STUDIES ON SUITABILITY OF DIFFERENT PACKAGES FOR TRANSPORT OF OKRA(Abelmoschus esculentus L. Moench).

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ABSTRACT

Freshly harvested, tender green okra fruits of cv. Sinnova, were packed in corrugated fibreboard (CFB) boxes as transport package with different percentages of ventilation (3% and 5%) and different types of liners (2% perforation) viz., polyethylene liner, polypropylene liner and newspaper liner. The okra fruits of different corrugated fibreboard boxes were stored in cool, dry place on racks at room temperature (average minimum and maximum temperature varied from 28^{0}C to 29^{0}C and 30.5^{0}C to 34^{0}C respectively and relative humidity from 57.5 to 74%). Results indicated that for transport package the treatment T_5 (with 5% ventilation + polyethylene liner) was the best followed by T_1 (CFB with 3%ventilation + polyethylene liner) and T_2 (CFB with 3%ventilation + polypropylene liner) up to 8th day of storage because of less physiological loss in weight, blackening, yellowing, high marketability, superior sensory quality and reasonably high ascorbic acid content. Up to 6th day T_6 (CFB with 5%ventilation + polypropylene liner) was also acceptable treatment.

Keywords: Corrugated fibreboard, liners, okra, package, ventilation,

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is an important vegetable of Tropics and Sub - tropics. It is widely grown in India for its mature, tender, green fruits which are used for culinary purpose. 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).

Okra 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. India is the highest okra producing country in the world with total production of 6.47 million tones (Anon., 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. Moisture loss, shrinkage, toughening, blackening, spoilage and yellowing are problems associated with the crop. If the rates of these activities are reduced, the shelf life of this commodity can be increased (Ghai, 2002). Further, often poor prepackaging, post harvest handling and transportation causes high post harvest losses of the commodity.

Previous report indicated the prospect of improving the shelf life of okra by prepackaging of fresh fruits in perforated and non-perforated consumer size polyethylene bags under room temperature and optimum storage condition (Assumi *et al.* 2009). Fontenot *et al.*, (1987) recommended plastic film packaging of okra as a protection against moisture loss and abrasion. Packaging increases the shelf-life by creating a modified atmosphere with an increase in the concentration of CO_2 in the package. The packaging material used should provide reasonable access to O_2, LDPE (Low density polyethylene) films which have high O_2 and CO_2 transmission rates are more durable. Polyethylene packaging of okra provides modified atmosphere and consequently reduces decay, softening and loss of solids (Sandha, 2002).

MATERIALS AND METHODS

Freshly harvested, tender green okra fruits, free from blemishes, were packed in corrugated fibreboard (CFB) boxes as transport package with different percentages of ventilation with different types of liners (with 2% perforation) in the following treatment combination: T_1=CFB with 3%ventilation, polyethylene liner, T_2=CFB with 3%ventilation, polypropylene liner, T_3=CFB with 3%ventilation, newspaper liner, T_4=CFB with 3%ventilation, no liner, T_5=CFB with 5%ventilation, polyethylene liner, T_6=CFB with 5%ventilation, polypropylene liner, T_7 =CFB with

5%ventilation, newspaper liner, T_8 =CFB with 5%ventilation, no liner. The okra fruits in different corrugated fibreboard boxes were stored in cool, dry place on racks at room temperature in the laboratory of Post Harvest Technology of Horticultural Crops, Bidhan Chandra Krishi Viswavidyalaya.. The average minimum and maximum temperature during storage period at ambient condition varied from 28°C to 29°C and 30.5°C to 34°C respectively and relative humidity varied from 57.5 to 74%. The experiment was laid out in 2 factor factorial completely randomized design with three replication (Factor 1 : Treatments, Factor 2 : Days of storage).

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.,* 1988). The ascorbic acid content of the samples were determined by 2,6-dichlorophenol-indophenol dye method as reported by Ranganna (2000).

RESULTS AND DISCUSSION

PLW% of different packaging treatment at 2 days interval up to 10 days has been presented in Table 1. The data indicated that the PLW (%) as influenced by different treatments was significant (5%) at different days of storage. The result showed the lowest PLW of okra fruits packed in CFB with polyethylene liner i.e. T_1 (CFB with 3% ventilation, polyethylene liner) and T_5 (CFB with 5%ventilation, polyethylene liner) followed by those with polypropylene liner i.e. T_2 (CFB with 3%ventilation + polypropylene liner) and T_6 (CFB with 5%ventilation + polypropylene liner) throughout the period of storage. On the 8^{th} day of storage, lowest PLW (14.67%) was observed in T_5 closely followed by 15.05% in T_1, 20.59% in T_6 and 21.20% in T_2 respectively. Blackening (%) on the 2^{nd} day of storage was low (0.25%) in T_3, T_4, T_7 and T_8 and was significantly high (0.5%) in T_1 (CFB with 3%ventilation + polyethylene liner), T_2 (CFB with 3%ventilation + polypropylene liner), T_5 (CFB with 5%ventilation + polyethylene liner) and T_6 (CFB with 5%ventilation + polypropylene liner) respectively on 2^{nd} day of storage (Table 2). In later period of storage, blackening was less in T_1 and on 8^{th} day of storage, it was least (2.0%) in T_1 (CFB with 3% ventilation + polyethylene liner) and T_4 (CFB with 3%ventilation, no liner) followed by 2.5% in T_6

(CFB with 5%ventilation + polypropylene liner), T_7 (CFB with 5%ventilation + newspaper liner) and T_8 (CFB with 5%ventilation + no liner). Yellowing increased gradually and on the 8th day, least yellowing with a score of 3.0 was observed in T_1 and T_2 followed by 2.67 in T_5, T_6 and T_7 respectively (Table3). Marketability of fruits on 4th day of storage was highest (100%) in T_6 followed by 83.33% in T_1, 82.35% in T_5 , 76.47% in T_2 and so on (Table 4). However during the later period of storage i.e. on 8th day of storage, highest percentage of marketable fruits (61.11%) was observed in T_5 followed by 52.94% in T_2 and 50% in T_1 .Marketable fruits of other treatments was less than 50%.

On 8th day of storage, T_6, T_1, T_2 and T_5 recorded superior sensory score of 3.33 (for T_6) and 3.67 (for T_1, T_2 and T_5) over T_3 and T_7 (score 4.67) and T_4 and T_8 (5.0) (Table5). It was noticed that polyethylene and polypropylene liner gave good sensory score of okra fruit irrespective of the percentage of ventilation in CFB boxes, while sensory quality with paper liner and no liner was low.

It was also noticed that among the various packages, when the liners were compared, fruits packed in CFB without any liner (T_4 and T_8) had the lowest ascorbic acid content on the 4th and 8th day of storage irrespective of the percentage of ventilation of CFB boxes (Table6). .Highest ascorbic acid content (6.24mg/100g) was observed in T_3 (CFB with 3%ventilation + newspaper liner) followed by 5.76mg/100g in T_7 (CFB with 5%ventilation + newspaper liner), 5.66mg/100g in T_2 (CFB with 3%ventilation + polypropylene liner) and 4.8mg/100g in T_1 (CFB with 3%ventilation + polyethylene liner), 4.56mg/100g in T_4 (CFB with 3%ventilation + no liner), T_5 (CFB with 5%ventilation + polyethylene liner) and T_6 (CFB with 5%ventilation + polypropylene liner) and 4.08mg/100g in T_8 (CFB with 5% ventilation + no liner) on 8th day of storage.

Thus for transport package the treatment T_5 (CFB with 5%ventilation + polyethylene liner) was the best followed by T_1 (CFB with 3%ventilation + polyethylene liner) and T_2 (CFB with 3%ventilation + polypropylene liner) up to 8th day of storage because of less PLW, blackening, yellowing, high marketability, superior sensory quality, comparatively high ascorbic. The prospect of the use of CFB boxes as transport packages has been highlighted earlier by Hardenburg (1986). He reported that fibreboard cartons are effective as master containers for consumer-packed vegetables with polyethylene or cellophane-wrapping, etc. The efficacy of polyethylene and polypropylene as liner in CFB boxes has been reported by Roy *et al.* (2000).

Okra has a very high respiration rate (Ghai, 2002) which results in imbalance of gaseous concentration inside the package (polyethylene/polypropylene + CFB). The liners particularly polyethylene has a role of controlling transmission rate and maintenance of oxygen, carbon dioxide and water vapour inside the package to desirable level (Kader *et al.,* 1989). High rate of PLW in T_3 (CFB with 3%ventilation + newspaper liner) and T_7 (CFB with 5%ventilation + newspaper liner) where paper liner used as wrapping or cushioning material on 6^{th} day of storage corroborate the results of Sankaran *et al.* (2005) in ambient condition in okra. The shelf life in the present investigation was 8 days for T_5 (CFB with 5%ventilation + polyethylene liner), T_1 (CFB with 3%ventilation + polyethylene liner) and T_2 (CFB with 3%ventilation + polypropylene liner) in ambient condition in contrast to 14 days at 10 or 12°C in CFB boxes (1% ventilation) with paper material as cushioning in okra (Sankaran *et al.* 2005) and 18 days in room condition when packed in CFB boxes (2% ventilation) with polyethylene bags (2% vents) in bottlegourd (Wasker *et al.,* 1999). The rate of textural deterioration leading to sensory quality varies widely depending upon the commodity, packaging material and storage conditions. The reduced level of weight loss in fruits is due to the low moisture loss regulated by the packaging (prepackaging + CFB boxes) material. Besides, O_2 depression and CO_2 build up in CFB boxes reach an equilibrium level as a result, the respiratory activity is slowed down (Taimura and Minamide, 1984 and Jayaram and Raju, 1992).

Thus it can be concluded from the results that for transport package the treatment T_5 (CFB with 5%ventilation + polyethylene liner) was the best followed by T_1 (CFB with 3%ventilation + polyethylene liner) and T_2 (CFB with 3%ventilation + polypropylene liner) up to 8^{th} day of storage because of less PLW, blackening, yellowing, high marketability, superior sensory quality, comparatively high ascorbic acid and chlorophyll. Up to 6^{th} day T_6 (CFB with 5%ventilation + polypropylene liner) was also acceptable treatment.

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Table 1. Physiological loss of weight (%) as influenced by different packaging conditions for transport.

Treatment	Storage period (Days)					Mean
	2	4	6	8	10	
T_1	2.91	7.77	11.46	15.05	16.84	10.81
T_2	4.35	9.78	14.39	21.20	23.66	14.68
T_3	8.91	20.79	27.21	39.60	45.44	28.39
T_4	11.86	21.13	36.47	42.27	48.15	31.98
T_5	3.26	7.61	11.91	14.67	17.98	11.09
T_6	4.90	8.82	14.94	20.59	23.88	14.63
T_7	9.00	20.00	28.00	36.00	46.00	27.80
T_8	11.98	22.68	37.09	50.00	55.08	35.37
Mean	7.15	14.82	22.68	29.92	34.63	
	S.E.m	CD(0.05%)				
Treatment(T)	0.1480	0.4440				
Days (D)	0.0783	0.2210				
T x D	0.2215	0.6260				

Table 2. Blackening (%) as influenced by different packaging conditions for transport.

Treatment	Storage period (Days)					Mean
	0	2	4	6	8	
T_1	0.00	0.50	1.00	1.25	2.00	0.95
T_2	0.00	0.50	1.00	2.50	3.00	1.40
T_3	0.00	0.25	0.50	2.00	3.00	1.15
T_4	0.00	0.25	1.50	1.75	2.00	1.10
T_5	0.00	0.50	2.00	2.50	3.00	1.60
T_6	0.00	0.50	1.00	2.25	2.50	1.25
T_7	0.00	0.25	1.50	2.00	2.50	1.25
T_8	0.000	0.25	1.00	2.00	2.50	1.15
Mean	0.00	0.38	1.19	2.03	2.56	
	S.E.m	CD(0.05%)				
Treatment\(T)	0.0669	0.2006				
Days (D)	0.0318	0.0899				
T x D	0.0898	0.2539				

T_1=CFB with 3%ventilation + polyethylene liner ; T_2 =CFB with 3%ventilation + polypropylene liner ; T_3 =CFB with 3%ventilation + newspaper liner ; T_4 =CFB with 3%ventilation + no liner ; T_5 =CFB with 5%ventilation + polyethylene liner ; T_6 =CFB with 5%ventilation + polypropylene liner ; T_7 =CFB with 5%ventilation + newspaper liner ; T_8 =CFB with 5%ventilation + no liner

Table 3. Yellowing as influenced by different packaging conditions for transport.

Treatment	Storage period (Days)					Mean
	0	2	4	6	8	
T_1	5.00	4.33	4.00	3.33	3.00	3.93
T_2	5.00	4.33	4.00	3.33	3.0	3.93
T_3	5.00	4.00	3.67	3.00	2.33	3.60
T_4	5.00	4.33	3.67	3.33	2.33	3.73
T_5	5.00	4.00	3.67	3.00	2.67	3.67
T_6	5.00	4.33	4.00	3.33	2.67	3.87

T_7	5.00	4.33	4.00	3.00	2.67	3.80
T_8	5.00	4.00	3.67	2.33	2.33	3.47
Mean	5.00	4.21	3.833	3.08	2.63	
	S.E.m	CD(0.05%)				
Treatment(T)	0.1472	0.4413				
Days (D)	0.0728	0.2059				
T x D	0.2058	0.5820				

Table 4. Marketable fruits (%) as influenced by different packaging conditions for transport.

Treatment	Storage period (Days)					Mean
	0	2	4	6	8	
T_1	100.00	100.00	83.33	72.22	50.00	81.11
T_2	100.00	100.00	76.47	64.71	52.94	78.82
T_3	100.00	100.00	66.67	55.56	44.44	73.33
T_4	100.00	100.00	50.00	44.44	33.33	65.55
T_5	100.00	100.00	82.35	70.58	61.11	82.81
T_6	100.00	100.00	100.00	77.78	44.44	84.44
T_7	100.00	100.00	55.56	44.44	35.29	67.06
T_8	100.00	100.00	44.44	38.89	22.22	61.11
Mean	100.00	100.00	69.85	58.58	42.97	
	S.E.m	CD(0.05%)				
Treatment(T)	1.5230	4.5659				
Days (D)	0.7530	2.1295				
T x D	2.1298	6.0231				

T_1=CFB with 3%ventilation + polyethylene liner ; T_2 =CFB with 3%ventilation + polypropylene liner ; T_3 =CFB with 3%ventilation + newspaper liner ; T_4 =CFB with 3%ventilation + no liner ; T_5

=CFB with 5%ventilation + polyethylene liner ; T_6 =CFB with 5%ventilation + polypropylene liner ; T_7 =CFB with 5%ventilation + newspaper liner ; T_8 =CFB with 5%ventilation + no liner

Table 5. Sensory quality as influenced by different packaging conditions for transport.

Treatment	Storage period (Days)					Mean
	0	2	4	6	8	
T_1	1.00 (5.74)	1.67 (7.33)	2.67 (9.36)	3.00 (9.97)	3.67 (11.02)	2.40 (8.68)
T_2	1.00 (5.74)	1.67 (7.33)	2.67 (9.36)	3.00 (9.97)	3.67 (11.02)	2.40 (8.68)
T_3	1.00 (5.74)	2.00 (8.13)	3.00 (9.97)	3.33 (10.50)	4.67 (12.46)	2.80 (9.36)
T_4	1.00 (5.74)	2.00 (8.13)	3.00 (9.97)	3.67 (11.02)	5.00 (12.92)	2.93 (9.56)
T_5	1.00 (5.74)	1.67 (7.33)	2.67 (9.36)	3.00 (9.97)	3.67 (11.02)	2.40 (8.68)
T_6	1.00 (5.74)	1.67 (7.33)	2.67 (9.36)	3.33 (10.50)	3.33 (10.50)	2.40 (8.68)
T_7	1.00 (5.74)	2.00 (8.13)	3.00 (9.97)	4.00 (11.54)	4.67 (12.46)	2.93 (9.57)
T_8	1.00 (5.74)	2.00 (8.13)	3.00 (9.97)	4.00 (11.54)	5.00 (12.92)	3.00 (9.97)
Mean	1.00 (5.74)	1.83 (7.73)	2.83 (9.67)	3.42 (10.63)	4.21 (11.79)	
	S.E.m	CD(0.05%)				
Treatment(T)	0.1563	0.4686				
Days (D)	0.0597	0.1688				
T x D	0.1687	0.4771				

(Angular transformed values are given in the parenthesis)

Table 6. Ascorbic acid (mg/100g) as influenced by different packaging conditions for transport.

Treatment	Storage period (Days)			Mean
	0	4	8	
T_1	14.00	10.75	4.80	9.85
T_2	14.00	11.53	5.66	10.40
T_3	14.00	11.85	6.24	10.70
T_4	14.00	9.23	4.56	9.26
T_5	14.00	10.01	4.56	9.52
T_6	14.00	11.32	4.56	9.96
T_7	14.00	12.11	5.76	10.62
T_8	14.00	9.27	4.08	9.12
Mean	14.00	10.76	5.03	
	S.E.m	CD(0.05%)		
Treatment(T)	0.3275	0.9818		
Days (D)	0.1638	0.4720		
T x D	0.4634	1.3360		

T_1=CFB with 3%ventilation + polyethylene liner ; T_2 =CFB with 3%ventilation + polypropylene liner ; T_3 =CFB with 3%ventilation + newspaper liner ; T_4 =CFB with 3%ventilation + no liner ; T_5 =CFB with 5%ventilation + polyethylene liner ; T_6 =CFB with 5%ventilation + polypropylene liner ; T_7 =CFB with 5%ventilation + newspaper liner ; T_8 =CFB with 5%ventilation + no liner