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Studies of Various Packaging Materials and Waxing on Quality Traits of Kinnow

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A B S T R A C T

An investigation was conducted at post-harvest laboratory, Department of Horticulture, Lovely Professional University, Punjab during the academic year 2016-17 to study the effect of various packaging materials on fruit quality and shelf life of Kinnow. The packaging films include LDPE (25 micron), HDPE (15 micron), Polypropylene (25 micron), Shrink film (15 micron) and Cling film (15 micron) were used for experimentation. Liquid paraffin wax (10%) was used as a coating material. The fruits were then kept at ambient temperature. In case of quality related traits, the fruits under treatment T_{11} (Cling film at 15 micron + wax at 10%) recorded the maximum value for "TSS" when compared with other packaging treatments including control at 25th day after storage. With regard to remaining quality related traits, the fruits under treatment T_{11} (Cling film at 15 micron + wax at 10%) expressed the maximum value for "TSS: acid ratio", Total sugars", "Non-reducing sugars" and "Sugar: acid ratio" at 25th day after storage.

Introduction

Citrus fruits are grown commercially in tropics and subtropic regions of the world. Kinnow, a mandarin hybrid (King x Willow leaf) occupies the prime position amongst the citrus fruits grown in India. In subtropical regions of Punjab, it occupies around 50% area of fruit growing regions. In Kinnow, improper post-harvest handling practices lead to quality deterioration and fetch poor market price. In mandarin, loss of 20-25% has been estimated due with transportation of fruits from field to market (PHLRD, 2005). Qualitative losses, in sense of caloric and nutritive value, non-acceptability by consumers, and poor edibility are more difficult to measure than quantitative losses of fresh fruits. Among for stored fruits, post-harvest losses account to 20-30%. In most of the storability studies for fruits, it is found to be observed that the levels of CO_2 and O_2 inside package altered due to fruit respiration and permeability of the film, resulted in recommendation of modified atmosphere packaging (MAP) for fresh fruit storage (Geeson *et al.*, 1981). When the rate of oxygen and carbon dioxide transmission through the package equal the product's respiration rate then desirable equilibrium modified atmosphere gets created in the package film at right permeability, edible

coatings have long been used for quality retention and shelf life extension of several fresh fruits *viz.*, apple, citrus. They have been applied directly on fruit surface with several mode of application *viz.*, dipping, spraying or brushing to create a modified atmosphere (McHugh and Senesi, 2000). Basically the usage of food grade wax coatings on fresh fruits and vegetables have been approved by the Government of India and with implementation of this technology on with several wax formulations are now-a-days being supplied by suppliers in market. So, the impact of these waxes coating plays a vital role in monitoring the storability of fresh fruits, especially kinnow. However, the role of these waxes alone or in combination with packaging needed much focus on correlating the positive mode of applicability to kinnow.

Materials and Methods

The present investigations were carried out at the horticulture laboratory of Lovely Professional University, Phagwara Punjab, from January to March, 2017.

Selection and harvest of fruits

The fresh kinnow fruits of uniform size and well matured ones were selected. Apart, other traits of healthiness for fruits free from that of disease and bruising on skin were also taken in consideration for selection of fruits for harvest. The selected fruits were randomly picked from entire direction of the plant with the help of secateurs. The act of fruit harvest commenced during the month of February, collected and brought to Horticulture laboratory.

Details of experiment

The experiment was laid out in Completely Randomized Design (CRD). A total of 27 fruits per treatment were divided into equal lots for all 3 replications and each of lot under every replication found to be accumulated with 9 fruits. The treated fruits were kept for storage and observed at 5 days interval upto 25 days.

Packaging and coating materials for fruits

The packaging films used in this experimentation were purchased from Jalandhar commercial market area. The materials include LDPE (25 micron), HDPE (15 micron), Polypropylene (25 micron), Shrink film (15 micron) and Cling film (15 micron). Liquid paraffin wax (10%) was used as a coating material.

Treatment details

Treatments	Treatment Details
T_1	Control (Room temperature)
T_2	LDPE (25 micron)
T_3	HDPE (15 micron)
T_4	Polypropylene (25 micron)
T_5	Shrink film (15 micron)
T_6	Cling film (15 micron)
T_7	LDPE (25 micron) + wax (10%)
T_8	HDPE (15 micron) + wax (10%)
T_9	Polypropylene (25 micron) + wax (10%)
T_{10}	Shrink film (15 micron) + wax (10%)
T_{11}	Cling film (15 micron) + wax (10%)

Observations recorded

Chemical parameters

Randomly selected fruits in each treatment of the experimentation were used for assessing the quality parameters. TSS (˚Brix), Titrable acidity, Ascorbic acid (mg/100ml), pH, TSS: acid ratio, Total sugars (%), Reducing sugars (%), Non-reducing sugars (%) and Sugar: Acid. These parameters were determined by the methods described by AOAC.

Statistical Analysis

The data were subjected to statistical analysis as outlined by Panse and Sukhatme (1985). The various comparisons were made after working out the standard errors and critical difference at 5 per cent level of significance.

Results & Discussions

Observations recorded on chemical parameters exhibited significant differences among the treatments in 5, 10, 15, 20 and 25 days after storage of Kinnow. The data presented in the (tables 1–9) is significant.

Among the packaging treatments, the fruits under the treatment T_1 retained maximum 'TSS' (11.56˚B), which were on par with each other including T_3 (11.10˚B) at 5 days after storage. The minimum 'TSS' was recorded in T_7 (10.20˚B). It was found to be on par with T_9 (10.50˚B) and T_{10} (10.60˚B). At 25days after storage, the observations among various packaging treatments revealed that the fruits under treatment T_{11} retained maximum 'TSS' (12.20˚B). The minimum 'TSS' was recorded in T_6 (11.95˚B), which was on par with T_3 (12.00˚B). In rest of the treatments, no fruits were found to be retained for observation. The retention of better TSS value of with the increasing storability could be due to the degradation of complex insoluble compounds, like starch, to simple soluble compounds, like sugars, which acts as the major TSS components. These results are in line with the findings of Efiuvwere and Oyelade (1991) on orange; Kumar *et al.,* (1991) on Kinnow mandarin. And the fruits under the treatment T_1 retained maximum 'Titrable acidity' (1.33%). The minimum 'Titrable acidity' was recorded in T_7 (1.17%). At 25days after storage, the observations among various packaging treatments revealed that the fruits under treatment T_6 retained maximum 'Titrable acidity' (0.81%). The minimum 'Titrable acidity' was recorded in T_{11} (0.76%). In rest of the treatments, except T_3, no fruits were found to be retained for observation. The decline in acidity might be due to conversion of acids into sugars and its utility in respiration process. Results are in line with the results of Sonkar and Ladaniya (1999) in Nagpur mandarin and Mahajan *et al.,* (2005) in kinnow. The fruits under the treatment T_5 retained maximum 'Ascorbic acid' (25.58 mg/100ml), which were on par with each other including T_2 (25.24 mg/100 ml) and T_{11} (25.16 mg/100ml) at 5 days after storage. The minimum 'Ascorbic acid' was recorded in T_1 (21.33 mg/100ml). At 25days after storage, the observations among various packaging treatments revealed that the fruits under treatment T_6 retained maximum 'Ascorbic acid' (16.04 mg/100ml). The minimum 'ascorbic acid' was recorded in T_{11} (15.51 mg/100ml). In rest of the treatments, except T_3, no fruits were found to be retained for observation. Ascorbic acid content in fruits is known to decrease during storage possibly due to utilization of organic acids during respiration or their conversion to sugars (Kader, 2002). The trend in case of other treatments might be due to the fact that ascorbic acid is very susceptible to oxidative deterioration (Piga *et al.,* 2003). And the fruits under the treatment T_1 retained maximum 'pH' (3.90), which were on par with each other including T_9 (3.72) and T_7 (3.70) at 5 days after

storage. The minimum 'pH' was recorded in T_5 (3.42), which were on par with T_2 (3.46) and T_{11} (3.47). At 25days after storage, the observations among various packaging treatments revealed that the fruits under treatment T_{11} retained maximum pH (4.17). The minimum 'pH' was recorded in T_6 (4.06). In rest of the treatments, except T_3, no fruits were found to be retained for observation. The juice pH value was gradually increased with the advance in storage period. These results are in line with the findings of El-Hefnawi (2002) in mango; El-Hefnawi *et al.*, (2008) in guava; Artés-Hernández *et al.*, (2004, 2006) in grapes. The fruits under the treatment T_3 retained maximum 'TSS: Acid ratio' (9.17), which were on par with each other including T_6 (8.85) and T_{11} (8.86) at 5 days after storage. The minimum 'TSS: Acid ratio' was recorded in T_4 (8.08). It was found to be on par with T_2 and T_{10} (8.41). At 25days after storage, the observations among various packaging treatments revealed that the fruits under treatment T_{11} retained maximum 'TSS: Acid ratio' (16.05). The minimum 'TSS: Acid ratio' was recorded in T_6 (14.75). In rest of the treatments, except T_3, no fruits were found to be retained for observation. The higher change in TSS: Acid ratio is straightly related to hydrolytic changes in the starch concentration (conversion of starch to sugars).Manazano and Diaz (2003) reported that 'Valencia' oranges fruits harvested, sorted, graded and treated with a wax coating found that TSS: Acid ratio was increased with the passage of time. Among the packaging treatments, the fruits under the treatment T_1 retained maximum 'Total sugars' (5.82%) at 5 days after storage. The minimum 'Total sugars' was recorded in T_7 (5.25%). It was found to be on par with T_4 (5.35%) and T_9 (5.36%). At 25days after storage, the observations among various packaging treatments revealed that the fruits under treatment T_{11} retained maximum 'Total sugars' (6.12%). The minimum 'Total sugars' was recorded in T_6 (5.88%). In rest of the treatments, except T_3, no fruits were found to be retained for observation. The maximum value for sugars might be due to conversion of polysaccharides into soluble sugars, dehydration and transformation of certain cell wall materials like hemicelluloses and pectins and also due to decrease in ascorbic acid content. The results are in line with the findings of Kumar and Chauhan (1990) in mandarin; Haikerwal (2001) in Jaffa sweet orange. And the fruits under the treatment T_7 retained maximum 'Reducing sugars' (3.51%), which was on par with each other including T_5 (3.41%), T_6 (3.35%) and T_{11} (3.35%) at 5 days after storage. The minimum 'Reducing sugars' was recorded in T_1 (2.93%). It was found to be on par with T_{10} (3.11%). At 25days after storage, the observations among various packaging treatments revealed that the fruits under treatment T_6 retained maximum 'Reducing sugars' (3.83%). The minimum 'Reducing sugars' was recorded in T_3 (3.14%). In rest of the treatments, except T_{11}, no fruits were found to be retained for observation. The fruits under the treatment T_1 retained maximum 'Non-reducing sugars' (2.89%) at 5 days after storage. The minimum 'Non-reducing sugars' was recorded in T_7 (1.74%). It was found to be on par with T_5 (1.96%). At 25days after storage, the observations among various packaging treatments revealed that the fruits under treatment T_{11} retained maximum 'Non-reducing sugars' (2.86%), which was on par with each other including T_3 (2.81%).The minimum 'Non-reducing sugars' was recorded in T_6 (2.05%). In rest of the treatments, no fruits were found to be retained for observation. Several internal fruit physiological activities like respiration, transpiration and other metabolic processes enhanced. So, starch gets converted to sugars and reducing sugar quantity increased.

Table.1 Effect of different packaging materials on 'TSS (ºB)' in Kinnow

Treatments	TSS (ºB)				
	5 DAS	10 DAS	15 DAS	20 DAS	25 DAS
T_1	11.56	12.57	14.13	0.00	0.00
T_2	10.85	11.20	11.50	12.30	0.00
T_3	11.10	11.40	11.65	12.25	12.00
T_4	10.67	10.82	11.05	11.26	0.00
T_5	10.70	10.95	11.35	11.55	0.00
T_6	10.80	11.20	11.39	11.61	11.95
T_7	10.20	10.60	11.26	11.50	0.00
T_8	10.80	11.70	11.90	12.30	0.00
T_9	10.50	10.70	11.10	12.00	0.00
T_{10}	10.60	10.81	11.40	11.80	0.00
T_{11}	10.90	11.35	11.50	11.90	12.20
SE(d)	0.22	0.23	0.24	0.24	0.12
CD (0.05%)	0.47	0.48	0.50	0.49	0.24

DAS: Days after storage

Table.2 Effect of different packaging materials on 'Titrable Acidity (%)' in Kinnow

Treatments	Titrable Acidity (%)				
	5 DAS	10 DAS	15 DAS	20 DAS	25 DAS
T_1	1.33	1.19	0.93	0.00	0.00
T_2	1.29	1.14	0.98	0.96	0.00
T_3	1.21	1.15	1.03	0.95	0.78
T_4	1.32	1.16	1.05	0.98	0.00
T_5	1.25	1.10	0.99	0.91	0.00
T_6	1.22	1.13	1.04	0.97	0.81
T_7	1.17	1.12	1.03	0.96	0.00
T_8	1.24	1.17	1.09	0.98	0.00
T_9	1.22	1.06	0.94	0.91	0.00
T_{10}	1.26	1.11	1.01	0.95	0.00
T_{11}	1.23	1.09	0.99	0.92	0.76
SE(d)	0.03	0.02	0.02	0.02	0.01
CD (0.05%)	0.06	0.05	0.04	0.04	0.02

DAS: Days after storage

Table.3 Effect of different packaging materials on 'Ascorbic Acid (mg/100ml)' in Kinnow

Treatments	Ascorbic Acid (mg/100ml)				
	5 DAS	10 DAS	15 DAS	20 DAS	25 DAS
T_1	21.33	17.52	12.49	0.00	0.00
T_2	25.24	22.17	19.02	17.36	0.00
T_3	23.74	21.87	19.62	17.42	15.75
T_4	23.85	21.9	19.48	17.74	0.00
T_5	25.58	22.24	19.2	17.86	0.00
T_6	24.37	21.71	19.89	18.11	16.04
T_7	23.33	21.2	18.43	17.13	0.00
T_8	24.51	22.08	18.77	17.83	0.00
T_9	23.15	21.43	18.17	16.82	0.00
T_{10}	24.83	22.39	19.25	17.08	0.00
T_{11}	25.16	22.89	19.41	17.24	15.51
SE(d)	0.50	0.45	0.38	0.34	0.15
CD (0.05%)	1.04	0.93	0.80	0.71	0.31

DAS: Days after storage

Table.4 Effect of different packaging materials on 'pH' in Kinnow

Treatments	pH				
	5 DAS	10 DAS	15 DAS	20 DAS	25 DAS
T_1	3.90	4.10	4.30	0.00	0.00
T_2	3.46	3.76	3.87	4.00	0.00
T_3	3.67	3.86	3.83	3.98	4.13
T_4	3.65	3.81	3.91	3.97	0.00
T_5	3.42	3.72	3.97	4.03	0.00
T_6	3.58	3.80	3.86	3.94	4.06
T_7	3.70	3.88	4.00	4.10	0.00
T_8	3.56	3.78	3.96	4.02	0.00
T_9	3.72	3.87	3.98	4.10	0.00
T_{10}	3.54	3.73	3.90	4.12	0.00
T_{11}	3.47	3.69	3.91	4.08	4.17
SE(d)	0.08	0.08	0.08	0.08	0.04
CD (0.05%)	0.16	0.17	0.17	0.16	0.08

DAS: Days after storage

Table.5 Effect of different packaging materials on 'TSS: Acid ratio' in Kinnow

Treatments	TSS: Acid ratio				
	5 DAS	10 DAS	15 DAS	20 DAS	25 DAS
T_1	8.69	10.56	15.19	0.00	0.00
T_2	8.41	9.82	11.73	12.81	0.00
T_3	9.17	9.91	11.31	12.89	15.38
T_4	8.08	9.32	10.52	11.48	0.00
T_5	8.56	9.95	11.46	12.69	0.00
T_6	8.85	9.91	10.95	11.96	14.75
T_7	8.71	9.46	10.93	11.97	0.00
T_8	8.70	10	10.91	12.55	0.00
T_9	8.60	10.09	11.80	13.18	0.00
T_{10}	8.41	9.73	11.28	12.42	0.00
T_{11}	8.86	10.41	11.61	12.93	16.05
SE(d)	0.18	0.21	0.24	0.25	0.15
CD (0.05%)	0.37	0.43	0.51	0.51	0.31

DAS: Days after storage

Table.6 Effect of different packaging materials on 'Total Sugars (%)' in Kinnow

Treatments	Total Sugars (%)				
	5 DAS	10 DAS	15 DAS	20 DAS	25 DAS
T_1	5.82	5.92	6.37	0.00	0.00
T_2	5.39	5.48	5.62	6.25	0.00
T_3	5.51	5.58	5.64	6.19	5.95
T_4	5.35	5.43	5.60	5.71	0.00
T_5	5.37	5.53	5.50	5.69	0.00
T_6	5.40	5.61	5.67	5.78	5.88
T_7	5.25	5.45	5.73	5.75	0.00
T_8	5.41	5.54	5.70	6.21	0.00
T_9	5.36	5.44	5.57	5.90	0.00
T_{10}	5.43	5.49	5.81	5.92	0.00
T_{11}	5.40	5.50	5.78	5.85	6.12
SE(d)	0.11	0.12	0.12	0.12	0.06
CD (0.05%)	0.23	0.24	0.25	0.25	0.12

DAS: Days after storage

Table.7 Effect of different packaging materials on 'Reducing Sugars (%)' in Kinnow

Treatments	Reducing Sugars (%)				
	5 DAS	10 DAS	15 DAS	20 DAS	25 DAS
T_1	2.93	3.21	3.78	0.00	0.00
T_2	3.31	3.37	3.57	4.09	0.00
T_3	3.20	3.26	3.80	4.27	3.14
T_4	3.27	3.22	3.75	3.80	0.00
T_5	3.41	3.42	3.47	3.61	0.00
T_6	3.35	3.51	3.93	3.10	3.83
T_7	3.51	4.01	3.91	3.80	0.00
T_8	3.19	3.37	3.81	3.54	0.00
T_9	3.25	4.11	3.78	4.11	0.00
T_{10}	3.11	3.19	3.62	3.70	0.00
T_{11}	3.35	3.46	4.16	2.93	3.26
SE(d)	0.07	0.07	0.08	0.07	0.03
CD (0.05%)	0.14	0.15	0.16	0.15	0.06

DAS: Days after storage

Table.8 Effect of different packaging materials on 'Non-Reducing Sugars (%)' in Kinnow

Treatments	Non-Reducing Sugars (%)				
	5 DAS	10 DAS	15 DAS	20 DAS	25 DAS
T_1	2.89	2.71	2.59	0.00	0.00
T_2	2.08	2.11	2.05	2.16	0.00
T_3	2.31	2.32	1.84	1.92	2.81
T_4	2.08	2.21	1.85	1.91	0.00
T_5	1.96	2.11	2.03	2.08	0.00
T_6	2.05	2.10	1.74	2.68	2.05
T_7	1.74	1.44	2.02	1.95	0.00
T_8	2.22	2.17	1.89	2.67	0.00
T_9	2.11	1.33	1.79	1.79	0.00
T_{10}	2.32	2.30	2.19	2.22	0.00
T_{11}	2.05	2.04	1.62	2.92	2.86
SE(d)	0.04	0.04	0.04	0.04	0.03
CD (0.05%)	0.09	0.09	0.09	0.09	0.06

DAS: Days after storage

Table.9 Effect of different packaging materials on 'Sugar: Acid ratio' in Kinnow

Treatments	Sugar: Acid ratio				
	5 DAS	10 DAS	15 DAS	20 DAS	25 DAS
T_1	4.37	4.97	6.84	0.00	0.00
T_2	4.17	4.80	5.73	6.51	0.00
T_3	4.55	4.85	5.47	6.51	7.62
T_4	4.05	4.68	5.33	5.82	0.00
T_5	4.29	5.02	5.55	6.25	0.00
T_6	4.42	4.96	5.45	5.95	7.25
T_7	4.48	4.86	5.56	5.98	0.00
T_8	4.36	4.73	5.22	6.33	0.00
T_9	4.39	5.13	5.92	6.48	0.00
T_{10}	4.30	4.94	5.75	6.23	0.00
T_{11}	4.39	5.04	5.83	6.35	8.05
SE(d)	0.09	0.10	0.12	0.12	0.07
CD (0.05%)	0.19	0.21	0.25	0.26	0.15

DAS: Days after storage

The results are in line with findings of Gul *et al.,* (1990) who observed that the effect of Fruitex (wax emulsion) on blood red oranges during room storage found that non-reducing sugars increased during storage. And the treatment T_3 retained maximum 'Sugar-Acid ratio' (4.55), which were on par with each other including T_7 (4.48) and T_6 (4.42) at 5 days after storage. The minimum 'Sugar-Acid ratio' was recorded in T_4 (4.05). It was found to be on par with T_2 (4.17). At 25days after storage, the observations among various packaging treatments revealed that the fruits under treatment T_{11} retained maximum 'Sugar-Acid ratio' (8.05). The minimum 'Sugar-Acid ratio' was recorded in T_6 (7.25). In rest of the treatments, except T_3, no fruits were found to be retained for observation.

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