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Response of bio-extract coatings on decay, carotenoid and enzymes activity of Kinnow (*Citrus reticulata*)

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Mandarin orange is most common among the citrus fruits grown in India (Rupakshi and Goyal 2021). Kinnow (*Citrus reticulata* Blanco) fruits are highly perishable since they contain very high amount of water and exhibit relatively high metabolic activity (Goyal 2017). Thus, it becomes necessary to store the fruits to make them available in the market during the off-season. Edible coatings have long been used for quality retention. Among the biological substances, botanical formulations of *Aloe vera*, til oil, lemongrass oil, carboxy methyl cellulose and lac are the most definite alternatives to overcome the undesirable effects of chemicals. The lac-wax is an organic product originated from plants, which has been developed by Indian Institute of Natural Resins and Gums, Ranchi, Jharkhand for use in fruits and vegetables, whereas, citrashine is commercially used wax in citrus fruits to enhance the storability (Mandal 2015). Therefore, the present study was carried out to study the influence of post-harvest application of different edible coatings on post-harvest quality of Kinnow fruits stored under ambient temperature conditions.

The present study was carried out during 2019 and 2020 at CCS Haryana Agricultural University, Hisar, Haryana. The fresh Kinnow fruits having uniform size were harvested (pedicel intact) from the Horticulture Farm, CCS Haryana Agricultural University, Hisar, Haryana. Fruits were treated with bio-extract coatings (*Aloe vera* gel (100%), til oil (2%), carboxymethyl cellulose (1%), lac formulation, lemongrass oil (0.1%) and commercial coating) by giving dip treatment for 2 min; shade dried and thereafter kept in CFB boxes. Decay loss was calculated by multiplying the ratio of weight of decayed fruits and initial weight with 100. Total carotenoids were determined using method given by Gao *et al.* (2007). Method proposed by Hagerman and Austin (1986) was used for extraction and assaying the activity of pectin methyl esterase (PME). The method proposed by Singh and Singh (1993) was used for extraction of polygalacturonase and cellulase enzyme. The method given by Ahmed and Labavitch (1980) was used for enzyme assay. Studies were carried out in Complete Randomized Design having 3 replications. The data on different parameters were collected and analyzed by using the technique of analysis of variance described by Fisher (1958). All the tests of significance were made at 5% level of significance.

Decay loss: The results (Table 1) shows that bio-extract coatings significantly reduced the decay loss in Kinnow fruits during both the years. No decay loss was observed up to 7th day and it was non-significant up to 14th day during both the years. On 21st day, minimum decay loss was observed in fruits coated with *Aloe vera* extract and maximum in untreated fruits during both the years. On 28th day of storage, minimum decay loss was recorded in *Aloe vera* coated fruits and maximum in control fruits during both the years.

The increased decay loss in fruits with the advancement of the storage period was also observed by Jain *et al.* (2017) in ber and Amanulla *et al.* (2017) in guava. Reduced decay loss in *Aloe vera* coated fruits might be due to anti-fungal and antibacterial activity of *Aloe vera* against various post-harvest fruit pathogens (Ravanfar *et al.* 2014, Mani *et al.* 2018). The results are in line with the findings of Jain *et al.* (2017) in ber and Parven *et al.* (2020) in papaya.

Total carotenoid content: Results (Table 2) shows that different bio-extract coatings and storage period did not affect the total carotenoid content of Kinnow fruits significantly; however, the interaction between different treatments and storage period significantly affected the total carotenoid content.

During 2019, maximum total carotenoids were observed in Kinnow fruits treated with commercial coating on 14th day of experiment, whereas, during 2020, it was maximum in Kinnow fruits coated with til oil on 14th day of experiment. The minimum carotenoids content was observed in untreated Kinnow fruits on 28th day during both the years.

Pectin methyl esterase activity: Results (Table 3) shows that the activity of pectin methyl esterase (PME) in peel of

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Table 1 Effect of different bio-extract coatings on decay loss (%) of Kinnow fruits stored at room temperature

Treatment	Storage period (Days)					
	2019			2020		
	14	21	28	14	21	28
A. vera extract (100%)	0.00	1.08	7.46	0.00	1.13	7.65
Til oil (2%)	2.09	6.65	12.01	2.14	6.73	12.17
CMC (1%)	4.11	7.88	14.66	3.20	8.15	14.21
Lac	3.48	9.49	14.43	4.79	9.61	14.68
Lemongrass oil (0.1%)	4.46	11.40	15.57	4.60	11.83	16.10
Commercial	1.05	5.24	9.56	1.08	6.62	9.80
Control	6.87	17.62	21.88	7.04	17.68	22.21
CD	NS	3.50	4.84	NS	3.10	5.15

Table 2 Effect of different bio-extract coatings on total carotenoid content (mg/100 ml) in Kinnow fruits stored at room temperature

Treatment	Storage period (Days)											
	2019						2020					
	0	7	14	21	28	Mean	0	7	14	21	28	Mean
A. vera extract (100%)	0.375	0.382	0.387	0.378	0.363	0.377	0.387	0.395	0.401	0.388	0.369	0.388
Til oil (2%)	0.375	0.384	0.388	0.380	0.365	0.378	0.387	0.397	0.402	0.390	0.370	0.389
CMC (1%)	0.375	0.380	0.384	0.375	0.360	0.375	0.387	0.393	0.397	0.384	0.365	0.385
Lac	0.375	0.379	0.385	0.376	0.362	0.375	0.387	0.392	0.397	0.384	0.366	0.385
Lemongrass oil (0.1%)	0.375	0.378	0.383	0.373	0.358	0.373	0.387	0.390	0.395	0.384	0.365	0.384
Commercial	0.375	0.384	0.389	0.379	0.364	0.378	0.387	0.396	0.400	0.388	0.369	0.388
Control	0.375	0.376	0.380	0.371	0.357	0.372	0.387	0.389	0.393	0.383	0.363	0.383
Mean	0.375	0.380	0.385	0.376	0.361		0.387	0.393	0.398	0.386	0.367	
CD	T = NS, D = NS, T × D = 0.001						T = NS, D = NS, T × D = 0.001					

Kinnow fruits varied significantly for different bio-extract coatings and storage period. The least PME activity was noticed in peel of Kinnow fruits coated with *Aloe vera* extract and highest in control during both the years. CMC delays the increase in PME activity as pectin are hydrolyzed by PME to generate demethylated pectin and thus depolymerize pectin helping in retaining crumbliness and firmness during storage (Zhou *et al.* 2011).

Pectin methyl esterase activity increased gradually with advancement of storage period. The minimum activity was recorded on zero day and maximum activity was recorded on 28th day of storage during both the years. The interaction between bio-extract coatings and storage period was significant for PME activity in Kinnow fruits.

Polygalacturonase activity: Results (Table 3) shows that polygalacturonase activity in Kinnow fruits revealed a significant variation with respect to bio-extract coatings and period of storage. The minimum activity was observed in peel of Kinnow fruits coated with commercial coating and the maximum activity was noticed in control. With advancement of storage period, polygalacturonase activity increased during both the years. Significant interaction between treatments and storage duration was observed for polygalacturonase activity in peel of Kinnow fruits. Minimum activity was recorded on zero day and maximum on 28th day in untreated fruits.

Cellulase activity: The cellulase activity of Kinnow fruits (Table 3) exhibited statistically significant variation with respect to different treatments and storage period. Minimum activity was observed in Kinnow fruits coated with *Aloe vera* extract and maximum in untreated Kinnow fruits during both the years. Edible coatings inhibited the cellulase activity in pear fruit (Zhou *et al.* 2011). Similar results were observed by Gol *et al.* (2013) where combination of CMC+chitosan exhibited lowest cellulase activity in strawberry.

Activity of cellulase increased with increase in storage period. The interaction between bio-extract coatings and storage duration was significant and minimum cellulase activity was observed on zero day and maximum on 28th day of storage in untreated fruits.

Reduction in the activity of PME, Polygalactouronase and Cellulase in *Aloe vera* gel coated fruits might be because of its inhibitory effect on these enzymes (Adetunji *et al.* 2012). Similar results were reported by Jahanbin *et al.* (2016) in tomato.

Table 3 Effect of different bio-extract coatings on activity of pectin methyl esterase, polygalacturonase and cellulase (units/g) in peel of Kinnow fruits stored at room temperature

Treatment	Storage period (Days)											
	2019						2020					
	0	7	14	21	28	Mean	0	7	14	21	28	Mean
Pectin methyl esterase activity												
A. vera extract (100%)	0.183	0.188	0.199	0.229	0.257	0.211	0.186	0.190	0.201	0.232	0.261	0.214
Til oil (2%)	0.183	0.193	0.204	0.231	0.264	0.215	0.186	0.196	0.207	0.235	0.268	0.219
CMC (1%)	0.183	0.191	0.202	0.236	0.268	0.216	0.186	0.195	0.206	0.238	0.268	0.218
Lac	0.183	0.191	0.202	0.232	0.269	0.215	0.186	0.193	0.204	0.229	0.270	0.216
Lemongrass oil (0.1%)	0.183	0.192	0.203	0.234	0.265	0.215	0.186	0.195	0.206	0.238	0.271	0.219
Commercial	0.183	0.190	0.201	0.231	0.260	0.213	0.186	0.194	0.205	0.230	0.263	0.215
Control	0.183	0.189	0.205	0.238	0.270	0.217	0.186	0.196	0.209	0.243	0.273	0.222
Mean	0.183	0.191	0.202	0.233	0.265		0.186	0.194	0.205	0.235	0.268	
CD	T = 0.001, D = 0.001, T × D = 0.001						T = 0.001, D = 0.001, T × D = 0.001					
Polygalacturonase activity												
A. vera extract (100%)	0.072	0.076	0.088	0.106	0.116	0.092	0.078	0.081	0.091	0.109	0.122	0.096
Til oil (2%)	0.072	0.080	0.087	0.108	0.118	0.093	0.078	0.083	0.093	0.112	0.125	0.098
CMC (1%)	0.072	0.079	0.089	0.111	0.119	0.094	0.078	0.084	0.095	0.114	0.122	0.098
Lac	0.072	0.078	0.087	0.109	0.119	0.093	0.078	0.085	0.096	0.112	0.123	0.099
Lemongrass oil (0.1%)	0.072	0.078	0.090	0.110	0.120	0.094	0.078	0.086	0.097	0.113	0.124	0.099
Commercial	0.072	0.075	0.086	0.107	0.115	0.091	0.078	0.080	0.090	0.109	0.119	0.095
Control	0.072	0.081	0.092	0.114	0.124	0.097	0.078	0.088	0.099	0.115	0.127	0.101
Mean	0.072	0.078	0.088	0.109	0.119		0.078	0.084	0.094	0.112	0.122	
CD	T = 0.001, D = 0.001, T × D = 0.001						T = 0.001, D = 0.001, T × D = 0.001					
Cellulase activity												
A. vera extract (100%)	0.082	0.087	0.100	0.112	0.132	0.103	0.085	0.089	0.101	0.115	0.134	0.105
Til oil (2%)	0.082	0.094	0.105	0.114	0.135	0.106	0.085	0.097	0.104	0.120	0.139	0.109
CMC (1%)	0.082	0.090	0.108	0.118	0.140	0.108	0.085	0.096	0.109	0.116	0.141	0.109
Lac	0.082	0.092	0.110	0.116	0.136	0.107	0.085	0.098	0.110	0.117	0.137	0.109
Lemongrass oil (0.1%)	0.082	0.095	0.109	0.120	0.140	0.109	0.085	0.099	0.111	0.122	0.141	0.112
Commercial	0.082	0.090	0.103	0.115	0.134	0.105	0.085	0.092	0.106	0.115	0.135	0.107
Control	0.082	0.098	0.111	0.126	0.145	0.112	0.085	0.104	0.114	0.125	0.146	0.115
Mean	0.082	0.093	0.107	0.117	0.137		0.085	0.096	0.108	0.118	0.139	
CD	T = 0.001, D = 0.001, T × D = 0.001						T = 0.001, D = 0.001, T × D = 0.001					

SUMMARY

Kinnow is a well-known mandarin grown in Haryana. Edible coatings are useful for controlling ripening by reducing the oxygen penetration into the fruits, thus, reducing metabolic activity and softening of fruits. Present study was carried out during 2019 and 2020 at Horticulture Farm, CCS Haryana Agricultural University, Hisar, Haryana. Kinnow fruits were treated with different bio-extract coatings, viz. *Aloe vera* extract, til oil, CMC, lac coating, lemongrass oil and commercial coating. The carotene content of the fruits did not differ significantly irrespective of the coatings. Decay loss and activities of pectin methyl esterase and cellulase were minimum resulting in better retention of the firmness in *Aloe vera*

extract coated fruits. Minimum polygalacturonase activity was noticed in commercial coating treated fruits.

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