bags of 50 micron thickness with 5% vents. The packaging material increased relative humidity inside the packaging leading to lower moisture loss and respiration rate. This lower respiration rate associated with lower ripening, helped in higher ascorbic acid content. These results are in conformity with Waskar and Nikam [12]; Joshua and Sathiamoorthy [14] in sapota. The ascorbic acid content was significantly highest in okra fruits kept in cold storage at 12^{0}C with 95% RH (S2) on the 4th (15.61 mg/100g) and 8th (12.28 mg/100g) day of storage, which was followed by treatment S1. However, lower ascorbic acid content was noted in okra fruits kept at ambient temperature throughout the storage period (S0). There was a gradual decline in ascorbic acid content of fruits throughout the storage period. This may be due to increased activity of ascorbic acid oxidize in stored fruits. These results confirm the findings of Deb and Suresh [15] in green chilli. Fruits stored at 12^{0}C temperature had higher ascorbic acid content, which may be due to a slowdown in the oxidation of ascorbic acid at low temperature. This was in agreement with the findings of Sankaran et. al. [16] in okra. Okra fruits stored in zero energy cool chamber had also higher ascorbic acid content than those stored at ambient temperature. It may be due to lower temperature maintained in zero energy cool chambers, which slow down the oxidation of ascorbic acid.

Table-3 *Effect of packaging and storage conditions on ascorbic acid (mg/100 g) of okra fruits var. 'Shakti' (4th and 8th day) (Two years pooled data).*

Treatment	Okra ascorbic acid(mg/100 g)							
	4th day				8th day			
	S0	S1	S2	Mean	S0	S1	S2	Mean
P0	12.77	12.93	13.08	12.93	10.23	10.35	10.46	10.35
P1	14.35	15.30	15.93	15.19	11.37	12.05	12.51	11.98
P2	14.03	16.56	16.88	15.82	11.14	12.96	13.19	12.43
P3	13.71	15.61	16.25	15.19	10.91	12.28	12.74	11.98
P4	13.40	14.66	14.98	14.35	10.68	11.60	11.83	11.37
P5	14.19	15.14	15.77	15.04	11.25	11.94	12.40	11.86
P6	13.87	16.40	16.72	15.66	11.03	12.85	13.07	12.31
P7	13.55	15.45	16.09	15.03	10.80	12.17	12.62	11.86
P8	13.24	14.50	14.83	14.19	10.57	11.48	11.71	11.25
Mean	13.68	15.18	15.61		10.89	11.96	12.28	
Factors	P	S	P x S	Y x P x S	P	S	P x S	Y x P x S
S.Em. ±	0.103	0.061	0.172	0.260	0.081	0.048	0.137	0.207
C.D. at 5%	0.29	0.17	0.56	NS	0.23	0.14	0.51	NS
C.V. %	3.04				3.06			

P= Packaging material; S= Storage condition

Table-4 *Interaction between packaging and storage conditions on ascorbic acid (mg/100g) of okra fruits var. 'Shakti' (two years pooled)*

Treatments	Storage periods in days			
	4th day	8th day	12th day	16th day
P0S0	12.77	10.23	*	*
P0S1	12.92	10.34	*	*
P0S2	13.08	10.46	*	*
P1S0	14.34	11.37	*	*
P1S1	15.30	12.05	*	*
P1S2	15.93	12.51	*	*
P2S0	14.03	11.14	*	*
P2S1	16.56	12.96	10.86	*
P2S2	16.88	13.19	11.35	9.82
P3S0	13.71	10.91	*	*
P3S1	15.61	12.28	*	*
P3S2	16.24	12.73	*	*
P4S0	13.40	10.68	*	*
P4S1	14.66	11.60	*	*
P4S2	14.98	11.82	*	*
P5S0	14.19	11.25	*	*
P5S1	15.14	11.94	*	*
P5S2	15.77	12.39	*	*
P6S0	13.87	11.03	*	*
P6S1	16.40	12.85	10.69	*
P6S2	16.72	13.07	11.19	9.57
P7S0	13.55	10.80	*	*
P7S1	15.45	12.16	*	*
P7S2	16.09	12.62	*	*
P8S0	13.24	10.57	*	*
P8S1	14.50	11.48	*	*
P8S2	14.82	11.71	*	*
S. Em. ±	0.172	0.137		
C.D. at 5%	0.56	0.51		
C.V. %	3.04	3.06		

*= The fruits were not available for analysis due to completely spoilage.
P= Packaging material; S= Storage condition

The effect of interaction between packaging materials and storage conditions [Table-4] were found significant on ascorbic acid content (mg/100g). Okra fruits packed in LDPE bags of 50 micron thickness with 5% vents and stored in cold storage at 12^{0}C with 95% RH (P2S2) retained significantly maximum ascorbic acid (16.88 and 13.19 mg/100 g, respectively) on the 4th and 8th day of storage which was at par with treatment P6S2, P2S1 and P6S1. The higher content of ascorbic acid in treatment P2S2 may be due to combined effects packaging material and storage condition. Whereas, minimum retention of ascorbic acid was recorded in treatment P0S0 (12.77 and 10.23 mg/100g, respectively) on 4th and 8th day. After 8th day of storage okra fruits stored at ambient temperature in all packaging treatments were discarded due to spoilage. On 12th day of storage, treatment P2S2 had higher retention of ascorbic acid i.e., 11.35 mg/100g. On 16th day of storage the maximum retention of ascorbic acid (9.82 mg/100g) was recorded in treatment P2S2

Disease incidence (%)

Disease incidence per cent of okra fruits was significantly influenced by the packaging materials and storage conditions [Table-5]. Packaging material had

significant influence on disease incidence in okra fruits on the 4th and 8th day of storage. Significantly, the minimum disease incidence (0.46 and 11.77 per cent, respectively) was recorded in fruits packed in LDPE bags of 50 micron thickness with 5% vents (P2) on 4th and 8th day of storage which was followed by treatment P6. The maximum disease incidence was observed in treatment P0 (CFB Box) i.e., 1.88 and 41.53 per cent on 4th and 8th day of storage, respectively. Lower disease incidence could be due to optimum permeability of gases and moisture in bags of 50 micron thickness with 5% vents as compared to other treatments. The highest disease incidence in HDPE bags of 50 micron thickness without vents may be due to high relative humidity and water condensation around the fruits, which promote the development of post-harvest decay. These finding are in conformity with those of Anandaswamy et al.[6] in okra, Brar et al. [16] in chilli.

Table-5 *Effect of packaging materials and storage conditions on disease incidence (per cent) in okra fruits cv. 'Shakti' (4th and 8th day)*

Treatments	Disease incidence in okra (per cent) at 4th Day							
	4th day				8th day			
	S0	S1	S2	Mean	S0	S1	S2	Mean
P0	1.95	1.88	1.81	1.88	43.13	41.53	39.94	41.53
P1	1.25	0.83	0.54	0.88	27.21	17.65	11.29	18.72
P2	1.39	0.00	0.00	0.46	30.39	4.92	0.00	11.77
P3	1.53	0.68	0.40	0.87	33.57	14.47	8.11	18.72
P4	1.67	1.11	0.97	1.25	36.76	24.03	20.84	27.21
P5	1.32	0.89	0.61	0.94	28.80	19.25	12.88	20.31
P6	1.46	0.00	0.00	0.49	31.98	6.51	0.00	12.84
P7	1.60	0.75	0.47	0.94	35.17	16.07	9.70	20.31
P8	1.74	1.18	1.04	1.32	38.35	25.61	22.43	28.80
Mean	1.55	0.81	0.65		33.93	18.89	13.91	
Factors	P	S	P X S	Y X P X S	P	S	P X S	Y X P X S
S.Em. ±	0.006	0.003	0.010	0.016	0.120	0.071	0.199	0.301
C.D. at 5%	0.02	0.01	0.02	NS	0.34	0.20	0.56	NS
C.V. %	2.77				2.34			

P= Packaging material; S= Storage condition

The data on disease incidence percent showed significant effect of storage conditions. The minimum disease incidence in okra fruits (0.65 and 13.91 per cent, respectively) was observed in treatment S2 which was followed by treatment S1 (0.81 and 18.89 per cent, respectively) on 4th day and 8th day of storage. The maximum disease incidence in okra fruit (1.55 and 33.93 per cent on 4th day and 8th day of storage, respectively) was observed in ambient temperature (S0). Low temperature retards the growth of pathogens and this could have reduced disease incidence. These results are similar to those reported by Anandaswamy et al.[6] in okra, Tano et al.[17] in bell pepper and Ngure et al.[18] in okra. Okra fruits stored in zero energy cool chambers had also lower disease incidence than those stored at ambient temperature. This might be due to lower temperature maintained in zero energy cool chambers, which retards the growth of pathogens, and this could be reduced disease incidence.

Table-6 *Interaction between packaging and storage conditions on disease incidence (per cent) of okra fruits var. 'Shakti' (two years pooled)*

Treatments	Storage periods in days			
	4th day	8th day	12th day	16th day
P0S0	1.94	43.12	*	*
P0S1	1.88	41.53	*	*
P0S2	1.81	39.94	*	*
P1S0	1.25	27.21	*	*
P1S1	0.83	17.66	*	*
P1S2	0.54	11.29	*	*
P2S0	1.39	30.39	*	*
P2S1	0.00	4.92	8.33	*
P2S2	0.00	0.00	6.62	10.18
P3S0	1.52	33.57	*	*
P3S1	0.68	14.47	*	*
P3S2	0.40	8.10	*	*
P4S0	1.67	36.76	*	*
P4S1	1.11	24.02	*	*
P4S2	0.96	20.84	*	*
P5S0	1.32	28.80	*	*
P5S1	0.89	19.25	*	*
P5S2	0.61	12.88	*	*
P6S0	1.46	31.98	*	*
P6S1	0.00	6.51	8.55	*
P6S2	0.00	0.00	6.98	10.42
P7S0	1.59	35.16	*	*
P7S1	0.75	16.06	*	*
P7S2	0.47	9.69	*	*
P8S0	1.73	38.35	*	*
P8S1	1.18	25.61	*	*
P8S2	1.03	22.43	*	*
S. Em. ±	0.010	0.199		
C.D. at 5%	0.02	0.56		
C.V. %	2.77	2.34		

*= The fruits were not available for analysis due to completely spoilage.

P= Packaging material; S= Storage condition

The two years pooled data given in [Table-6] showed that effect of interaction between packaging materials and storage conditions were found significant with regards to disease incidence. The lowest disease incidence (0.00 and 0.00 per cent, respectively) was recorded in treatment P2S2 on 4th and 8th day of storage, which was at par with treatment P6S2. Whereas, the highest disease incidence (1.95 and 43.13 per cent, respectively) was recorded in okra fruits packed in P0S0. After 8th day all treatments kept in ambient temperature were discarded due to end of their shelf life and spoilage. On 12th day of storage treatments P1, P3, P4, P5, P7 and P8 kept in zero energy cool chambers and cold storage were discarded due to end of shelf life. The minimum disease incidence was observed in okra fruits on 12th day in treatment P2S2 (6.62 per cent) whereas, maximum disease incidence percent was observed in treatment P6S1 (8.55 per cent). On 16th day of storage the minimum (10.18 per cent) disease incidence was recorded in treatment, whereas, it was maximum (10.42 per cent) observed in okra fruits kept in treatment P6S2. Packaging reduces the exposure of fruits to microorganisms. Besides, pathogen growth and multiplication is retarded at low temperature, which probably explains the minimum disease incidence in okra fruits packed in LDPE bags of 50 micron thickness with 5% vents and stored at 12^0C.

Conclusion

Post-harvest treatments, packaging materials and storage conditions greatly affected quality of okra fruits. However, among the treatments investigated in this work, the best post-harvest treatment combination to manage okra quality was where okra fruits were dipped in citric acid 500 ppm + sodium benzoate 100 ppm, packed in LDPE bags of 50 micron thickness with 5% vents and stored in 12^0C temperature with 95% RH. The okra fruits subjected to these treatments had extending the shelf life of okra fruits up to 16 days with maximum ascorbic acid and moisture content also with minimum TSS and lesser disease incidence. This was followed by the okra fruits packed in same packaging and kept in zero energy cool chamber which had extended the shelf life of okra fruits up to 12 days.

Conflict of Interest: None declared

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