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Efficacy of different storage conditions of okra (*Abelmoschus esculentus* L. Moench)

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ABSTRACT : Tender, freshly harvested fruits of cv. ARKA ANAMIKA were subjected to different combination of packaging with different storage conditions *viz.*, T_1= cool chamber, polypropylene (100 gauge) with 0 per cent perforation, T_2= cool chamber, polypropylene (100 gauge) with 1 per cent perforation, T_3= cool chamber, no packaging (in open condition), T_4= low temperature, polypropylene (100 gauge) with 0 per cent perforation, T_5= low temperature, polypropylene (100 gauge) with 1 per cent perforation, T_6 = low temperature, no packaging (in open condition), T_7= room temperature, polypropylene (100 gauge) with 0 per cent perforation, T_8= room temperature, polypropylene (100 gauge) with 1 per cent perforation, T_9= room temperature, no packaging (in open condition). The temperature during storage period at cool chamber varied from 22^0C to 28^0C, respectively and relative humidity varied from 90 per cent to 94 per cent. Low temperature condition was maintained at 8 ± 1^0C and relative humidity was around 67 per cent (outside plastic) and 80 per cent (inside plastic) during the storage period. The temperature during storage at room temperature condition varied from 28^0C to 33^0C, respectively and relative humidity varied from 60.5 to72 per cent and 65.5 to 77 per cent. Results indicate that T_4 (low temperature + polypropylene + 0 % perforation) at a temperature of 8 ± 1^0C and relative humidity 80 per cent was the best treatment for storage of okra. It increased the shelf-life upto 12 days by considerably reducing the PLW, blackening, yellowing, retaining sensory quality, increases marketability. It also retained the ascorbic acid and chlorophyll content better during storage. Cool chamber was suitable for storing okra for 10 days with or without polypropylene.

KEY WORDS : Cool chamber, Low temperature, Okra, Polypropylene, Storage

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Okra [*Abelmoschus esculentus* (L.) Moench] has captured a permanent position among vegetable crops in India because of prolong period of cultivation, almost cultivated throughout the year except few winter months. Okra is a good source of vitamin A, B and contains vitamin C also. It is rich in protein and mineral contents. It is an excellent source of iodine and also useful for control of goitre and said to be good for people suffering from weakness of the heart (Yawalkar, 2004).

India is the highest okra producing country in the world with total production of 6.47 million tones (Anonymous, 2013). In spite of high production, in a tropical country like India, it is difficult to maintain the quality and storability of okra after harvest. Okra has also been classified as a vegetable of high respiratory activity (>120 mg CO_2/kg/hr). The fruit thus, losses its marketability and become unfit for consumption within 2 days of picking under ambient condition. At higher temperature of storage, moisture loss, shrinkage, toughening, yellowing and decay are rapid in fruits of okra. If the rates of these activities are reduced, the

shelf-life of this commodity can be increased (Ghai, 2002). In okra low temperature can most effectively extend the shelf-life and reduce the post harvest losses by arresting the metabolic breakdown and fungal deterioration of the commodity (Barbarinde and Fabunmi, 2009). High humidity storage in evaporative cool chamber as developed at IARI, New Delhi has been reported to minimize the dessication, dehydration and subsequent yellowing and spoilage and suitable for short term storage of fruits and vegetables (Khurdiya and Roy, 1986). Thus, present investigation was undertaken to study the efficacy of different storage conditions for okra.

RESEARCH METHODS

Freshly harvested, tender green okra fruits of cv. ARKA ANAMIKA, free from blemishes were packed with polypropylene packages (100 gauge; 20.5cm × 25.0cm packet size) with 0 per cent and 1 per cent perforation and also without any package and stored in three different conditions *viz.*, zero energy cool chamber, low temperature condition and at room temperature in the Department of Post Harvest Technology of Horticultural Crops, Bidhan Chandra Krishi Viswavidyalaya. Thus, the combination of packaging (with and without perforation) and non-packaging with different storage conditions are presented as: T_1 = cool chamber, polypropylene (100 gauge) with 0 per cent perforation; T_2 = cool chamber, polypropylene (100 gauge) with 1 per cent perforation; T_3 = cool chamber, no packaging (in open condition); T_4 = low temperature, polypropylene (100 gauge) with 0 per cent perforation; T_5 = low temperature, polypropylene (100 gauge) with 1 per cent perforation; T_6 = low temperature, no packaging (in open condition); T_7 = room temperature, polypropylene (100 gauge) with 0 per cent perforation; T_8 = room temperature, polypropylene (100 gauge) with 1 per cent perforation T_9 = room temperature, no packaging (in open condition). Each treatment was replicated thrice in a Completely Randomized Design and each replicate consisted of 24 fruits. The temperature during storage period at cool chamber varied from 22°C to 28°C and relative humidity varied from 90 per cent to 94 per cent. Low temperature storage condition was maintained at 8±1 °C and relative humidity 67 per cent (outside plastic) to 80 per cent (inside plastic). The temperature during storage at room temperature condition varied from 28°C to 33°C and relative humidity varied from 60.5 to 77 per cent (inside plastic). Observations were recorded on physiological loss in weight (PLW %), blackening (%), yellowing, sensory quality, marketable fruits (%) and ascorbic acid content (mg/100g) at different days interval. Yellowing was recorded visually by individually examining the okra pods and graded for their colour as follows (Chakraborty *et al.*,1991) : 5= fresh green , 4= green, 3= slight yellowing, 2= light yellow, 1= yellow. Sensory quality was recorded by grading for their general appearance and acceptability depending upon the condition of the okra fruits by a panel of judges (1-5 scale) (Kalra *et al.*, 1998). The ascorbic acid content of the samples were determined by 2, 6-dichlorophenol-indophenol dye method as reported by Ranganna (2000).

Statistical analysis :

The obtained data was analyzed by statistical significant at $P<0.05$ level, S.E. and C.D. at 5 per cent level by the procedure given by (Gomez and Gomez, 1984).

RESEARCH FINDINGS AND DISCUSSION

Table 1 indicated that PLW of different storage conditions was significant (5%) at different days of storage. PLW of T_1 (cool chamber + polypropylene + 0 % perforation) was nil throughout the period of storage. Significantly low PLW was recorded in T_4 (low temperature + polypropylene + 0 % perforation) and T_2 (cool chamber + polypropylene + 1 % perforation) treated fruits during storage. Fruits of T_6 (low temperature + no packaging) and T_9 (room temperature, no packaging in open condition) were not available for observation after 4nd day while the fruits of T_5 (low temperature + polypropylene + 1 % perforation) were not available for observation after 10nd day of storage due to rejection owing to very high moisture loss and shrinkage. The PLW on the 12th day of storage was significantly low (*i.e.*, 0 % and 0.90 %) in T_1 and in T_4 compared to other treatments. Blackening (%) of okra fruit was, however, significantly high in T_7 (Low temperature + no packaging) and T_1 (cool chamber + polypropylene + 0 % perforation) compared to other treatments on 12 day of storage (Table 1). It was also observed that blackening was least throughout the period of storage ranging from 0 per cent on the 2nd day of storage to 0.83 per cent on the 12th day of storage in T_4.

Yellowing was evaluated on the basis of colour/ appearance of the okra fruits and it increased gradually with the increase in storage period (Table 2). Yellowing

was significantly low in T_4 compared to other treatments. On 12th day of storage, least yellowing with a score of 4.0 was observed in T_4 followed by T_1 and T_7 in that increasing order, respectively. Sensory quality was evaluated on the basis of general appearance and acceptability depending on the condition of okra pods (Table 2). Throughout the period of storage, the sensory score was highest in T_4 ranging from 1 on 2nd day to 3 on 12th day of storage followed by T_1 and T_7 with a score of 1 on 2nd day to 4.00 on 12th day of storage.

Marketable fruits (%) affected by different storage conditions was significant (5%) at different days of storage (Table 3). On the 4th day of storage, there was no marketable fruits for the treatments T_6 and T_9. On 8th day of storage, percentage of marketable fruits was highest (100%) in T_1 and T_4 followed by 85.71 per cent in T_2, 71.43 per cent in T_3 and T_7, 66.67 per cent in T_8 and 52.38 per cent in T_5. On 12th day of storage, marketable fruits of T_4 (61.90 %) still remained significantly higher than T_3 (47.61 %) and T_1 (42.85 %). The ascorbic acid content was found to decrease in all the storage conditions with the increase in the number of days of storage (Table 3). The data also revealed that ascorbic acid content of okra pods packed in

Table 1: Physiological loss of weight (%) and as influenced by different packaging and storage conditions in okra

Treatments	Physiological loss of weight (%)						Blackening (%)					
	Storage period (Days)						Storage period (Days)					
	2	4	6	8	10	12	2	4	6	8	10	12
T_1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.13	0.281	2.15	5.81
T_2	0.00	0.00	0.00	0.63	0.63	2.47	0.09	0.12	0.15	0.179	1.75	4.10
T_3	0.00	0.66	1.51	4.60	8.71	9.57	0.10	0.15	0.18	0.242	1.38	2.02
T_4	0.00	0.19	0.34	0.47	0.84	0.90	0.00	0.00	0.10	0.250	0.40	0.83
T_5	4.25	9.06	12.28	16.31	-	-	0.00	0.00	0.58	7.167	-	-
T_6	14.34	-	-	-	-	-	0.15	-	-	-	-	-
T_7	0.25	0.44	1.38	1.89	2.45	2.97	0.04	0.11	0.18	0.371	2.47	6.07
T_8	1.59	3.46	13.87	20.51	-	-	0.10	0.13	0.14	0.164	-	-
T_9	8.67	-	-	-	-	-	0.11	-	-	-	-	-
S.E. ±	0.316	0.780	0.390	0.663	0.268	0.378	0.017	0.020	0.041	0.164	0.204	0.522
C.D. (P=0.05)	0.940	2.388	1.182	2.012	0.843	1.192	0.049	0.059	0.123	0.371	0.644	1.646

'-': Okra pods unavailable for observation as all are spoilt/rejected.

T_1 = Cool chamber, polypropylene (100 gauge) with 0%perforation; T_2 = Cool chamber, polypropylene (100 gauge) with 1%perforation; T_3 = Cool chamber, no packaging (in open condition); T_4 = Low temperature, polypropylene (100 gauge) with 0%perforation; T_5 = Low temperature, polypropylene (100 gauge) with 1%perforation; T_6 = Low temperature, no packaging (in open condition); T_7 = Room temperature, polypropylene (100 gauge) with 0%perforation; T_8 = Room temperature, polypropylene (100 gauge) with 1%perforation; T_9 = Room temperature, no packaging (in open condition)

Table 2: Yellowing and sensory quality as influenced by different packaging and storage conditions in okra

Treatments	Yellowing						Sensory quality					
	Storage period (Days)						Storage period (Days)					
	2	4	6	8	10	12	2	4	6	8	10	12
T_1	5.00	4.67	4.33	4.00	3.67	3.00	1.00	1.33	2.00	2.33	3.00	4.00
T_2	4.67	4.33	4.00	3.33	3.00	2.33	1.33	1.67	2.67	3.00	3.67	4.67
T_3	5.00	4.67	4.33	4.00	3.33	3.00	1.33	1.67	2.67	3.00	3.67	4.67
T_4	5.00	5.00	5.00	5.00	5.00	4.00	1.00	1.00	1.00	1.67	2.00	3.00
T_5	5.00	4.67	4.33	4.00	-	-	2.00	2.33	3.00	4.33	5.00	-
T_6	5.00	-	-	-	-	-	4.00	-	-	-	-	-
T_7	4.67	4.33	3.33	3.00	3.00	2.67	1.00	1.67	2.00	3.00	3.67	4.00
T_8	4.67	4.00	3.33	2.33	-	-	1.67	2.00	3.00	4.00	5.00	-
T_9	4.33	4.00	-	-	-	-	2.67	5.00	-	-	-	-
S.E. ±	0.222	0.263	0.282	0.178	0.211	0.211	0.222	0.248	0.178	0.218	0.2182	0.192
C.D. (P=0.05)	NS	NS	0.855	0.540	0.664	0.664	0.660	0.738	0.540	0.662	0.662	0.593

'-': Okra pods unavailable for observation as all are spoilt/rejected; NS = Non-significant; Sensory score: 1= Outstanding (fresh like); 2= Good- bright green colour, free from blemishes; 3= Fair- bright green colour, slight limping; 4= Poor pod colour, blackening on the ridges, rough and dry appearance, slight limping; and 5= Unacceptable, colour deteriorated, shrivelled pods and microbial spoilage of pods

Table 3 : Ascorbic acid (mg/100g) and marketable fruits as influenced by different packaging and storage conditions in okra

Treatments	Ascorbic acid (mg/100g)				Marketable fruits			
	Storage period (Days)				Storage period (Days)			
	Initial	4	8	12	4	8	12	
T_1		8.70	6.76	6.12	100.00	100.00	42.86	
T_2		8.66	6.58	4.16	100.00	71.43	38.10	
T_3		7.80	5.53	4.19	100.00	85.71	47.62	
T_4		10.20	9.39	8.56	100.00	100.00	61.91	
T_5	14.00	10.44	7.58	-	100.00	52.38	0	
T_6		-	-	-	0	0	0	
T_7		8.20	6.58	4.36	100.00	71.43	38.10	
T_8		6.54	5.39	-	95.24	66.67	0	
T_9		-	-	-	0	0	0	
S.E. ±	-	0.116	0.226	0.154	1.587	3.549	4.200	
C.D. (P=0.05)	-	0.346	0.684	0.486	4.717	10.546	12.478	

NS= Non-significant; '-' Okra pods unavailable for observation as all spoilt/rejected; T_1 = Cool chamber, polypropylene (100 gauge) with 0% perforation; T_2 = Cool chamber, polypropylene (100 gauge) with 1% perforation; T_3 = Cool chamber, no packaging (in open condition); T_4 = Low temperature, polypropylene (100 gauge) with 0% perforation; T_5 = Low temperature, polypropylene (100 gauge) with 1% perforation; T_6 = Low temperature, no packaging (in open condition); T_7 = Room temperature, polypropylene (100 gauge) with 0% perforation; T_8 = Room temperature, polypropylene (100 gauge) with 1% perforation; T_9 = Room temperature, no packaging (in open condition)

polypropylene bags at low temperature without perforation (T_4) remained high during later period of storage as compared to those packed in polypropylene bags with 1 per cent perforation (T_5) and other storage conditions.

Results indicate that T_4 (Low temperature + polypropylene + 0 % perforation) at a temperature of 8±1 °C and relative humidity 80 per cent was the best treatment for storage of okra. It increased the shelf-life upto 12 days by considerably reducing the PLW, blackening, yellowing, retaining sensory quality, increasing marketability. It also retained the ascorbic acid content better during storage. This finding is in accordance with the previous reports of Baxter and Waters (1990) and Rice *et al*. (1990). Low temperature in okra extends the shelf-life by arresting the metabolic breakdown and fungal deterioration of the commodity (Babarinde and Fabunmi, 2009). Okra should be stored above 7 °C in order to avoid the development of chilling disorders, which includes pitting and discoloration (Salunkhe and Desai, 1984; Lyons and Breidenbach, 1987 and Joyce *et al.*, 2009). At higher temperatures, toughening, yellowing and decay are rapid and a relative humidity of 85-90 per cent is desirable to prevent shrivelling (Jambhale and Nerkar, 1998). Pantastico *et al*. (1975) recommended a temperature of 8.8 °C and 90 per cent relative humidity to store okra for about 2 weeks in marketable condition. The treatment T_1 (Cool chamber + polypropylene + 0 % perforation) also was equally effective treatment particularly in maintaining the freshness of okra fruits although blackening was slightly higher compared to low temperature storage. High humidity condition and comparatively lower temperature of cool chamber from outside during the period of storage retarded metabolic activities by restricting the respiration and transpiration (Roy and Khurdiya,1982; Pal and Roy, 1988 and Mitra *et al*., 2003). Low physiological loss of weight and shrinkage in cool chamber increased the shelf-life of different vegetables (Chakraborty *et al.*, 1991; Naiya and Kabir, 2006 and 2007). Ekka and Chakrabarti (2007) in conformity with the present findings reported that shelf-life of okra cv. PUSA-4 and PARBHANI KRANTI is 12 days in cool chamber.

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