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Post harvest treatments on storage behaviour of okra

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ABSTRACT

Freshly harvested, tender green okra fruits cv. Sinnova were subjected to different post harvest treatments *viz*.,T_1 = Virosil Agro (0.5%), T_2 = NaOCl (100 ppm Cl), T_3 = $Ca(OCl)_2$ (100 ppm Cl), T_4 = Virosil Agro + wax (1%), T_5 = NaOCl (100 ppm Cl) + wax (1%), T_6 = $Ca(OCl)_2$ (100 ppm Cl) + wax (1%), T_7 = wax (1%) and packed in polypropylene packages with no perforation in ambient condition (maximum and minimum temperature varied from 23° to 24°C and 19° to 22°C, respectively and relative humidity from 47 to 65%). Considering the overall quality it was found that T_5 was the best treatment followed by T_7, T_4 and T_1. However, T_7 retained better ascorbic acid and chlorophyll during later period of storage.

Key words: Okra, virosil agro, storage, wax.

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is an important vegetable of tropics and sub-tropics which is widely grown in India for its mature, tender, green fruits which are used for culinary purpose. Okra is a good source of vitamins A, B and small amount of 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, 24). India is the highest okra producing country in the world with 0.45 million hectares of land under cultivation and total production of 4.80 million tonnes (NHB, 15). Inspite 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/h). The fruit thus losses its marketability and become unfit for consumption within two 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, 10). Nowadays, a range of formulation of edible coatings has been developed to increase the shelf life of fruit and vegetable by post harvest treatments. Some of these coatings are Semperfresh (Curtis, 5) a fungicidal wax contaning 25% O-phenyl phenol, Chitosan (El Ghaouoth, 8), Corn zein film (Park *et al.*, 16), Stayfresh (Anon., 2), a natural plant compound like trans-cinnamaldehyde *etc*. which extends the shelf-life by reducing physiological loss of weight, respiration, ethylene production, postharvest diseases and by delaying senescence. The research into alternative fungicidal techniques to control post harvest diseases is increasing. One reason for this intensified interest is that the use of synthetic fungicides imposes selective pressure upon the pathogen population (Spotts and Cervantes, 20). There is also an increasing concern among consumers' regulatory agencies about the health hazards of chemical residues (Wilson and Wisniewski, 22). Therefore, alternative means of controlling diseases and decay and increase storage life by post harvest treatment with ecofriendly chemicals like Virosil Agro® is needed (Naiya and Kabir, 14). Thus, the main objective of the study is to increase the shelf life of okra by post harvest treatments.

MATERIALS AND METHODS

Freshly harvested, tender green okra fruits cv. Sinnova, free from blemishes, adhering sand or soil or foreign matters obtained from Horticultural Research Station, Mondouri were used for the experiment. The fruits under observations were subjected to different treatments as T_1 = Virosil Agro® (0.5%); T_2 = NaOCl (100 ppm Cl); T_3 = $Ca(OCl)_2$ (100 ppm Cl); T_4 = Virosil Agro + wax (1%); T_5 = NaOCl (100 ppm Cl) + wax (1%); T_6 = $Ca(OCl)_2$ (100 ppm Cl) + wax (1%); T_7 = wax (1%). The wax used for the experiment was carnauba wax. Then, after giving the above treatments, the 7-8 fruits were packed in polypropylene packages (23.0 cm × 30.5 cm) of 100 gauge thickness with no perforation. Experimental design adopted was 2 factor factorial completely randomized design with

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treatment as Factor 1 and days of storage as Factor 2 and replicated thrice. The packed fruits were then stored in cool, dry place on racks at room temperature in the Department of Post Harvest Technology of Horticultural Crops during October-December. The maximum and minimum temperature during storage period at ambient conditions varied from 23° to 24°C and 19° to 22°C respectively and relative humidity varied from 47 to 65%.

Observations were recorded on physiological loss in weight (%), blackening (%), marketable fruits (%), sensory quality and yellowing. Blackening was recorded by visual means by observing the pre-packed fruits individually in each experimental lot on the day of observation and expressed in percentage (Assumi *et al.*, 3). Okra fruits were also estimated for ascorbic acid content (Ranganna, 17) and chlorophyll content at 4 days interval. Total chlorophyll content was estimated spectrophotometrically by following the procedure as described by Ranganna (17) and expressed as mg/g of fresh weight.

RESULTS AND DISCUSSION

The mean physiological loss of weight (PLW%) of okra pods as affected by various post harvest treatments was found to increase significantly (0.05%) throughout the period of storage (Table 1). It was observed that the okra pods treated with wax had the lowest PLW after 2nd day of storage. On 2nd day, T_5 (NaOCl + wax) and T_6 {$Ca(OCl)_2$ + wax} had PLW of 0.280% and 0.275% respectively followed by 0.285% in T_7 (wax) and 0.286% in T_4 (Virosil Agro + wax). Highest PLW of 0.346% in T_1 (Virosil Agro) was followed by 0.311% in T_2 (NaOCl) and 0.299% in T_3 {$Ca(OCl)_2$}. PLW increased gradually in all the treatments and on 14th day of storage, lowest PLW was observed in T_7 (1.97%) followed by 2.098% in T_5 (NaOCl + wax) and 2.15% in T_2 (NaOCl). Highest PLW was recorded in okra pods with treatment T_4 (2.446%) followed by 2.408% in T_1 (Virosil Agro), 2.34% in T_3 {$Ca(OCl)_2$}, 2.301% in T_6 {$Ca(OCl)_2$ + wax} in that decreasing order on 14th day of storage.

When the treatment means were compared, T_7 had the lowest PLW (1.131%) followed by T_2 (1.223%), T_5 (1.232%), T_6 (1.307%), T_4 (1.369%), T_3 (1.371%) and T_1 (1.442%) respectively in increasing order. The mean treatment effect of T_7 was at par with other treatments except T_1 (Virosil Agro). PLW of T_7, *i.e.*, wax treatment was significantly lower than T_1 (Virosil Agro), T_3 {$Ca(OCl)_2$}, T_4 (Virosil Agro + wax) and T_6 {$Ca(OCl)_2$ + wax} but was significantly at par with T_2 (NaOCl) and T_5 (NaOCl + wax) both on 12th and 14th day of storage.

Blackening (%) has been tabulated in Table 1. On 2nd day of storage, T_7 (wax) and T_5 (NaOCl + wax) had the lowest blackening (%) of 0.092% and 0.094% followed by 0.15% in T_6 {$Ca(OCl)_2$ + wax}, 0.181% in T_3 {$Ca(OCl)_2$}, 0.195% in T_2 (NaOCl), 0.222% in T_1 (Virosil Agro) and 0.382% in T_4 (Virosil Agro + wax) respectively. Blackening remained lowest up to 12th day of storage in comparison to other treatments. However, on 14th day of storage, lowest blackening (%) was observed in T_5 (3.216%), followed by T_3 (4.236%), T_1 (4.611%), T_4 (4.758%) and T_7 (4.772%) respectively. When the treatment means were compared, it was found that T_2 had the highest blackening followed by T_4.

The sensory quality of okra pods as affected by various post harvest treatments decreased throughout the period of storage (Table 2). When the treatment means were compared, T_1 (Virosil Agro) had the best sensory score of 2.4 followed by T_4 (Virosil Agro + wax) with a score of 2.5 and T_5 (NaOCl + wax) with a score of 2.6 respectively. On 6th day of storage, sensory score (2) was similar for all the treatments except for T_2 and T_3 with a score of 2.3. On 10th day of storage, sensory score of T_1, T_2, T_4 and T_7 was similar (score of 3) but better than T_3, T_5 and T_6 (score of 3.3). However all the treatment effect was statistically at par. During the later period of storage, *i.e.* on 12th and 14th day of storage T_1 (Virosil Agro) (score of 3.0 and 3.7, respectively) maintained significantly superior quality compared to other treatments and it was followed by T_4 (Virosil Agro + wax).

From Table 2, it is evident that up to 8th day of storage, pods of all the treatments were marketable. For treatments T_5 and T_7, 100% pods were marketable up to 10th day of storage. When the treatment means were compared, it was found that T_5 (NaOCl + wax) had the highest number of marketable pods (92.86%) followed by T_1 (Virosil Agro), T_7 (wax) and T_4. Lowest number of marketable pods was obtained in T_3 {$Ca(OCl)_2$} and T_6 {$Ca(OCl)_2$ + wax} with a percentage of 85.71%. On 12th day of storage marketable pods as high as 83.33% was observed in T_1 (Virosil Agro) and T_5 (NaOCl + wax) followed by 77.78% in T_7 (wax) and 72.22% in T_4 (Virosil Agro + wax). However, all the treatment effect was at par with each other. Similar trend was followed on 14th day of storage but the per cent of marketable pods decreased abruptly and varied from 50 to 66.67%.

Ascorbic acid (mg/100 g) content at different days of storage has been presented in Table 3. The data revealed that the ascorbic acid content of okra pods as affected by various post harvest treatments and packaging decreases significantly throughout the period of storage. When the treatment means

Table 1. Effect of post-harvest treatments on physiological loss of weight (%) and blackening (%) of okra.

Treatment	PLW (%)							Mean	Blackening (%)							Mean
Storage period (days)	2	4	6	8	10	12	14		2	4	6	8	10	12	14	
T_1	0.346	0.655	1.170	1.517	1.832	2.168	2.408	1.442	0.222	1.486	0.836	1.128	1.253	2.092	4.611	1.486
T_2	0.311	0.595	0.957	1.179	1.527	1.843	2.150	1.223	0.195	1.760	0.786	1.091	1.282	2.986	5.771	1.760
T_3	0.299	0.670	1.141	1.393	1.716	2.036	2.340	1.371	0.181	1.434	0.772	0.792	1.367	2.486	4.236	1.434
T_4	0.286	0.639	1.050	1.380	1.758	2.024	2.446	1.369	0.382	1.674	0.739	1.036	1.593	3.050	4.758	1.674
T_5	0.280	0.607	1.000	1.270	1.557	1.818	2.098	1.233	0.094	1.139	0.469	0.772	1.080	2.211	3.217	1.139
T_6	0.275	0.620	1.021	1.304	1.634	1.995	2.301	1.307	0.150	1.509	0.517	0.814	1.098	2.267	5.517	1.509
T_7	0.285	0.552	0.883	1.120	1.404	1.705	1.970	1.131	0.092	1.252	0.425	0.714	0.994	1.664	4.772	1.252
Mean	0.297	0.620	1.032	1.309	1.6325	1.941	2.245		0.188	0.181	0.649	0.907	1.238	2.394	4.697	
		$CD_{0.05}$								$CD_{0.05}$						
Treatment (T)		0.3982								1.8565						
Day		0.093								0.8076						
T × day		0.2451								2.1364						

T_1 = Virosil Agro; T_2 = NaOCl; T_3 = $Ca(OCl)_2$; T_4 = Virosil Agro + wax; T_5 = NaOCl + wax; T_6 = $Ca(OCl)_2$ + wax; T_7 = wax.

Table 2. Effect of post-harvest treatments on sensory quality and marketable fruits (%) of okra.

Treatment	Sensory quality							Mean	Marketable fruits (%)							Mean
Storage period (days)	2	4	6	8	10	12	14		2	4	6	8	10	12	14	
T_1	1.0	2.0	2.0	2.3	3.0	3.0	3.7	2.4	100 (90)	100 (90)*	100 (90)	100 (90)	94.44 (81.97)	83.33 (70.21)	66.67 (55.21)	92.06 (81.06)
T_2	1.0	2.3	2.3	2.3	3.0	3.7	4.3	2.7	100 (90)	100 (90)	100 (90)	100 (90)	88.89 (78.25)	66.67 (55.21)	50.00 (45)	86.51 (76.92)
T_3	1.0	2.0	2.3	2.3	3.3	3.7	4.3	2.7	100 (90)	100 (90)	100 (90)	100 (90)	83.33 (70.21)	66.67 (55.21)	50.00 (45)	85.71 (75.78)
T_4	1.0	2.0	2.0	2.0	3.0	3.3	4.0	2.5	100 (90)	100 (90)	100 (90)	100 (90)	88.89 78.25)	72.22 (58.46)	55.56 (48.25)	88.09 (77.85)
T_5	1.0	2.0	2.0	2.0	3.3	3.7	4.0	2.6	100 (90)	100 (90)	100 (90)	100 (90)	100.00 (90)	83.33 (65.90)	66.67 (54.74)	92.86 (81.52)
T_6	1.0	2.0	2.0	2.3	3.3	3.7	4.7	2.7	100 (90)	100 (90)	100 (90)	100 (90)	83.33 (65.90)	66.67 (54.74)	50.00 (45)	85.71 (75.09)
T_7	1.0	2.0	2.0	2.3	3.0	3.7	5.0	2.7	100 (90)	100 (90)	100 (90)	100 (90)	100.00 (90)	77.78 (66.97)	55.56 (48.25)	90.48 (80.74)
Mean	1.0	2.0	2.1	2.0	3.1	3.5	4.3		100 (90)	100 (90)	100 (90)	100 (90)	91.27 (79.23)	73.81 (60.96)	56.35 (48.78)	

	$CD_{0.05}$	$CD_{0.05}$
Treatment (T)	0.5293	9.5421
Day	0.242	5.0176
T × day	0.6402	13.2753

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.
T_1 = Virosil Agro; T_2 = NaOCl; T_3 = $Ca(OCl)_2$; T_4 = Virosil Agro + wax; T_5 = NaOCl+ wax; T_6 = $Ca(OCl)_2$ + wax; T_7 = wax
*Angular transformed values are given in the parenthesis

Table 3. Effect of post harvest treatments on ascorbic acid (mg/100 g) and total chlorophyll (mg/g f.w.) of okra.

Treatment	Ascorbic acid (mg/100 g)				Mean	Total chlorophyll (mg/g f.w.)				Mean
Storage period (days)	0	4	8	12		0	4	8	12	
T_1	15.96	10.04	8.43	6.06	10.12	1.290	1.110	0.843	0.690	0.983
T_2	15.96	14.36	7.30	5.19	10.71	1.290	1.100	0.970	0.720	1.020
T_3	15.96	10.81	6.74	6.25	9.94	1.290	0.990	0.820	0.660	0.940
T_4	15.96	12.20	8.43	6.68	10.82	1.290	1.130	0.990	0.770	1.045
T_5	15.96	10.81	8.43	6.68	10.47	1.290	1.180	1.120	0.780	1.093
T_6	15.96	15.14	10.11	6.84	12.01	1.290	1.070	0.920	0.760	1.010
T_7	15.96	12.98	11.80	8.84	12.39	1.290	1.150	1.110	0.820	1.093
Mean	15.96	12.33	8.75	6.65		1.290	1.104	0.968	0.743	
		$CD_{0.05}$								
Treatment (tr)		0.5502					0.03655			
Day		0.225					0.02763			
tr × day		0.596					0.07311			

T_1 = Virosil Agro; T_2 = NaOCl; T_3 = $Ca(OCl)_2$; T_4 = Virosil Agro + wax; T_5 = NaOCl + wax; T_6 = $Ca(OCl)_2$+ wax; T_7 = wax

were compared, it was observed that T_7 (wax) had the highest ascorbic acid content of 12.39 mg/100 g followed by 12.01 mg/100 g in T_6 {$Ca(OCl)_2$ + wax}, 10.82 mg/100 g in T_4 (Virosil Agro + wax), 10.71 mg/100 g in T_2 (NaOCl), 10.47 mg/100 g in T_5 (NaOCl + wax), 10.12 mg/100 g in T_1 (Virosil Agro) and lowest ascorbic acid of 9.94 mg/100 g was observed in T_3 {$Ca(OCl)_2$}.

The initial ('0'days) average ascorbic acid content of 15.96 mg/100 g decreased abruptly in storage at later period of storage. On 4th day of storage highest ascorbic acid (15.14 mg/100 g) was estimated in T_6 {$Ca(OCl)_2$ + wax} followed by 14.36 mg/100 g in T_2 (NaOCl), 12.98 mg/100 g in T_7 (wax), 10.81 mg/100 g in T_3 {$Ca(OCl)_2$} and T_5 (NaOCl + wax) and 10.04 mg/100 g in T_1 (Virosil Agro). On 8th day of storage, T_7 and T_6 maintained higher ascorbic acid content of 11.80 mg/100 g and 10.11 mg/100 g, respectively but the ascorbic acid of T_2 decreased at a faster rate and reduced to 7.30 mg/100 g. Ascorbic acid of T_7 was significantly higher than the other treatments. On 12th day ascorbic acid of treatments, T_1, T_2, T_3, T_4, T_5 and T_6 was more or less similar and ranged from 5.19 to 6.84 mg/100 g. However, T_7 (wax) still retained ascorbic acid to the extent of 8.84 mg/100 g and remained significantly higher than all other treatments.

Changes of chlorophyll content (mg/g) of different treatments during the period of storage have been shown in Table 3. Degradation of chlorophyll irrespective of treatment was evident during storage. Chlorophyll content of T_7 (wax) and T_5 (NaOCl + wax) remained significantly high throughout the period of storage compared to other treatments. However, on 12th day, the chlorophyll content of most of the treatments (T_4, T_5, T_6 and T_7) were similar and there was not significant difference between them.

Salts of hypochlorite acts as surface sterile which can prevent the infection of bacterial soft rot caused by *Erwinia carotovora* (Eckert, 7; Wyatt and Lund, 23; Lund, 13). In the present investigation, sodium hypochlorite (NaOCl) and calcium hypochlorite have been used as post-harvest treatment. However, T_5 (NaOCl + wax) was most effective in maintaining the post harvest quality for longer period. This may be due to an easier dissociation of NaOCl which tended to be more effective in controlling decay than $Ca(OCl)_2$ (Ketsa and Piyasaengthong, 12). In addition, Na has less atomic number than Ca, thus Na is more dissoluble than Ca and consequently more dissociated and dissoluble chlorine in water. Subsequently more bacteria in water were suppressed (Ketsa and Piyasaengthong, 12). The combined effect of wax emulsion and sodium hypochlorite might have an additive effect in reducing the PLW, blackening, increasing marketable fruits and maintaining sensory quality in okra for longer period.

The superiority of T_7 (wax coating) in increasing marketability is because the wax coating plugs the openings of fruit skin surface thereby reduces

their respiration and transpiration, thus successfully prolonging their storage life (Dalal *et al*., 6; Subramanium *et al*., 21; Agnihotri and Ram, 1). Further carnauba wax reduces weight losses and chlorophyll degradation (Ribeiro *et al*., 18). The efficacy of Virosil Agro® as a postharvest treatment alone (T_1) or with wax emulsion (T_4) was also significant in the present experiment. Virosil Agro being a strong oxidant that content 48% hydrogen peroxide and 0.05% silver ions as a stabilized agent (Fallik *et al*., 9) effectively kills micro-organisms (Ito *et al*., 11; Smith and Brown, 19) because of its capacity to generate reactive and cytotoxic oxidants species (Berglin *et al*., 4). The vapour of hydrogen peroxide has been reported to inhibit decay causing organisms and increase shelf life in eggplant and Sweet pepper (Fallik *et al*., 9).

Thus, it may be concluded from the experimental results that the storage of okra fruits up to 12 days of storage is worthwhile because of high marketability and superior postharvest quality. Among the post harvest treatments, considering the overall quality it was found that T_5 (NaOCl + wax) was the best treatment followed by T_7 (wax), T_4 (Virosil Agro + wax) and T_1 (Virosil Agro). However, T_7 (wax) retained better ascorbic acid and chlorophyll during later period of storage.

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