

## **Original Research Article**

### **Impact of Different Packaging Materials on the Quality And Shelf Life Of Kinnow Mandarin (*Citrus Reticulata*)**

#### **Abstract**

The experiment carried out on the “**Impact of Different Packaging Materials on The Quality and Shelf Life Of Kinnow Mandarin (*Citrus reticulata*)**” was conducted at Post Harvest Laboratory, Department of Horticulture, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.) during the academic year 2022. Under the study the packaging treatments include T<sub>1</sub> (Control or no packaging), T<sub>2</sub> (Fruits packed in Newspaper), T<sub>3</sub> (Fruits wrapped in Brown paper bags), T<sub>4</sub> (Fruits packed in Aluminium Foil), T<sub>5</sub> (Fruits wrapped in LDPE (Low Density Polyethylene), T<sub>6</sub> (Fruits packed in Rice stubble), T<sub>7</sub> (fruits packed in Perforated boxes), T<sub>8</sub> (Fruits packed in Gunny bags), T<sub>9</sub> (Fruits packed in Nylon net bags). The main objective of the experiment was to evaluate the effect of various packaging materials on physico-chemical characteristics of Kinnow fruit during storage. The physico-chemical evaluation of the fruits of each treatment was done upto 24 days and all the observations were recorded at every 6 days interval. The Fruit Weight, Polar Diameter, Radial Diameter, Peel weight having the decreasing trend, the highest mean was found in T<sub>5</sub> during storage which were (151.70), (57.58), (59.11), (36.08) respectively. The TSS(<sup>0</sup>Brix) and pH were recorded lowest in the fruits packed in T<sub>5</sub> during storage which were (10.45) and (4.02) respectively. Specific gravity of fruits had decreasing trend during storage period and found highest (0.86) in T<sub>5</sub> at 24 days while ascorbic acid and titrable acidity had decreasing trend and mean values was found highest (17.89) and (0.89) in T<sub>5</sub> respectively during storage. On basis of study results shown by physico-chemical characteristics of kinnow, it was concluded that kinnow fruits packed in T<sub>5</sub> LDPE packing has highest overall acceptability at 24 days of storage. These practices may be passed on for obtaining higher returns with B:C ratio of 2.39.

**Keywords:** Kinnow, LDPE, Shelf life, Economics, Physico-chemical.

## Introduction

Citrus is one of the most important subtropical fruits in the world. It primarily refers to *Citrus × sinensis*, which is also called sweet orange, to distinguish it from the related *Citrus × aurantium*. The sweet orange reproduces asexually (apomixis through nucellar embryony); varieties of sweet orange arise through mutations. The orange is a hybrid between pomelo (*Citrus maxima*) and mandarin (*Citrus reticulata*). The orange originated in a region encompassing Southern China, Northeast India, and Myanmar, and the earliest mention of the sweet orange was in Chinese literature in 314 BC. As of 1987, orange trees were found to be the most cultivated fruit tree in the world. Orange trees are widely grown in tropical and subtropical climates for their sweet fruit. The fruit of the orange tree can be eaten fresh, or processed for its juice or fragrant peel. As of 2012, sweet oranges accounted for approximately 70% of citrus production. In 2019, 79 million tones of oranges were grown worldwide, with Brazil producing 22% of the total, followed by China and India. The total mandarin production in India was 3698.99 thousand tons, 29.97 percent of which is produced in Punjab during 2014-15.

Kinnow is an important citrus fruit grown

in subtropical regions of India. Kinnow is a hybrid between King (*Citrus nobilis*) and Willow leaf (*Citrus deliciosa*) mandarins developed in 1915 (Dr. H.B. Frost) at Citrus Research Centre, University of California, River side, USA. After a long evaluation period of 20 years, it was released in 1935 as a new variety for its commercial cultivation in Kinnow. In India, kinnow is cultivated primarily in Punjab, Rajasthan, Haryana, Himachal Pradesh, Jammu & Kashmir and Uttar Pradesh.

The post harvest shelf life of kinnow fruit at room temperature is very limited and shelf life can be extended to a maximum period of up to 45 days under refrigerated storage condition. In view of its limited shelf 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. Like all fresh products the quality of kinnow mandarin juice changes with time. Several key parameters influence the rate of microbial spoilage, enzymatic degradation, chemical changes and deterioration in flavor or turn bitter extraction. For improving the taste, aroma, palatability, nutritive value and reducing bitterness kinnow juice was

blended with some other highly nutritive fruit juice namely pomegranate and aonla juice with spice extract like ginger.

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, informs and sells. In many countries it is fully integrated into government, business, and institutional, industrial and personal use. The first packages used natural materials available at that time: baskets of reeds, wineskin (bota bags), wooden boxes, clay vases, ceramic amphora, wooden canisters, woven bags, etc. After their development, refined materials were used to make packages: for example, the glass and bronze vessels of the East. The study of old packages is an important aspect of archaeology. The epoch from the stipulated time to age in the manufacture of the cane began in the mid- 19th century.

The role of packaging is very important in post harvest operations of horticultural crops but its role is still underestimated in the country. Use of polymeric films is very pronounced in packaging of fruits with a purpose to extend their storage life. 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 (**Lange 2000**) thereby allowing lower physiological weight loss, reducing decay incidence and maintaining retention of colour and texture of fruits during extended shelf life (**Sharma et al. 2010**).

### **Materials and Methods**

The present investigation entitled “Impact of Different Packaging Materials On The Quality And Shelf Life Of Kinnow Mandarin (*Citrus reticulata*)” was carried out at post-harvest lab, Department of Horticulture, SHUATS, Naini Agricultural Institute, PRAYAGRAJ in the year 2022.

The treatments were T<sub>1</sub> (Control or no packaging), T<sub>2</sub> (Fruits packed in Newspaper), T<sub>3</sub> (Fruits wrapped in Brown paper bags), T<sub>4</sub> (Fruits packed in Aluminium Foil), T<sub>5</sub> (Fruits wrapped in LDPE (Low Density Polyethylene), T<sub>6</sub> (Fruits packed in Rice stubble), T<sub>7</sub> (fruits packed in Perforated boxes), T<sub>8</sub> (Fruits packed in Gunny bags), T<sub>9</sub> (Fruits packed in Nylon net bags).

### Experimental Findings

The maximum fruit weight of kinnow fruit after 24 days was observed in T<sub>5</sub> packed by using LDPE where Initial Reading was (162.56g), (159.78g) 6days, (157.00g) 12days, (152.47g) 18days, (151.70g) 24Days, followed by T<sub>4</sub> (Aluminium Foil) where Initial reading was (155.22g), (150.56g) 6 Days, (140.84g) 12 Days, (135.04g) 18 Days, (130.21g) 24 Days. Whereas the maximum weight loss of fruit was found in fruits of Treatment T<sub>1</sub> (Control) (142g) Initial Reading, (132g) 6 Days, (116g) 12Days, (95.01g) 18Days, (83.00g) 24 Days.

Maximum Radial Diameter of Kinnow fruit after 24 days was observed in Treatment T<sub>5</sub> where Kinnow fruits were packed using LDPE the Initial

Reading was (68.30mm), (66.35mm) 6days, (64.73mm) 12days, (64.26mm) 18days, (59.11mm) 24days, followed by T<sub>4</sub> (Aluminium Foil) where Initial reading was (62.34mm), (62.15mm) 6 Days, (58.51mm) 12 Days, (57.71mm) 18 Days, (54.67mm) 24 Days. Whereas the minimum Radial Diameter of kinnow fruit after 24 Days was found in fruits of Treatment T<sub>1</sub> (Control) where Initial Reading was (62.65mm), (59.35mm) 6 Days, (54.70mm) 12Days, (53.83mm) 18Days, (46.50mm) 24 Days.

Maximum Polar Diameter of the Kinnow fruit after 24 Days was observed in Treatment T<sub>5</sub> where fruits packed by using LDPE there (63.57mm) Initial Reading, (60.80mm) 6days, (59.11mm) 12days, (58.45mm) 18days, (57.58mm) 24days, followed by T<sub>4</sub> (Aluminium Foil) where Initial reading was (62.53mm), (60.80mm) 6 Days, (59.11mm) 12 Days, (58.45mm) 18 Days, (57.58mm) 24 Days. Whereas the minimum Polar Diameter of Kinnow fruit was recorded in fruits of Treatment T<sub>1</sub> (Control) (54.50mm) Initial Reading, (51.02mm) 6 Days, (46.67mm) 12Days, (44.77mm) 18Days, (43.85mm) 24 Days.

Maximum Specific gravity of Kinnow fruits after 24 Days was recorded in the Treatment T<sub>5</sub> where the fruits were packed using LDPE the Initial Day Reading was (1.32 g/m<sup>3</sup>), (1.28 g/m<sup>3</sup>) 6 days, (1.19 g/m<sup>3</sup>) 12 days, (0.93 g/m<sup>3</sup>) 18 days, (0.86 g/m<sup>3</sup>) 24 days, followed by T<sub>4</sub> (Aluminium Foil) where Initial reading was (1.31 g/m<sup>3</sup>), (1.23 g/m<sup>3</sup>) 6 days, (1.04 g/m<sup>3</sup>) 12 Days, (0.92 g/m<sup>3</sup>) 18 Days, (0.84 g/m<sup>3</sup>) 24 Days. Whereas the minimum specific gravity was observed in fruits of Treatment T<sub>1</sub> (1.22 g/m<sup>3</sup>) Initial Reading, (0.98 g/m<sup>3</sup>) 6 days, (0.86 g/m<sup>3</sup>) 12days, (0.79 g/m<sup>3</sup>) 18 days, (0.74 g/m<sup>3</sup>) 24 days.

Minimum Peel weight loss of the Kinnow fruit was observed in Treatment T<sub>5</sub> in which fruits were packed using LDPE the Initial Day Reading was (46.75g), (46g) 6days, (43.34g) 12days, (38.05g) 18days, (36.08g) 24days, followed by T<sub>4</sub> (Aluminium Foil) where Initial reading was (42.04g), (38.33g) 6 Days, (34.57g) 12 Days, (30.58g) 18 Days, (28.87g) 24 Days. Whereas the maximum Peel Weight loss of fruit was found in fruits of Treatment T<sub>1</sub> (Control) (32.43g) Initial Reading, (27.56g) 6

Days, (20.92g) 12Days, (15.88g) 18Days, (9.37g) 24 Days.

Minimum TSS of the Kinnow fruit was observed in Treatment T<sub>5</sub> in which fruits were packed using LDPE where Initial Reading was (9.40 ° Brix), (9.80 ° Brix) 6 days, (9.86 ° Brix) 12 days, (10.22 ° Brix) 18 days, (10.45 ° Brix) 24 days, followed by T<sub>4</sub> (Aluminium Foil) where Initial reading was (9.55 ° Brix), (9.98 ° Brix) 6 Days, (10.03 ° Brix) 12 Days, (10.33 ° Brix) 18 Days, (10.65 ° Brix) 24 Days. Whereas the highest TSS found in Treatment T<sub>1</sub> Control in which the fruits are not packed with any packing material (9.93 ° Brix) Initial Reading, (10.37 ° Brix) 6days, (10.51 ° Brix) 12 days, (10.87 ° Brix) 18 days, (11.80 ° Brix) 24 days.

Maximum titrable acidity of Kinnow fruit was observed in Treatment T<sub>5</sub> in which fruits were packed by using LDPE (1.03 %) Initial day, (0.98 %) 6 days, (0.94 %) 12 days, (0.92 %) 18 days, (0.89 %) 24 days, followed by T<sub>4</sub> (Aluminium Foil) where Initial reading was (1.03 %) Initial day, (0.93 %) 6 days, (0.92 %) 12 days, (0.88 %) 18 days, (0.85 %) 24 days. Whereas the

average low titrable acidity was found in Treatment T<sub>1</sub> fruits (1.02 %) 0 day, (0.93 %) 6 days, (0.89 %) 12 days, (0.84 %) 18 days, (0.74 %) 24 days.

pH of Kinnow fruit juice showed significant increase in pH. Minimum pH was found in Treatment T<sub>5</sub> fruits packed by using LDPE (3.52) Initial day, (3.57) 6days, (3.64) 12days, (3.97) 18days, (4.02) 24days, followed by T<sub>4</sub> (Aluminium Foil) where Initial reading was (3.64), (3.78) 6days, (3.91) 12days, (3.94) 18days, (4.09) 24days. Whereas the highest pH of kinnow fruit juice was found in fruits of Treatment T<sub>1</sub> (4.14) Initial Reading, (4.16) 6 days, (4.32) 12days, (4.39) 18days, (4.48) 24 days.

Ascorbic acid in Kinnow fruit showed the ideal decrease in ascorbic acid. Maximum Ascorbic Acid was found in Treatment T<sub>5</sub> where fruits were packed using LDPE (24.42 mg/100g) Initial Reading, (23.13 mg/100g) 6 days, (21.47 mg/100g) 12 days, (19.81 mg/100g) 18 days, (17.89 mg/100g) 24 days, followed by T<sub>4</sub> (Aluminium Foil) where Initial reading was (23.71 mg/100g), (22.37 mg/100g) 6 days, (21.40 mg/100g) 12 days, (19.61 mg/100g) 18 days, (17.30 mg/100g) 24

days. Whereas the minimum Ascorbic Acid was recorded in Treatment T<sub>1</sub> (Control) (24.56 mg/100g) Initial reading, (22.69 mg/100g) 6 days, (19.38 mg/100g) 12 days, (16.60 mg/100g) 18 days, (14.43 mg/100g) 24 days.

Total Sugars showed the significant increase of total sugars. Maximum total sugars were recorded in Treatment T<sub>5</sub> where fruits were packed using LDPE (4.72%) Initial reading, (4.97%) 6 days, (5.50%) 12 days, (6.12%) 18days, (6.49%) 24 days, followed by T<sub>4</sub> (Aluminium Foil) where Initial reading was (5.25 %), (5.48 %) 6 days, (5.75 %) 12 days, (6.23 %) 18 days, (6.47 %) 24 days. Whereas the minimum total sugar was found in Treatment T<sub>1</sub> where fruits were not packed using any packaging material (4.85%) Initial reading, (5.04%) 6day, (5.45%) 12 days, (5.73%) 18 days, (5.75%) 24 days.

Highest B:C ratio of 2.39 was found under treatment T<sub>5</sub> followed by T<sub>4</sub> with 1.81.

## Conclusion

From the present investigation it is concluded that effect of Treatment T<sub>5</sub>

i.e. LDPE was found to be best, in terms of physico-chemical attributes weight (g), radial diameter (mm), polar diameter (mm), specific gravity ( $\text{g}/\text{m}^3$ ), peel weight (g), total soluble solids ( $^{\circ}\text{Brix}$ ), titrable acidity (%), ascorbic acid ( $\text{mg}/100\text{g}$ ), pH, total sugars (%). From the economics point of view, Highest B:C ratio of 2.39 was found in treatment T<sub>5</sub>.

**Future Scope:--**

Importance of Post-harvest technology lies in the fact that it has the capability to meet food requirement of growing population by eliminating losses making more nutritive food items from raw commodities by proper processing and fortification. Post-harvest technology has potential to create rural industries. India, where 80 percent people live in the villages and 70 percent of them depend on agriculture has experienced that the process of industrialization has shifted the food, feed and fibre industries to urban areas. The farmer whose role has been reduced to producer can be transformed into producer cum processor and thus getting more dividends for hard labour, input, kind of risk taken and generating

resource for socio-economic advancement keeping pace with the modern times.

**Table 1 Effect of different packaging materials on Fruit weight, Radial Diameter and Polar diameter.**

Treatment	Fruit Weight (g)					Radial Diameter (mm)					Polar Diameter (mm)				
	0 DAP	6 DAP	12 DAP	18 DAP	24 DAP	0 DAP	6 DAP	12 DAP	18 DAP	24 DAP	0 DAP	6 DAP	12 DAP	18 DAP	24 DAP
T <sub>1</sub>	142.00	132.00	116.0 0	95.01	83.00	62.65	59.35	54.70	53.83	46.50	54.50	51.02	46.67	44.77	43.85
T <sub>2</sub>	112.22	107.56	100.9 3	94.36	88.40	64.11	62.05	58.11	57.29	50.30	51.00	49.39	48.08	46.83	44.22
T <sub>3</sub>	131.00	122.14	107.7 5	95.58	92.20	60.44	58.69	53.63	52.72	47.11	54.07	52.74	51.64	50.87	50.01
T <sub>4</sub>	155.22	150.56	140.8 4	135.0 4	130.2 1	62.34	62.15	58.51	57.71	54.67	62.53	59.82	58.33	57.82	56.74
T <sub>5</sub>	162.56	159.78	157.0 0	152.4 7	151.7 0	68.30	66.35	64.73	64.26	59.11	63.57	60.80	59.11	58.45	57.58
T <sub>6</sub>	146.00	139.67	132.8 6	129.9 2	126.6 0	63.23	61.22	57.98	55.22	52.75	57.87	56.32	55.44	53.21	52.66
T <sub>7</sub>	154.00	146.22	139.4 1	130.8 7	125.6 2	61.28	59.95	56.18	54.56	52.84	58.00	57.18	54.67	54.12	53.48
T <sub>8</sub>	142.44	131.33	120.6 9	110.2 0	104.7 0	58.61	54.87	51.24	50.56	47.25	57.13	55.88	52.44	49.97	48.12
T <sub>9</sub>	151.00	144.11	137.6 6	128.9 6	126.6 0	66.60	63.80	58.79	57.39	48.67	54.67	52.50	49.11	46.20	45.02
F Test	S	S	S	S	S	S	S	S	S	S	S	NS	S	S	S
SE (m)	2.57	2.51	5.95	1.32	3.48	1.6	1.77	1.8	1.37	1.84	1.66	2.38	1.76	1.8	1.57
CD at 5%	87.81	99.04	50.88	334.0 8	144.3 3	5.6	6.06	8.2	12.24	10.7 9	8.46	5.95	12.09	13.56	16.55

**Table 2 Effect of different packaging materials on Specific Gravity, Peel Weight and TSS..**

Treatment	Specific Gravity					Peel Weight (g)					TSS °Brix				
	0 DAP	6 DAP	12 DAP	18 DAP	24 DAP	0 DAP	6 DAP	12 DAP	18 DAP	24 DAP	0 DAP	6 DAP	12 DAP	18 DAP	24 DAP
T <sub>1</sub>	1.22	0.98	0.86	0.79	0.74	32.43	27.56	20.92	15.88	9.37	9.93	10.37	10.51	10.87	11.80
T <sub>2</sub>	1.17	1.07	0.88	0.82	0.77	28.56	26.11	17.27	13.40	10.79	9.67	9.76	10.25	10.48	10.68
T <sub>3</sub>	1.15	1.07	0.94	0.84	0.81	30.12	27.11	20.04	12.50	10.67	9.14	9.68	9.80	9.95	10.70
T <sub>4</sub>	1.31	1.23	1.04	0.92	0.84	42.04	38.33	34.57	30.58	28.87	9.55	9.98	10.03	10.33	10.65
T <sub>5</sub>	1.32	1.28	1.19	0.93	0.86	46.75	46.00	43.34	38.05	36.08	9.40	9.80	9.86	10.22	10.45
T <sub>6</sub>	1.20	1.11	0.99	0.88	0.81	41.40	38.11	34.08	26.16	23.57	9.33	9.99	10.10	10.64	10.85
T <sub>7</sub>	1.27	1.19	0.98	0.88	0.83	48.67	45.67	35.92	29.08	25.81	9.53	9.96	10.35	10.50	10.73
T <sub>8</sub>	1.35	1.18	1.03	0.89	0.78	35.04	33.33	25.81	20.56	18.61	9.67	9.91	9.99	10.60	10.90
T <sub>9</sub>	1.13	1.07	0.93	0.82	0.77	38.69	36.44	31.42	26.91	25.39	9.86	10.32	10.58	10.66	11.03
F Test	NS	S	S	S	S	S	S	S	S	S	S	NS	S	S	S
SE (m)	0.02	0.02	0.02	0.07	0.04	1.58	2.09	1.48	1.21	0.85	0.18	0.19	0.16	0.14	0.20
CD at 5%	0.05	0.11	0.59	0.29	0.18	32.37	27.25	51.32	61.95	105.14	1.26	0.22	1.18	0.73	0.76

**Table 3 Effect of different packaging materials on titrable acidity, pH and Ascorbic acid.**

Treatment	Titrable Acidity (%)					pH					Ascorbic Acid (mg/100g)				
	0 DAP	6 DAP	12 DAP	18 DAP	24 DAP	0 DAP	6 DAP	12 DAP	18 DAP	24 DAP	0 DAP	6 DAP	12 DAP	18 DAP	24 DAP
T <sub>1</sub>	1.02	0.93	0.89	0.84	0.74	4.14	4.16	4.32	4.39	4.48	24.56	22.69	19.38	16.60	14.43
T <sub>2</sub>	1.02	0.93	0.90	0.85	0.81	3.63	3.75	3.86	4.2	4.25	23.77	22.28	20.39	17.62	17.09
T <sub>3</sub>	1.02	0.92	0.86	0.83	0.78	3.69	3.85	3.88	4.07	4.19	23.64	22.81	18.71	18.36	15.56
T <sub>4</sub>	1.03	0.93	0.92	0.88	0.85	3.64	3.78	3.91	3.94	4.09	23.71	22.37	21.40	19.61	17.30
T <sub>5</sub>	1.03	0.98	0.94	0.92	0.89	3.52	3.57	3.64	3.97	4.02	24.42	23.13	21.47	19.81	17.89
T <sub>6</sub>	1.02	0.93	0.87	0.84	0.79	3.77	3.79	4.07	4.22	4.44	23.80	22.59	19.33	17.71	16.12
T <sub>7</sub>	1.03	0.91	0.86	0.83	0.80	3.78	3.88	3.95	4.13	4.19	24.28	23.63	19.67	15.87	14.51
T <sub>8</sub>	1.03	0.92	0.90	0.83	0.81	3.31	3.63	3.77	4.05	4.15	23.63	22.19	21.54	18.59	16.73
T <sub>9</sub>	1.02	0.89	0.85	0.82	0.79	3.43	3.76	3.83	3.94	4.18	23.8	23.00	20.11	18.78	16.91
F Test	NS	NS	S	S	S	NS	NS	S	S	S	NS	NS	S	S	S
SE (m)	0.01	0.04	0.03	0.01	0.01	0.15	0.11	0.17	0.1	0.05	0.29	0.36	0.34	0.53	0.06
CD at 5%	0.01	0.02	0.11	0.05	0.09	0.26	0.25	0.65	0.39	0.43	0.45	0.59	3.26	3.42	29.04

**Table 4 Effect of different packaging materials on Total Sugar, B:C Ratio**

Treatment	Total Sugar					B:C Ratio
	0 DAP	6 DAP	12 DAP	18 DAP	24 DAP	
T <sub>1</sub>	4.85	5.04	5.45	5.73	5.75	0.06
T <sub>2</sub>	4.81	5.16	5.36	5.68	6.14	0.36
T <sub>3</sub>	4.84	4.99	5.40	5.92	6.41	0.61
T <sub>4</sub>	5.25	5.48	5.75	6.23	6.47	1.81
T <sub>5</sub>	4.72	4.97	5.50	6.12	6.49	2.39
T <sub>6</sub>	4.80	5.09	5.46	5.90	6.37	1.04
T <sub>7</sub>	4.89	5.09	5.55	5.85	6.24	1.66
T <sub>8</sub>	4.71	4.85	5.35	5.78	5.90	1.09
T <sub>9</sub>	4.84	5.06	5.51	5.89	6.17	1.01
F Test	S	NS	S	S	S	
SE (m)	0.01	0.17	0.04	0.05	0.15	
CD at 5%	2.3	0.24	0.41	0.55	0.52	

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