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RESEARCH ARTICLE

QUALITY ASSURANCE AND SHELF LIFE EXTENSION OF KINNOW MANDARIN UNDER SUPERMARKET

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ABSTRACT

The present study entitles “Quality assurance and shelf life extension of Kinnow Mandarin under supermarket was conducted at department of Horticulture, College of Agriculture, Guru Kashi University, Talwandi Sabo during year 2022. Packaging treatment include T_1 (fruit packed in shrink film), T_2 (fruit packed in LDPE film), T_3 (fruit packed in HDPE film), T_4 (control or no packaging). . Experiment was carried out in complete block design with four replications. The Physio-chemical evaluation of the fruits of each treatment was done upto 25 days and all the observation were recorded at 5 days, 10 days, 15 days, 20 days and 45 days interval for all quality parameters. Results showed that packaging with Shrink film fruits registered minimum decline in the fruit length, fruit width, lowest loss in fruit size, peel percentage, rag percentage, seed weight, juice percentage, fruit firmness, TSS, acidity, vitamin C and organoleptic quality followed by LDPE and HDPE films. Whereas, controlled fruits recorded rapid decrease in fruit length, fruit width, lowest loss in fruit size, peel percentage, rag percentage, seed weight, juice percentage, fruit firmness, TSS, acidity, vitamin C and organoleptic quality of fruits.

INTRODUCTION

Kinnow is a hybrid of citrus cultivars "King" (*Citrus nobilis*) x "Willow Leaf" (*Citrus* x *deliciosa*) belongs to family rutaceae developed by H. B. Frost at the Citrus Research Centre of the University of California, Riverside, USA in 1915 and was released for cultivation in U.S.A in 1935. In India it was introduced in 1954 by J.C. Bakhshi at the Punjab Agricultural University, Regional Fruit Research Station, Abohar (Aulakh *et al.* 2008). This "easy peeler" citrus has special importance due to its attractive color (a major asset from marketing viewpoint), high juice content, special flavor and as a rich source of vitamin A and vitamin C.Fruits play an important role in human diet. Fruits have a very high nutritive value because they are rich in vitamins and highly nutritious in fresh as well as in processed form**.** Medicinal use of fruits like aonla, bael, citrus, ber, cranberry, wild fig, jamun, mango, banana, pomegranate, almond etc. have been mentioned in Charak Samhita and Sushruta Samhita. So they are termed as protective foods. It is generally stated that the standard of living of the people of a country can be judged by its production and consumption of fruits per capita. In Punjab during the year 2018-19 total area under fruits was 86673 ha. Out of which 53045 ha. Were under Kinnow alone. This accounts for about 61.20% area under total fruit crops. The total production of Kinnow in Punjab was 1246821 MT which is about 67.38% of total production of fruit crops with the yield of 23505 kg/ha (Anonymous, 2019).

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It is grown under hot climate and its plants can grow up to 35 ft high. Kinnow tree is highly productive and; it is not uncommon to find 1500 fruits per tree. It peels easily and has high juice content. Kinnow is commercially grown in the arid irrigated and sub-mountainous zone of Punjab *i.e.* Fazilka, Ferozepur, Faridkot, Muktsar, Bathinda, Mansa, Hoshiarpur, Ropar and Gurdaspur. It becomes exceedingly popular with the growers and consumers in North-India because of its superb fruit quality as compared to other citrus fruits.

MATERIALS AND METHODS

The experiment was conducted at department of Horticulture, College of Agriculture, Guru Kashi University, Talwandi Sabo during year 2022 with the objective of determining suitable treatment for better shelf life and quality of kinnow. Healthy kinnow fruits were collected for experiment purpose with uniform size, colour, firmness and maturity was selected. A set of 06 fruit of uniform size and maturity were selected replication wise for packaging in different materials. The kinnow fruit were harvested with the help of secateurs at the firm mature and full colour development stage from well managed orchard located in Abohar district in Punjab. The surface of kinnow were cleaned and packed. Unhealthy and diseased kinnow were separated and healthy kinnow and uniform sized sample were selected for the study. Thereafter, the packed fruits were stored under ambient conditions (18-20°C & 90-95% RH) in laboratory of department of Horticulture, Guru Kashi University ,Talwandi Sabo. The lab was properly ventilated and thoroughly cleaned.

All the packaging materials via; ; LDPE film, HDPE film , Shrink film used for experimental study. The perforated packaging materials used was prepared by making 9 pin holes in the packaging materials. The treatment include T_1 (fruit packed in shrink film), T_2 (fruit packed in LDPE film), T_3 (fruit packed in HDPE film), T_4 (control or no packaging). The Physio-chemical evaluation of the fruits of each treatment was done upto 25 days and all the observation were recorded at 5 days, 10 days, 15 days, 20 days and 45 days interval for all quality parameters. Randomly selected kinnow fruits of uniform maturity were selected. Weight of the fruits was measured on top pan balance individually and their average weight was calculated and expressed in gram. Fruit length from apex to the pedicel end was measured by vernier caliper and expressed in millimeter.

Physiological loss in weight (%)

This formula is used by physiological loss in weight

$$PLW = 5_1 - 5_2/100$$

Where, W1 = Original weight, W_2 = Estimated weight
The total soluble solids (TSS) was determined with the help of hand refractrometer of range 0-45 0Brix (QA Supplies, LLC). Titrable acidity was calculated by the method given by Ranganna, 1986

Titrable Acidity = Eq.wt.of acid X Normality of NaoH X Titer X 100/ Sample weight

RESULTS AND DISCUSSION

Loss in fruit size: Data depicted in Table-1 showed that the loss in fruit size of mandarin during storage significantly differed with the different packaging material. Packaging with Shrink film fruits registered the lowest loss in fruit size (5.80, 5.73, 5.67, 5.57 and 5.46 cm length and 6.05, 5.99, 5.87, 5.75 and 5.64 cm width at 5, 10, 15, 20 and 25 days after storage, respectively) followed by LDPE (5.65, 5.58, 5.53, 5.45 and 5.34 cm length and 5.89, 5.84, 5.72, 5.60 and 5.49 cm width at 5, 10, 15, 20 and 25 days after storage, respectively) and HDPE films (5.72, 5.66, 5.60, 5.50 and 5.39 cm length and 5.98, 5.92, 5.80, 5.69 and 5.57 cm width at 5, 10, 15, 20 and 25 days after storage, respectively). The control fruits, on the other hand, recorded the highest loss in fruit size (5.32 5.16, 5.11, 5.06 and 4.98 cm length and 5.58, 5.45, 5.36, 5.28 and 5.10 cm at width at 5, 10, 15, 20 and 25 days after storage, respectively). It can be noticed that storage period and packaging material had significantly impacted the fruit length and width, where the fruit length and width reduced gradually as the storage period increased. The decrease in fruit length and width with the increase in storage period might be due to increased moisture loss through respiration and transpiration, which affected the fruit shape and weight resulting in Shrinkage of fruits. The highest reduction of length and width was measured under control fruits, as the fruits were treated without wrapped under ambient conditions causing absence of barrier enabling to moisture loss, as compared to all other packaging. Whereas, in case of fruits stored under packed condition, the lowest reduction of fruit length and width might be due to modified atmosphere created inside packaging material, which might also act as physical barrier resulting in reduced respiration and transpiration. In addition, Shrinkage mainly occurs due to water loss by transpiration and loss of carbon reserves due to respiration. The results are in close agreement with the findings of Bhatnagar (2012), Singh *et al.* (2017) and Manisha and Gandhi *et al.* (2019) in kinnow fruits.

Physiological weight loss: It is evident from the experimental data in table 2 revealed that the physiological weight loss mandarin fruit during storage significantly differed with the different packaging material. Packaging with Shrink film fruits registered the lowest physiological weight loss (0.78, 0.81, 1.13, 1.73 and 2.05 per cent at 5, 10, 15, 20 and 25 days after storage, respectively) followed by LDPE (1.74, 2.68, 4.58, 6.32 and 7.32 per cent at 5, 10, 15, 20 and 25 days after storage, respectively) and HDPE films (2.66, 2.37, 3.97, 5.48 and 6.75 per cent at 5, 10, 15, 20 and 25 days after storage, respectively). The control fruits, on the other hand, recorded the highest PLW (4.08, 5.26, 8.29, 15.94 and 24.02 per cent at 5, 10, 15, 20 and 25 days after storage, respectively). The increased PLW % of fruits in all the treatments with Increasing period of storability was due to moisture loss by evapo-transpiration and loss of reserved food material by respiration. During respiration process, various reserved food materials present in fruits are used. In addition, the process of transpiration from fruit surface also continues even after harvest. Hence, due to the respiration and evapo-transpiration, the physiological loss in weight of fruits increased with increasing period of storage. The acceptable level of weight loss for Kinnow fruit is <5.5% above which the fruits show symptoms of shriveling and wilting and are liable to fetch lower prices in the market (Mahajan *et al.,* 2002). The data revealed that Kinnow fruits without wrapping can have less than 10 days shelf life, whereas fruits wrapped in heat shrink film recorded a significant reduction in weight loss even after 25 days of storage life. Although fruits packed in LDPE and HDPE film also recorded lower weight loss as compared to unpacked control fruits, these looked dull due to poor gloss characteristics of films, hence resulting in poor market acceptability. The highest weight loss in unpacked control fruit might be due to exposure of fruit surface to the open atmosphere resulting in a higher rate of transpiration and respiration thereby leading to a higher weight loss. Heat shrinkable films have been reported to reduce weight loss of pomegranate and papaya (Nanda *et al.,* 2001; Singh and Rao, 2005) during storage.

Peel percentage: Data presented in table 3 indicated that the decrease in peel percentage of total fruit weight of mandarin during storage significantly differed with the different packaging material. Packaging with Shrink film fruits registered the minimum decrease in peel percentage (31.40, 30.21, 30.05, 29.43 and 27.34 per cent at 5, 10, 15, 20 and 25 days after storage, respectively) and recorded higher peel weight followed by LDPE and HDPE films. On the other hand, the control fruits, recorded the highest loss in peel percentage (25.26, 24.20, 22.41, 22.41 and 20.69 at 5, 10, 15, 20 and 25 days after storage, respectively). The reducing trends in peel per cent of fruit at initial days of observation to last days of observation during the storage might be due to losses of moisture from the peel. Packagings with shrink films fruits showed less reduction in peel per cent during storage as compared to control fruits. This might be due to the fact that shrinks packaging acted as a barrier, which had checked the losses of the moisture from the fruit surface. These results are in close agreement with the findings of Sonkar et al. (2009), Miri et al.(2018), Rashid et al. (2019) and Haider et al. (2021)in kinnow fruit.

Table 1. Effect of packaging material on size (cm) mandarin fruit

Treatments	Days of storage									
	5		10		15		20		25	
	Length	Width	Length	Width	Length	Width	Length	Width	Length	Width
Shrink film	5.80	6.05	5.73	5.99	5.67	5.87	5.57	5.75	5.46	5.64
LDPE film	5.65	5.89	5.58	5.84	5.53	5.72	5.45	5.60	5.34	5.49
HDPE film	5.72	5.98	5.66	5.92	5.60	5.80	5.50	5.69	5.39	5.57
Control	5.32	5.58	5.16	5.45	5.11	5.36	5.06	5.28	4.98	5.10
SEm±	0.17	0.17	0.18	0.18	0.13	0.17	0.15	0.16	0.14	0.12
C.D. at 5 %	0.52	0.52	0.55	0.55	0.40	0.52	0.47	0.50	0.43	0.38

Table 2. Effect of packaging material on fruit weight loss of mandarin

Treatments	Days of storage				
	5	10	15	20	25
Shrink film	0.78	0.81	1.13	1.73	2.05
LDPE film	1.74	2.68	4.58	6.32	7.32
HDPE film	2.66	2.37	3.97	5.48	6.75
Control	4.08	5.26	8.29	15.94	24.02
SEm±	0.14	0.12	0.27	0.29	0.24
C.D. at 5 %	0.43	0.36	0.83	0.90	0.75

Table 3. Effect of packaging material on peel percentage mandarin fruit

Treatments	Days of storage				
	5	10	15	20	25
Shrink film	31.40	30.21	30.05	29.43	27.34
LDPE film	26.22	25.14	25.08	24.56	23.07
HDPE film	27.71	26.60	26.52	25.97	24.45
Control	25.26	24.20	22.41	22.41	20.69
SEm±	1.03	1.68	0.84	1.15	0.88
C.D. at 5 %	3.18	5.18	2.58	3.55	2.71

Table 4. Effect of packaging material on acidity (%) of mandarin fruit

Treatments	Days of storage				
	5	10	15	20	25
Shrink film	0.53	0.50	0.48	0.42	0.38
LDPE film	0.58	0.55	0.52	0.50	0.44
HDPE film	0.55	0.52	0.50	0.48	0.47
Control	0.63	0.60	0.56	0.51	0.50
SEm±	0.01	0.01	0.01	0.01	0.01
C.D. at 5 %	0.04	0.04	0.03	0.02	0.02

Table 5. Effect of packaging material on organoleptic quality mandarin fruit

Treatments	Days of storage				
	5	10	15	20	25
Shrink film	7.72	7.87	8.13	8.51	7.76
LDPE film	7.27	7.40	7.47	6.52	5.45
HDPE film	7.47	7.67	7.59	6.66	6.16
Control	7.07	6.85	6.47	5.20	4.82
SEm±	0.14	0.11	0.15	0.15	0.22
C.D. at 5 %	0.44	0.36	0.48	0.49	0.71

Table 4.10 Effect of packaging material on TSS (%) mandarin fruit

Treatments	Days of storage				
	5	10	15	20	25
Shrink film	9.62	10.59	11.25	12.47	11.84
LDPE film	9.17	10.14	10.46	11.59	11.01
HDPE film	9.37	10.31	10.65	11.80	11.21
Control	10.07	11.11	10.73	10.89	9.79
SEm±	0.14	0.16	0.21	0.19	0.24
C.D. at 5 %	0.44	0.50	0.66	0.62	0.78

Acidity per cent: Appraisal of data in table 4 revealed that the acidity per cent of mandarin during storage significantly differed with the different packaging material. The acidity of Kinnow fruit showed a linear declining trend with advancement of storage period. The minimum acidity (0.53, 0.50, 0.48, 0.42 and 0.38 per cent acidity at 5, 10, 15, 20 and 25 days after storage, respectively) was recorded in the fruit wrapped in shrink films and the maximum acidity (0.63, 0.60, 0.56, 0.51 and 0.50 per cent acidity at 5, 10, 15, 20 and 25 days after storage, respectively) was recorded in control fruits. 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 (Echeverria and Valich, 1989). The packaging films helped in better retention of acidity as compared to control. In wrapped fruits, the lowering of acidity was delayed, which might be due to the effect of packaging films in delaying the respiratory and ripening process. Nanda *et al.* (2001) observed higher acidity content in shrink-wrapped pomegranate and kiwi fruits. The present results are in close agreements with the findings of Sharma *et al.* (2012) in kiwi fruit and Mahajan and Singh (2016), Miri e*t al.* (2018), Sharma et al. (2018), Joshi (2020), and Barsha *et al.* (2021) in kinnow mandarin.

Organoleptic quality: Appraisal of data in table 5 revealed that the organoleptic quality of mandarin during storage significantly differed with the different packaging material. The film packed Kinnow fruits showed a gradual and steady increase in the organoleptic quality attributes up to 20 days, after which a gradual decline was observed; whereas in control fruits, the sensory score increased up to 5 days of storage and thereafter declined at a faster pace. The highest organoleptic rating (7.72, 7.87, 8.13, 8.51, 7.76 at 5, 10, 15, 20 and 25 days after storage, respectively) was recorded in shrink-film-wrapped fruits. The control fruits displayed the lowest value in sensory rating (7.07, 6.85, 6.47, 5.20 and 4.82 at 5, 10, 15, 20 and 25 days after storage, respectively). The recording of higher sensory score in shrink-wrapped fruit might be due to the ability of heat-shrinkable film to retain the desirable gaseous atmosphere inside the package, which is responsible for maintaining the texture and flavor of the fruit (Nanda *et al.,* 2001). Wrapping of banana and kiwi fruits in heat-shrinkable film have been reported to maintain an acceptable appearance, flavor, and overall eating quality (Kudachikar *et al.,* 2007; Sharma *et al.,* 2012).

Total soluble solids: Data in table 4.10 and fig 4.11 revealed that the total soluble solids of mandarin during storage significantly differed with the different packaging material. The shrink-wrapped Kinnow fruits maintained TSS (9.62, 10.59, 11.25, 12.47 and 11.84 per cent at 5, 10, 15, 20 and 25 days after storage, respectively). Further data showed that the shrink-wrapped Kinnow fruits maintained TSS (9.62 %) after 5 days of storage, which reached to peak value of 12.47% after 20 days of storage, then declined. The control fruit registered TSS (10.07%) after 5 days of storage, which reached to peak value at 10 days of storage (11.11%) and then declined faster afterward. The increment of total soluble solids with the extended duration of storage period could be due to the deterioration of complex insoluble compounds, like starch to simple soluble compounds like sugars, which act as the main components of total soluble solids. The increase in TSS of fruits during storage may possibly be due to a breakdown of complex organic metabolites into simple molecules (Wills *et al.,* 1980). The delayed increase in TSS over a longer period of time in film-wrapped Kinnow fruits might be attributed to delayed ripening and senescence processes. The present results confirmed the findings of Sharma *et al.* (2012) and Mahajan *et al.* (2013) who have reported a delayed and sustained increase in the total soluble solids and sugars in shrink-film-packed kiwi and pear fruits.

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