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Effect of post-harvest treatments on shelf-life and quality of Kinnow mandarin

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ABSTRACT

The experiment was conducted during 2007-2008 with the objective of determining suitable treatment for better shelf-life and quality of mandarin. The experiment was laid out in 3×3 factorial randomized block design (RBD) comprising nine treatments. The fruits of all the treatments were packed in 200 gauge polythene bags of 55 cm × 35 cm size with 30 perforated holes of 30 mm size. The treatment combination W_2C_1 (waxol (8%) + captan (0.2%) was found better in terms of physiological loss in weight, total soluble solids, acidity, reducing sugars, total sugar, vitamin C and β-carotene, *i.e.* minimum physiological loss in weight (3.56%), highest TSS (8.43%), highest total sugars (10.78%), highest reducing sugar (4.84%), non-reducing sugar (5.95%), acidity (0.735%), vitamin C (19.41mg/100g) and β-carotene (6.35 IU/ 100 g) contents.

Key words: Waxol, captan, quality, shelf-life, Kinnow.

INTRODUCTION

The oranges are commercially, the most important among the citrus species widely cultivated in India. It occupies about 70% of the total acreage under citrus fruit. The oranges cultivated in India are of two distinct kinds, namely sweet orange (*Citrus reticulata* Blanco) and Kinnow mandarin, a hybrid variety of California origin evolved from a cross of King orange × Willow leaf mandarin at the California Citrus Research Center, Riverside, California. This was introduced to India and has been found to be more promising than the local mandarins NW plains because of its good fruits quality and relatively more tolerant to diseases. It is a non-climacteric fruit and highly perishable in nature and should be marketed immediately after harvest. The short post-harvest life of horticultural crop is due to their highly perishable nature and physiological break-down during handling, transport, storage and these losses are further enhanced by infection of post-harvest diseases. Various viable technologies for improving shelf-life and storage of horticultural commodities have evolved during the past decades, like the use of fungicides, cold storage, controlled atmosphere storage, anti- transpirants, wax coating, growth retardants, irradiation and different type of packing material, *etc.*, to increase the shelf-life of harvested fruits. The post-harvest management technology start right from determination of proper harvesting stage, time and method of harvest, collection, sorting, grading, packaging and transportation, have an important role to play in minimizing the post-harvest loss. The technology aim to preserve quality, nutritional and economic value and assure food safety and regulated supply of commodities for processing, domestic markets and export.

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MATERIALS AND METHODS

The experiment was conducted at Department of Horticulture, Allahabad Agricultural Institute-Deemed University, Allahabad during 2007-2008 with the objective of determining suitable treatment for better shelf-life and quality of mandarin. The experiment was laid out in a 3 × 3 RBD factorial comprising nine treatments, *i.e.* Control (T_0), captan (0.2%) + waxol (0%) (T_1), captan (0.4%) + waxol (0%)(T_2), captan (0%) + waxol (6%) (T_3), captan (0.2%) + waxol (6%) (T_4), captan (0.4%) + waxol (6%) (T_5), captan (0%) + waxol (8%) (T_6), captan (0.2%) + waxol (8%) (T_7) and captan (0.4%) + waxol (8%) (T_8) with three replications. The fruits were first treated with different concentration of fungicide and waxol. The ingredient of the waxol was parafin wax and fungicide (carbedazim). The company of waxol was Varosil India Pvt. Ltd., Mumbai. The treated fruits were dried in shade and packed in 200 gauge polythene bags of 55 cm × 35 cm. with thirty perforated holes of 30 mm in size as per the treatment. The storage temperature and relative humidity were 29°C and 75% respectively. Observations on physiological loss in wt. (%), shelf-life (days), TSS (%), acidity (%), reducing sugar (%), Non-reducing sugar (%), total sugars (%), β-carotene (IU /100 g) and vitamin C (mg/ 100 g) were recorded. Titrable acidity was measured according to the methods described by Ranganna (6). Sugar was estimated by following the method of Lane and Eynon as described by Ranganna (6). Ascorbic acid was determined through visual titration method of Freed (3).

RESULTS AND DISCUSSION

The data presented in Table 1 revealed that the results pertaining to the effect of different treatments were significant during storage period. The increasing trend of physiological loss in weight was recorded during storage period. Minimum physiological loss in weight (3.56%) was recorded with the treatment combination W_2C_1 [waxol (8%) + captan (0.2%)] followed by W_1C_1 (3.66%), W_2C_2 (3.70%), W_1C_2 (3.90%), W_2C_0 (3.97%), W_1C_0 (4.33%), and maximum physiological loss in weight (7.14%) was recorded with the treatment combination W_0C_0 [waxol (0%) + captan (0%)] after twenty days of storage. This might be due to the fact that the interaction effect of captan and wax coating acts as microbial inhibitor as well as moisture inhibitor respectively. Similar results were recorded by Singh *et al.* (8), and Pandit and Singh (5). Meena *et al.* (4) had suggested that wax coated fruits packed in polythene bags had minimum loss in weight and maximum increase in TSS.

The different treatment had significant effect on TSS (Table 2). All the treatments showed increasing trend of TSS during storage period. Maximum total soluble solids (10.10%) was recorded with the treatment combination W_2C_1 [waxol (8%) + captan (0.2%)], followed by W_1C_1 (10.10%), W_2C_2 (9.93%), W_1C_2 (9.87%), W_2C_0 (9.83%), W_1C_0 (9.67%), and minimum total soluble solids (8.43%) was recorded with the treatment combination W_0C_0 [waxol (0%) + captan (0%)] after 20 days of storage. This result was also in agreement with the work of Singh *et al.* (8), Athani and Hulamani (1), and Zode *et al.* (10). Meena *et al*., (4) had suggested that wax coated fruits packed in polythene bags had maximum increase in TSS.

Table 1. Effects of different levels of waxol, captan and their interaction on physiological loss in weight (%) of Kinnow fruits at different intervals during storage.

Waxol (W)	15 days				20 days			
	Captan (C)			Mean (W)	Captan (C)			Mean (W)
	C_0 (0.0%)	C_1 (0.2%)	C_2 (0.4%)		C_0 (0.0%)	C_1 (0.2%)	C_2 (0.4%)	
W_0 (0%)	5.3	5.1	5.2	5.2	7.14	7.07	7.13	7.11
W_1 (6%)	2.12	1.6	1.96	1.89	4.33	3.66	3.9	3.96
W_2 (8%)	2.02	1.57	1.76	1.78	3.97	3.56	3.7	3.75
Mean (C)	3.15	2.76	2.97	2.96	5.15	4.77	4.91	4.94
		F - test		CD at 5%		F - test		CD at 5%
Waxol (W)		S		0.06		S		0.07
Captan (C)		S		0.06		S		0.07
Interaction (W × C)		S		0.11		S		0.13

Table 2. Effect of different levels of waxol, captan and their interaction on total soluble solids (%) of Kinnow fruits at different intervals during storage.

Waxol (W)	15 days				20 days			
	Captan (C)			Mean (W)	Captan (C)			Mean (W)
	C_0 (0.0%)	C_1 (0.2%)	C_2 (0.4%)		C_0 (0.0%)	C_1 (0.2%)	C_2 (0.4%)	
W_0 (0%)	8.67	9.87	9.7	9.41	8.43	9.37	9.33	9.04
W_1 (6%)	9.93	10.33	10.1	10.12	9.67	10.1	9.87	9.88
W_2 (8%)	10.03	10.4	10.23	10.22	9.83	10.1	9.93	9.96
Mean (C)	9.54	10.2	10.01	9.92	9.31	9.86	9.71	9.63
		F - test		CD at 5%		F - test		CD at 5%
Waxol (W)		S		0.13		S		0.06
Captan (C)		S		0.13		S		0.06
Interaction (W × C)		S		0.22		S		0.11

It was clear from Table 3 that the effect of different levels of waxol, captan and interaction (waxol + captan) was significant at 15 and 20 days of storage. All the treatment showed decreasing trend during storage. Maximum acidity (0.735%) was recorded with the treatment combination W_2C_1 [waxol (8%) + captan (0.2%)] followed by W_1C_1 (0.733%), W_2C_2 (0.732%), W_1C_2 (0.672%), W_2C_0 (0.643%), W_1C_0 (0.637%), and minimum acidity (0.576%) was recorded with the treatment combination W_0C_0 [Waxol (0%) + captan (0%)] after twenty days of storage. This might due to slow rate of degradation of fruits due to fungicide and waxol treatment. This finding was supported by Wang *et al.* (9), Singh *et al.* (8), Athani and Hulamani (1), and Zode *et al.* (10).

The data presented in Table 4 revealed, that the results pertaining to the effect of different levels of waxol, captan and interaction (waxol + captan) was significant at 15 and 20 days of storage. Maximum total sugar (10.78%) was recorded with the treatment combination W_2C_1 [Waxol (8%) + captan (0.2%)] followed by W_1C_1 (10.61%), W_2C_2 (10.56%), W_1C_2 (10.26%), W_2C_0 (10.24%), W_1C_0 (10.01%), and minimum total sugar (9.41%) was recorded with the treatment combination W_0C_0 [Waxol (0%) + Captan (0%)]. The view was supported by Singh *et al.* (8), Wang *et al.* (9), and Athani and Hulamani (1). Sidhu *et al.* (7) also reported that wax treated fruits stored in CFB had minimum loss in weight, reducing sugar, non-reducing sugar and total sugars.

The effect of different levels of waxol and captan and their interaction at 15 and 20 days of storage is presented in Table 5. The effect of waxol, captan and there interaction were found significant. An increasing trend of reducing sugar was recorded up to 15 days of storage and thereafter it decreased during storage period. Maximum reducing sugar (4.84%) was recorded with the treatment combination W_2C_1 [Waxol (8%) + Captan (0.2%)] followed by W_1C_1 (4.78%), W_2C_2 (4.75%), W_1C_2 (4.75%), W_2C_0 (4.56%), W_1C_0 (4.33%),

Table 3. Effect of different levels of waxol, captan and their interaction on acidity (%) of Kinnow fruits at different intervals during storage.

Waxol (W)	15 days				20 days			
	Captan (C)			Mean (W)	Captan (C)			Mean (W)
	C_0 (0.0%)	C_1 (0.2%)	C_2 (0.4%)		C_0 (0.0%)	C_1 (0.2%)	C_2 (0.4%)	
W_0 (0%)	0.640	0.671	0.641	0.65	0.576	0.607	0.578	0.587
W_1 (6%)	0.677	0.739	0.691	0.702	0.637	0.733	0.672	0.681
W_2 (8%)	0.69	0.74	0.734	0.721	0.643	0.735	0.732	0.703
Mean (C)	0.669	0.716	0.689	0.691	0.619	0.692	0.661	0.657
		F - test		CD at 5%		F - test		CD at 5%
Waxol (W)		S		0.004		S		0.006
Captan (C)		S		0.004		S		0.006
Interaction (W × C)		S		0.007		S		0.01

Table 4. Effect of different levels of waxol, captan and their interaction on total sugars (%) of Kinnow fruits at different intervals during storage.

Waxol (W)	15 days				20 days			
	Captan (C)			Mean (W)	Captan (C)			Mean (W)
	C_0 (0.0%)	C_1 (0.2%)	C_2 (0.4%)		C_0 (0.0%)	C_1 (0.2%)	C_2 (0.4%)	
W_0 (0%)	8.76	9.66	9.12	9.18	9.41	9.81	9.48	9.56
W_1 (6%)	9.83	10.17	9.91	9.97	10.01	10.61	10.26	10.29
W_2 (8%)	9.87	10.4	10	10.09	10.24	10.78	10.56	10.53
Mean (C)	9.49	10.07	9.68	9.75	9.89	10.4	10.1	10.13
		F - test		CD at 5%		F - test		CD at 5%
Waxol (W)		S		0.05		S		0.04
Captan (C)		S		0.05		S		0.04
Interaction (W × C)		S		0.09		S		0.07

and minimum total soluble solids (3.89%) was recorded with the treatment combination W_0C_0 [waxol (0%) + captan (0%)] at 15 and 20 days of storage period. However, wax and catpan treated fruits resulted in more accumulation of reducing sugar in comparison to untreated fruits. This investigation was supported by Singh *et al.* (8), Wang *et al.* (9), and Athani and Hulamani (1). Sidhu *et al.* (7) also reported that wax treated fruits stored in CFB had minimum loss in weight, reducing sugar, non-reducing sugar and total sugars.

It was clear from Table 6 that the effect of different levels of waxol, captan and interaction (waxol + captan) was significant at 15 and 20 days of storage. Maximum non-reducing sugar (5.95%) was recorded with the treatment combination W_2C_1 [waxol (8%) + captan (0.2%)] followed by W_1C_1 (5.83%), W_2C_2 (5.81%), W_1C_2 (5.70%), W_2C_0 (5.68%), W_1C_0 (5.68%), and minimum non-reducing sugar (5.51%) was recorded with the treatment combination W_0C_0 [waxol (0%) + captan (0%)]. However, wax and catpan treated fruits resulted in more accumulation of non-reducing sugar in comparison to untreated fruits. Similar results were recorded by Singh *et al.* (8), Wang *et al.* (9), and Athani and Hulamani (1). Sidhu *et al.* (7) also reported that wax treated fruits stored in CFB had minimum loss in weight, reducing sugar, non-reducing sugar and total sugars.

The data presented in Table 7 revealed that the results pertaining to the effect of different levels of waxol, captan and interaction (waxol + captan) was significant at 15 and 20 days of storage. The retention of vitamin C was higher in waxol and catpan treated fruits. Maximum vitamin C (19.41 mg/100g) was recorded with the treatment combination W_2C_1 [waxol (8%) + captan (0.2%)] followed by W_1C_1 (19.19 mg/100g), W_2C_2 (19.13 mg/100g), W_1C_2 (18.51%), W_2C_0 (17.88 mg/100g), W_1C_0 (17.25 mg/100g), and minimum vitamin C (17.07 mg/100g) was recorded with the treatment combination W_0C_0 [Waxol (0%) + captan (0%)]. This might be due to oxidation of vitamin C in the presence of molecular oxygen by ascorbic acid

Table 5. Effect of different levels of waxol, captan and their interaction on reducing sugar (%) of Kinnow fruits at different intervals during storage.

Waxol (W)	15 days				20 days			
	Captan (C)			Mean (W)	Captan (C)			Mean (W)
	C_0 (0.0%)	C_1 (0.2%)	C_2 (0.4%)		C_0 (0.0%)	C_1 (0.2%)	C_2 (0.4%)	
W_0 (0%)	3.78	4.35	3.97	4.03	3.89	4.19	3.93	4
W_1 (6%)	4.48	4.72	4.54	4.58	4.33	4.78	4.56	4.56
W_2 (8%)	4.51	4.86	4.61	4.66	4.56	4.84	4.75	4.71
Mean (C)	4.26	4.64	4.37	4.42	4.26	4.6	4.41	4.43
		F - test		CD at 5%		F - test		CD at 5%
Waxol (W)		S		0.04		S		0.04
Captan (C)		S		0.04		S		0.04
Interaction (W × C)				0.04				0.03

Table 6. Effect of different levels of waxol, captan and their interaction on non-reducing sugar (%) of Kinnow fruits at different intervals during storage.

Waxol (W)	15 days				20 days			
	Captan (C)			Mean (W)	Captan (C)			Mean (W)
	C_0 (0.0%)	C_1 (0.2%)	C_2 (0.4%)		C_0 (0.0%)	C_1 (0.2%)	C_2 (0.4%)	
W_0 (0%)	4.98	5.31	5.16	5.15	5.51	5.62	5.55	5.56
W_1 (6%)	5.35	5.45	5.37	5.39	5.68	5.83	5.70	5.74
W_2 (8%)	5.36	5.54	5.39	5.43	5.68	5.95	5.81	5.81
Mean (C)	5.23	5.43	5.31	5.32	5.62	5.80	5.69	5.70
		F - test		CD at 5%		F - test		CD at 5%
Waxol (W)		S		0.02		S		0.02
Captan (C)		S		0.02		S		0.02
Interaction (W × C)		S		0.03		S	0.02	0.03

oxidase. This finding was supported by Wang *et al.* (10). Deka *et al.* (2) reported that Strafresh® treated fruits had the longest shelf-life of 29 days at ambient conditions with lowest PLW and higher retention of ascorbic acid.

It is clear from Table 8 that the effect of different levels of waxol, captan and interaction (waxol + captan) were significant at 15 and 20 days during storage. β-carotene increased up to 15 days of storage thereafter it decreased. Maximum retention of β-carotene (6.35 IU/100g) was recorded with the treatment combination W_2C_1 [waxol (8%) + captan (0.2%)] followed by W_1C_1 (6.33 I.U./100g), W_2C_2 (6.20 IU/100g), W_1C_2 (6.15 I.U./100g), W_2C_0 (6.14 IU/100g), W_1C_0 (6.09 IU/100g), and minimum β-carotene (5.99 IU/100g) was recorded with the treatment combination W_0C_0 [waxol (0%) + captan (0%)] after 20 days of storage. Slow degradation of β-carotene might be due to less microbial activity on the fruit surface and slow respiration rate of fruit.

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Table 7. Effect of different levels of waxol, captan and their interaction on vitamin C (mg/100 g) of Kinnow fruits at different intervals during storage.

Waxol (W)	15 days				20 days			
	Captan (C)			Mean (W)	Captan (C)			Mean (W)
	C_0 (0.0%)	C_1 (0.2%)	C_2 (0.4%)		C_0 (0.0%)	C_1 (0.2%)	C_2 (0.4%)	
W_0 (0%)	17.21	17.63	17.49	17.44	17.07	17.21	17.18	17.15
W_1 (6%)	17.83	19.96	18.66	18.82	17.25	19.19	18.51	18.32
W_2 (8%)	17.85	20.00	19.92	19.26	17.88	19.41	19.13	18.81
Mean (C)	17.63	19.20	18.69	18.51	17.40	18.60	18.27	18.09
		F - test		CD at 5%		F - test		CD at 5%
Waxol (W)		S		0.04		S		0.04
Captan (C)		S		0.04		S		0.04
Interaction (W × C)		S		0.14		S		0.14

Table 8. Effect of different levels of waxol, captan and their interaction on β-carotene (IU/100 g) of Kinnow fruits at different intervals during storage.

Waxol (W)	15 days				20 days			
	Captan (C)			Mean (W)	Captan (C)			Mean (W)
	C_0 (0.0%)	C_1 (0.2%)	C_2 (0.4%)		C_0 (0.0%)	C_1 (0.2%)	C_2 (0.4%)	
W_0 (0%)	6.26	6.32	6.26	6.28	5.99	6.03	6.00	6.01
W_1 (6%)	6.34	6.54	6.41	6.43	6.09	6.33	6.15	6.19
W_2 (8%)	6.37	6.56	6.44	6.46	6.14	6.35	6.20	6.23
Mean (C)	6.32	6.47	6.37	6.39	6.07	6.24	6.12	6.14
		F - test		CD at 5%		F - test		CD at 5%
Waxol (W)		S		0.01		S		0.01
Captan (C)		S		0.01		S		0.01
Interaction (W × C)		S		0.03		S		0.04

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