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Effect of different packaging materials on quality during storage of Kinnow Mandarin (*Citrus reticulata* Blanco)

Rohit Kumar, Priya Awasthi, Vigya Mishra, Vishal Chugh and SC Singh

Abstract

The present investigation entitled "Effect of different packaging materials on quality during storage of Kinnow Mandarin (*Citrus reticulata* Blanco)" was conducted at Post Harvest Technology and Biochemistry Laboratory, College of Horticulture, Banda University of Agriculture and Technology, Banda (U.P.) during the academic year 2020-21. Packaging treatments include T_1 (Control or no packaging), T_2 (Fruits packed in LDPE 25 micron), T_3 (Individual fruits wrapped in news paper and packed in LDPE 25 micron), T_4 (Fruits packed in brown paper bags), T_5 (Individual fruits wrapped in News Paper and packed in brown paper bags), T_6 (Fruits packed in Corrugated Fiber Board boxes), T_7 (Individual fruits wrapped in News Paper and packed in Corrugated Fiber Board boxes), T_8 (Fruits packed in perforated brown paper bags), T_9 (Fruits packed in perforated LDPE 25 micron). The Physio-chemical evaluation of the fruits of each treatment was done upto 45 days and all the observations were recorded at every 15 days interval *i.e*., 0, 15, 30 and 45 days of storage. The PLW, TSS, TSS: TA ratio, pH had increasing trend during whole storage period while weight, length, width and titrable acidity had decreasing trend. The fruits packed in corrugated fibre board were had minimum PLW% and volume loss percentage in comparison to other treatments during storage.

Keywords: Kinnow mandarin, packaging materials, quality, storage

Introduction

Kinnow is a member of Rutaceae family that belongs to class Magnoliopsida and order Sapindales. Kinnow has own importance at 3rd rank after banana and mango. Indian states like Haryana, Punjab, Himachal Pradesh, Rajasthan, U.P., and Jammu are major kinnow growing regions. It is a delicious fruit that have origin in South East Asia. Worldwide, it is well known for its nutrients rich juice and medicinal properties (Chopra *et al*., 2004; Hayat *et al*., 2010; Kelebek *et al*., 2008) [1, 3, 4]. Kinnow juice is a rich source of vitamin C and various antioxidant compounds that are required to sustain healthy life. It could be consumed in raw as well as processed form (Safdar *et al*., 2017a) [10]. Kinnow is a fruit crop which is famous among consumers due to its tasty and delicious juice. It is a multipurpose crop which could be utilized as an important source of nutrients for humans as well as animals. Depending on the environmental conditions and age of kinnow fruit the amount of juice may vary from 45 to 60%. Total soluble solids present in juice reside in range from 9.5 to 16%. Kinnow fruit is a rich source of bioactive constituents, along with specific minerals (sodium 0.01–0.03 mg/g; potassium 1.6–2.5 mg/g; calcium 0.14–0.47 mg/g, and copper 6–8 mg/100 ml), vitamins and volatile compounds. Kinnow fruit could be used for a variety of purposes ranging from fresh juice to candy, jellies and wine. The remaining waste of kinnow fruit after juice extraction could also be useful as animal feed. Addition of kinnow in diet chart could provide many health benefits. The orange is a hybrid between pomelo (*Citrus maxima*) and mandarin (*Citrus reticulata*). In India, kinnow is cultivated primarily in Punjab, Rajasthan, Haryana, Himachal Pradesh, Jammu & Kashmir and Utter Pradesh. Kinnow is well suited for the climatic conditions of the Bundelkhand region. The post harvest shelf life of kinnow fruit at room temperature is very limited and self life can be extended to a maximum period of up to 45 days under refrigerated storage condition. In view of its limited self life the fruit must be processed to extend its availability period and also minimize the glut in the market in its peak season of production. Packaging is the science, art and technology of enclosing or securing products for distribution, storage, sale and consumption. Packaging also refers to the design process, evaluation and production of cans.

Packaging can be described as an integrated system of preparing products for transportation, storage, logistics, sale and consumption. Packaging, holds, protects, preserves, transports. Packing of fruits in polymeric films creates modified atmospheric conditions around the produce inside the package allowing lower degree of control of gases and can interplay with physiological processes of commodity resulting in reduced rate of respiration, transpiration and other metabolic processes of fruits (Sandhya 2010, Soltani *et al.* 2016) [12].

Materials and Methods

The investigation was conducted in department of Post-Harvest-Technology and biochemistry laboratory, College of Horticulture, Banda University of Agriculture and Technology, Banda, Uttar Pradesh during year 2020-2021. Healthy kinnow fruit were collected from local mandi of district Banda. For experiment purpose the fruit with uniform size, colour, firmness and maturity was 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. Before packing the fruit, they were properly washing chlorinated water (100 ppm) and dried under shade to remove the surface water. Thereafter, the packed fruits were stored under ambient conditions (18-20 °C & 90-95% RH) in PG laboratory of department of Post Harvest Technology, College of Horticulture, Banda University of agriculture and technology, Banda (U.P.). The lab was properly ventilated and thoroughly cleaned. All the packaging materials via; Brown paper, Perforated brown paper, LDPE (25 micron), Perforated LDPE (25 micron), News paper, Corrugated Fiber Board boxes used for experimental study. The perforated packaging materials used was prepared by making 9 pin holes in the packaging materials. The details of the treatments allotted to them are as follow. T_1 Control (no packaging), T_2 Fruits packed in LDPE (25 micron), T_3 Individual fruits wrapped in News Paper and packed in LDPE (25 micron), T_4 Fruits packed in brown paper bags, T_5 Individual fruits wrapped in News Paper and packed in brown paper bags, T_6 Fruits packed in Corrugated Fiber Board boxes, T_7 Individual fruits wrapped in news paper and packed in Corrugated Fiber Board boxes, T_8 Fruits packed in perforated brown paper bag, T_9 Fruits packed in perforated LDPE (25 micron). The various physio-chemical attributes of the fruits were recorded at 0, 15, 30 and 45 days of storage period.

Weight of the fruits was measured on top pan balance individually and their average weight was calculated and expressed in gram (g).The physiological loss in weight (PLW) of storage fruits was calculated by subtracting final weight from the initial weight of the fruits and expressed in percentage. The fruits length from apex to the pedicel end was measured by vernier caliper and expressed in millimeter. The width of the fruits were measured by vernier calipers as diameter and expressed in millimeters.

The total soluble solids (TSS) was determined with the help of hand refractrometer of range 0-45 ^{0}Brix (QA Supplies, LLC). Titrable acidity was calculated by the method given by Ranganna, 1986.

$$\text{Titrable Acidity} = \frac{\text{Eq.wt.of acid X Normality of NaoH X Titer X 100}}{\text{Sample weight}}$$

ELTOP-3030 pH meter pH was used to measure pH of fruit juice.

Results and Discussion

Weight (g)

Data depicted in Table-1 showed that the weight was significantly affected by packaging materials. The maximum weight was found in T_2 (152.193) then T_9 (141.358) and T_3 (132.625) minimum weight in T_1 (113.215). Weight of fruit was also significantly affected by Storage period. There is a continuous decrease in the fruit weight during storage. This might be due to the fact that in ambient condition during storage, the moisture loss through respiration and transpiration affect the fruit weight eventually fruit becomes unsalable as a result of shrinking, Salunkhe and Desai (1984) [11].

Table 1: Effect of different packaging materials on weight (g) of kinnow fruits during storage

Treatment	Storage period (Days)				
	0 Day	15 Days	30 Days	45 Days	Mean
T_1	157.333	124.377	95.983	75.167	113.215
T_2	159.433	149.640	151.000	148.700	152.193
T_3	142.500	136.000	129.667	122.333	132.625
T_4	167.433	134.830	107.467	99.100	127.208
T_5	154.287	139.460	115.717	91.367	125.208
T_6	152.033	135.020	114.817	103.200	126.268
T_7	146.000	131.353	103.967	86.200	116.880
T_8	153.253	128.500	103.820	85.400	117.743
T_9	161.617	155.883	136.000	111.933	141.358
Mean	154.877	137.229	117.604	102.600	---
	Treatment (T)	Storage period (S)	Interaction (TXS)		
C.D. (0.05)	9.214	6.143	18.428		
S.Em ±	3.262	2.174	6.523		

Physiological loss in weight (%): Data related to physiological loss in weight given in Table-2 shows that the physiological loss in weight was significantly affected by packaging materials. The maximum value was found control or no packaging thus the minimum value in fruits packed in corrugated fiber board boxes. The physiological loss in weight was also significantly affected by storage period. The highest value was notice (0.603) at 45 days storage but lowest value (0.165) at 15 days. The increase physiological loss in weight during storage period is obvious due to loss in moisture, but also occurs through respiration phenomenon from the fruits with advancement of storage period. The similar results were recorded by Thakur *et al.* (2002) [14] in postharvest treatments and storage conditions on the fruit quality of Kinnow.

Table 2: Effect of different packaging materials on physiological loss in weight (%) of kinnow fruits during storage

Treatment	Storage period (Days)				
	0 Day	15 Days	30 Days	45 Days	Mean
T_1	0.000	0.323	0.613	0.823	0.440
T_2	0.000	0.037	0.427	0.823	0.322
T_3	0.000	0.167	0.370	0.490	0.257
T_4	0.000	0.320	0.600	0.687	0.402
T_5	0.000	0.147	0.387	0.630	0.291
T_6	0.000	0.065	0.128	0.202	0.099
T_7	0.000	0.147	0.423	0.600	0.293
T_8	0.000	0.223	0.493	0.677	0.348
T_9	0.000	0.057	0.257	0.497	0.203
Mean	0.000	0.165	0.411	0.603	---
	Treatment (T)	Storage period (S)	Interaction (TXS)		
C.D. (0.05)	0.119	0.079	N/S		
S.Em ±	0.042	0.028	0.084		

Length (mm)

The length of the fruits were should a decline trend during storage. It is clear by data of length that the highest mean value of length was found in T_3 and lowest in T_1. This might be due to the fact that in ambient condition during storage, the moisture loss through respiration and transpiration affected length. The similar result was also reported by Thakur *et al*. (2002) [14] in postharvest treatments and storage conditions on the fruit quality of Kinnow.

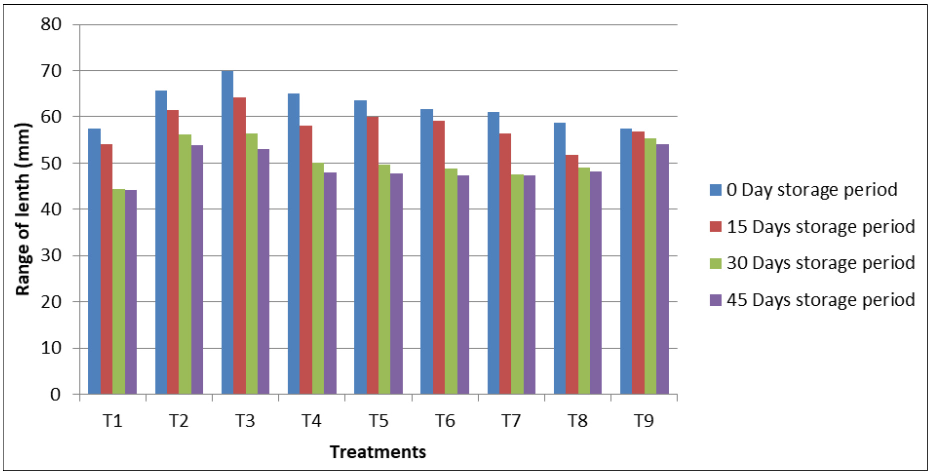

Fig 1: Effect of different packaging materials on length (mm) of kinnow during storage

Width (mm)

It is evident from the observation for in width presented in Fig-2 show that the packaging materials and storage period significantly affected the kinnow fruits. The interaction of both factor was reported that the non-significant on width. This reason due to fruit size increase with the increase in fruit width and fruit size is decrease with width was decrease. Same result was observed by Kumar (2006) [5] in Variability in Physico-chemical characteristics of mango genotypes.

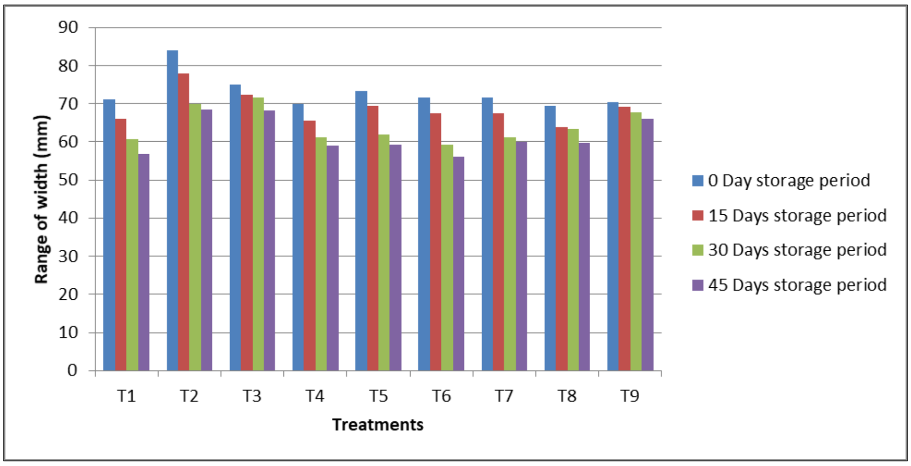

Fig 2: Effect of different packaging materials on width (mm) of kinnow during storage

Total soluble solids (^{0}Brix)

The observation recorded for total soluble solids (TSS) of kinnow fruits have been presented in Table-3 and it is clearly showed that the TSS of fruits increased in various packaging materials (T_1 to T_9) with the advancement of storage period. The increase in total soluble solids with prolongation of storage period may probably be due to increased hydrolysis of polysaccharides and concentration of juice due to dehydration. At the end of storage maximum TSS was recorded in control fruits. It may be due to maximum water loss in these fruits. Similar results were reported by Randhawa *et al*. (2009) [7] in 'Kinnow' mandarin during storage.

Table 3: Effect of different packaging materials on total soluble solids (°Brix) of kinnow fruits during storage

Treatment	Storage period (Days)				
	0 Day	**15 Days**	**30 Days**	**45 Days**	**Mean**
T_1	8.300	10.700	11.800	12.533	10.833
T_2	8.260	10.320	11.200	11.453	10.308
T_3	8.213	9.567	10.433	10.833	9.762
T_4	8.330	10.423	11.473	11.967	10.548
T_5	8.393	10.350	11.360	11.433	10.384
T_6	8.270	10.600	11.700	12.300	10.718
T_7	8.213	10.450	11.400	11.920	10.496
T_8	8.250	10.543	11.660	12.100	10.638
T_9	8.200	9.973	10.633	11.733	10.135
Mean	8.270	10.325	11.296	11.808	---
	Treatment (T)	Storage period (S)	Interaction (TXS)		
C.D. (0.05)	0.265	0.177	0.530		
S.Em ±	0.094	0.063	0.188		

Titrable acidity (%)

The titrable acidity of kinnow fruit showed a linear declining trend with advancement of storage period Table-4. The highest average acidity in T_8 (0.913) was recorded fruit packed perforated brown paper bag, but lowest average acidity in T_6 (0.829) Fruits packed in Corrugated Fiber boxes. The progressive reduction in the acidity with advancement of storage period might be due to the increased catabolism of organic acids present in fruit through the process of respiration. The decrease in titratable acids during storage may be attributed to utilization of organic acid in pyruvate decarboxylation reaction occurring during the ripening process of fruits. The result of study was also in accordance with Mahajan *et al*. (2016) [6] in kinnow.

Table 4: Effect of different packaging materials on titrable acidity (%) of kinnow Fruits During storage

Treatment	Storage period (Days)				
	0 Day	**15 Days**	**30 Days**	**45 Days**	**Mean**
T_1	1.013	0.930	0.850	0.793	0.897
T_2	0.980	0.933	0.873	0.813	0.900
T_3	0.960	0.910	0.843	0.783	0.874
T_4	0.957	0.900	0.840	0.780	0.869
T_5	0.947	0.880	0.817	0.750	0.848
T_6	0.920	0.860	0.800	0.737	0.829
T_7	0.937	0.867	0.810	0.740	0.838
T_8	1.003	0.947	0.883	0.820	0.913
T_9	0.953	0.880	0.827	0.767	0.857
Mean	0.963	0.901	0.838	0.776	---
	Treatment (T)	Storage period (S)	Interaction (TXS)		
C.D. (0.05)	0.015	0.010	N/S		
S.Em ±	0.005	0.003	0.010		

Total soluble solids: titrable acidity ratio

The data recorded on the chemical characteristics of kinnow fruits are presented in Fig-3. Data indicate as acidity percentage decrease during storage period the value TSS acidity ratio continuously increase, at 0 day the value of TSS acidity ratio was observed (8.616) but (11.158) at 15 days, (13.526) at 30 days and (15.277) at 45 days after storage period, the TSS titrable acidity was significance affected by packaging materials. Similarly the TSS: Acidity ratio of 13.33:1 has been reported by Ghawade *et al*. (2002) [2] Chandani disorder in (*Citrus reticulata* Blanco).

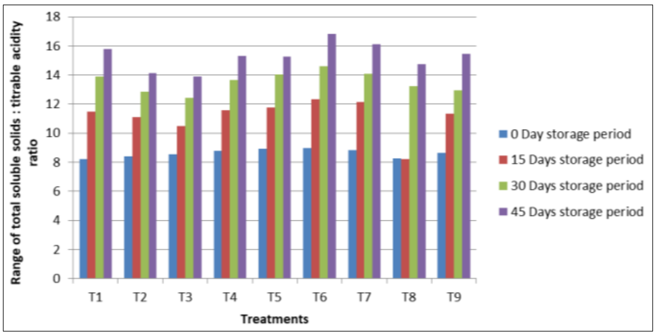

Fig 3: Effect of different packaging materials on total soluble solids: titrable acidity ratio of kinnow during storage

pH

The observation recorded for pH of kinnow juice has been presented in Fig-4 showed that the potential of hydrogen (p^H) was significant affected by packaging materials. pH of Kinnow juice was significantly increased during all storage periods under ambient condition. The maximum pH was reported at 45 days. The increase in pH during storage was accompanied with decrease in acidity of juice and is in conformity with the findings of Rehman *et al*. (2014) [9] on study the storage stability of fruit juice concentrates.

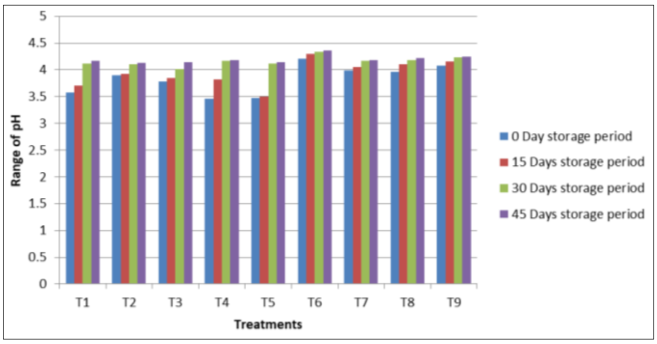

Fig 4: Effect of different packaging materials on pH of kinnow during storage

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