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ISSN: 0974-4908
Res. Environ. Life Sci.
9(9) 1072-1075 (2016)

Effect of different packaging materials on the storage life and quality of kinnow

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(Received: October 16, 2015; Revised received: June 21, 2016; Accepted: June 24, 2016)

Abstract: The Effect of different packaging materials on the storage life and quality of Kinnow were investigated. Fruits of Kinnow were harvested at physiological maturity and divided into requisite lots for further handling. First lot of fruit was packed in packaging films *viz*. LDPE film, LDPE film with 0.01% perforation, LDPE film with 0.02% perforation, HDPE film, HDPE film with 0.01% perforation, HDPE film with 0.02% perforation, PP film, PP film with 0.01% perforation, PP film with 0.01% perforation. The control fruits were kept unpacked. The fruits were stored under cold condtion (4-6°C and 90-95% RH). The observations on various physico-chemical quality attributes of fruits were recorded at different storage intervals. The data revealed that under cold conditions, Kinnow fruits were packed in PP, HDPE and LDPE film can be stored for 20, 40 and 60 days as compared to control fruits which maintained storage life of 10 days. The use of PP, LDPE and HDPE seems to hold promise in extending the marketability of Kinnow fruits stored under cold conditions at 4-6°C.

Key words: Kinnow, Packaging material, Storage, Temperature, Quality

Introduction

The economic value of trade in fresh produce is constantly growing, due to increasing consumer demand. Consumers care more and more about what they eat and fresh produce has been recognised as a healthy food, for example being rich in antioxidants (Llorach *et al.*, 2008; Alothman *et al.*, 2010; Yeoh *et al.,* 2014). The shelf-life of fresh produce, however, is shorter than other food products, and is determined by initial quality at harvest (Clarkson *et al.*, 2003; Zhang *et al.*, 2007) and subsequent storage conditions (Nunes *et al.*, 2009). New techniques for reducing undesired microbial contamination, spoilage and decay, as well as maintaining the product's visual, textural and nutritional quality are required at all steps of the production and distribution chain. Citrus is a sub-tropical fruit and belongs to family Rutaceae. It is one of the most famous fruit grown all over the world. It is prolific and precocious bearer with higher juice content. The shelf life of Kinnow fruit would help the growers to market it profitably for longer periods and up to the early summer months. Citrus fruits are non-climacteric and have low respiration rate. Thus, they are quite amenable to storage for long term. Internationally, several postharvest technologies have been introduced to control fruit disorders, maintain optimum quality, freshness and minimize the losses (Krochta, 1997; Hagenmaier, 2002; Bajwa and Anjum, 2007). The most common technologies used commercially are low temperature storage, polyethylene packaging, chlorination and emulsion applications as wax coatings (Perez *et al.*, 2002, Thakur *et al.*, 2002). The modified atmospheric conditions within the film packages can significantly reduce the rate of ripening and senescence primarily by reducing the synthesis and perception of ethylene (Burg and Burg, 1967; Abeles et al., 1992). The fruit keeps its firmness, appearance, luster and quality for longer period in HDPE packaging. Dhatt *et al* (1991) reported that Kinnow fruit has its shelf-life for 8 weeks when wrapped individually in high density polyethylene (HDPE) and stored at room temperature and helps in retaining its firmness and freshness without losing juice recovery. Keeping in view, scope for post harvest packaging the present studies were planned to extend the post harvest life of Kinnow by using different packaging materials (LDPE, HDPE and Polypropylene) with and without perforation and storage at 4-6°C with 90-95% RH.

Materials and Methods

Preparation of fruit samples : Kinnow fruits of uniform size, disease and bruise free were picked randomly from all the four directions of the plants with the help of secateurs at physiological mature stage. The fruits were sorted and graded, washed with chlorine solution (100 ppm). Thereafter fruits were divided into requisite lot for further handling. Packaging films: Three different types of packaging films were tried for packaging of kinnow fruits in corrugated tray having six cells (Clarilgemoulded fiber Ltd, Solan). These films were of (polypropylene, Low Density Polyethylene and High Density Polyethylene) 30µ gauge and were brought from local market. Perforation of films: In the present studies, 2 different perforations of 0.01% and 0.02% were done. The three different packaging films; LDPE with 0.01 and 0.02% perforation, HDPE with 0.01 and 0.02% perforation and PP with 0.01 and 0.02% perforation. There were ten treatments in an experiment with 3 replications in each were stored at cold condition 4-6° C and RH 90-95 percent. All the experiments were planned as factorial CRD (Completely Randomised Design) with three replications each. The fruits were analyzed after 20, 40 and 60 days at cold conditions for different physico-chemical constituents.

Method of packaging: Fruits were tray packed in different packaging films. The fruits packed in LDPE, HDPE and PP films were simply sealed with heat sealer and control in CFB boxes.

Observations recorded: Physiological loss in weight (PLW): All fruit were labelled and weighed on arrival (day 0). PLW (%) was determined by comparing the weight of each fruit on the sampling day with their initial weight determined on day 0. Rotting percentage: Per cent fruit rot was calculated by counting the total number of fruits that had rotten at each storage interval. Juice percentage: The fruit juice was extracted with the help of screw type extractor (Kalsi) and was strained through mesh (32 mm) and weighed. The percentage of

juice was calculated on fresh weight basis. Juice percentage is equal to the juice weight divided by weight of fruit multiple by 100. Total soluble solids (%): Total soluble solids (TSS) were determined from the juice at room temperature with the help of hand refractometer (Model Erma, Japan) and expressed in percent. These readings were corrected with the help of temperature correction chart at 20°C temperature (AOAC, 1990). Vitamin C (mg/100ml of juice): Ascorbic acid content of the juice was estimated using the detective dye 2,6 dichlorophenol indophenols (DCPIP) visual titration method (Ranganna, 1994). Sugars: The sugar content of the fruit was estimated according the method described by A.O.A.C. (1990). A sample of 10 ml fruit juice was neutralized with dilute NaOH and diluted with distilled water. Extraneous material was precipitated with the help of lead acetate. Excess of lead acetate was removed with potassium oxalate. Thereafter, solution was filtered and volume was made 100 ml with distilled water. This filtrate (aliquot) was kept for the estimation of total and reducing sugars. Total sugars: Total sugars were estimated by taking 25 ml of above aliquot in 100 ml volumetric flask. To this solution 5 ml 60 per cent HCl and 25 ml distilled water was added. It was allowed to stand overnight for hydrolysis. The excess HCl was neutralized with saturated NaOH solution and volume was made 100 ml with distilled water. Total sugars were then estimated by titrating the hydrolyzed aliquat against the boiling mixture containing 5 ml of each of Fehling's solution A and B against hydrolyzed aliquot, using methylene blue as an indicator. The adding of titre was stopped on the appearance of brick red colour. The values were expressed in per cent on fresh juice basis (AOAC 1990).

Statistical design : The data are analyzed statistically according to completely randomized design (Panse and Sukhatame, 1976).

Results and Discussion

Physiological loss in weight (PLW): Polyethylene packaging was found to be effective in reducing the PLW, with the fruits remaining marketable up to 18 days of storage Kumar et al (2005). Minimum reduction in PLW of Kinnow packed in non-perforated packaging was probably due to saturated humidity and no air circulated inside (Jawanda et al 2012). Various packaging treatments showed a significant influenced in PLW. It is evident from the data that packaged Kinnow showed steady increase in the PLW with passage of time as compared to control (faster rise in PLW was noticed with advancement of storage periods). On D1, D2 and D3 the mean loss in weight was 0.74, 1.09 and 1.98%, respectively. The maximum mean PLW (8.01%) was recorded in unpacked fruits (control). The minimum mean PLW (0.42%) was observed in fruits packed in PP without perforation followed by LDPE and HDPE without perforation (0.43%) each. The interaction between treatments and storage interval was found to be significant. In case of Kinnow fruit acceptable level of weight loss is <5.5% (Mahajan, 2002) above which the fruits show symptoms of shriveling and wilting and are liable to fetch lower prices in the market. The fruits in control recorded 7.10 % loss in weight after 40 days of storage and which increased to 12.21 % after 60 days of storage under cold conditions, Kinnow fruits without packaging films have less than 40 days of storage life in comparison to packed Kinnow fruits. The packed fruit in LDPE, HDPE and PP films with and without perforation can retain fruit weight up to 60 days of storage in cold conditions for the market acceptability. The weight loss found in LDPE, HDPE and PP films without perforation were (0.43%), (0.43%) and (0.42%) respectively and loss in weight with same films with 0.01 % and 0.02 % perforation were (0.51%), (0.56%), (0.52%) and (0.61%), (0.67%), (0.53%), respectively.

Rotting percentage: Kinnow fruits were tray packed in different packaging films showed significantly lower spoilage as compared to those in control. The trend showed that with the advancement of storage intervals the rate of spoilage increased. There was no spoilage of fruits in all the treatments (LDPE, HDPE and PP with and without perforation) and control up to 20 days of storage. On the D2 there was no rotting found in the film packed fruits but the spoilage starts in control (16.66%) rotting was observed. Maximum spoilage was found in control (22.22%) followed by HDPE and PP tray packaging without perforation (16.66%) and minimum spoilage was recorded in the film packaging with 0.01 % perforation (5.55%). Kinnow fruits packed in LDPE, HDPE and PP film recorded average spoilage of 3.00, 3.93 and 3.35%, respectively. The interaction between treatments and storage intervals was found to be significant. Kinnow mandarin washed in chlorine solution (100 ppm) followed by individually seal packaged in HDPE bags (20 µm) showed minimum spoilage after 60 days of storage. In present studies, among packaging films, the spoilage was observed to be higher in fruits packed in films without perforation as compared to fruits packed in films with perforation. This might be due to condensation of moisture in the surface of fruits, anerobic conditions and break down of enzymes etc. during storage, which encouraged the multiplication of micro flora. Likewise, Sharma et al (1994), Yameshita and Benassi (2000) observed higher spoilage in guava fruits packed in polythene films without ventilation. Nath et al (2011) in pear recorded minimum spoilage in fruits packed in film with perforation.

Juice percentage: It seems that minimum percentage of O2 is necessary for the respiration activity because proper aeration may remove the small amount of alcohol and ethylene produced during anaerobic respiration, thereby retarding decrease in juice percentage. However, Eaks and Masias (1965) and Cohen et al (1990) reported that the increase in juice content occur in lime and lemon, respectively during at ambient temperature but not in other citrus fruit. There was linear decline in juice percentage with the increase in storage period of Kinnow fruit packed in different films. The juice percentage on the day of harvesting after washing the fruits with chlorine is 52.89%. Juice percentage after D1, D2 and D3 intervals are 44.31, 40.12, 34.66 % respectively. perforation (48.23%) followed by PP tray packaging with 0.01 % perforation (46.43%) and minimum juice percentage was found in control (39.22%).On D2 of storage, maximum juice percentage was retain by the LDPE packaging with 0.01 % perforation (47.32%) followed by the PP tray packaging with 0.01 % perforation (44.19%) and the higher loss of juice percentage was recorded in PP with 0.02 % perforation. On D3 of storage, higher juice percentage was found in LDPE tray packaging with 0.01% perforation (42.61%) and lower was recorded in control (30.22%). The interaction between treatment and storage was found to be significant.

Total soluble solid: The trend showed that with the advancement of storage intervals up to 60 days of storage at cold conditions the TSS value of Kinnow fruits increased. The average TSS recorded on three different time intervals D1, D2 and D3 was 9.78, 9.96 and 10.12 respectively. The interaction between treatments and storage intervals were found to be significant. On D1 days of storage, maximum TSS was observed in LDPE tray packaging with 0.02 % perforation

Table-1: Effect of different packaging films on the Physiological Loss in Weight (%), Rotting (%), Juice (%), TSS (^{0}B) and Acidity (%) of tray packed Kinnow fruits stored under cold conditions (4-6°C and 90-95% RH)

Treatments	Rotten %			Juice %			TSS (^{0}B)			Acidity %		
	D_{20}	D_{40}	D_{60}	D_{20}	D_{40}	D_{60}	D_{20}	D_{40}	D_{60}	D_{20}	D_{40}	D_{60}
LDPE tray packaging	0.00	5.55	11.11	42.97	41.57	32.37	8.88	10.23	10.20	0.75	0.70	0.61
LDPE tray packaging with perforation 0.01 %	0.00	0.00	5.55	48.23	47.32	42.61	9.96	10.13	10.73	0.69	0.73	0.51
LDPE tray packaging with perforation 0.02 %	0.00	0.00	11.11	44.91	39.39	36.51	10.27	10.42	10.87	0.72	0.64	0.50
HDPE tray packaging	0.00	11.11	16.66	42.52	39.02	38.56	8.98	9.60	9.57	0.75	0.69	0.56
HDPE tray packaging with perforation 0.01 %	0.00	0.00	5.55	46.29	42.22	33.97	9.71	9.93	10.07	0.69	0.61	0.67
HDPE tray packaging with perforation 0.02 %	0.00	0.00	11.11	44.77	38.29	33.33	9.50	9.86	10.97	0.67	0.70	0.54
PP tray packaging	0.00	5.55	16.66	42.97	36.14	32.24	9.50	9.96	9.67	0.77	0.89	0.76
PP tray packaging with perforation 0.01 %	0.00	0.00	5.55	46.43	44.19	34.06	9.27	9.80	10.10	0.77	0.73	0.64
PP tray packaging with perforation 0.02 %	0.00	0.00	11.11	44.81	35.45	32.71	9.59	9.66	10.00	0.63	0.59	0.66
Control	0.00	16.66	22.22	39.22	37.63	30.22	10.17	10.33	10.43	0.65	0.73	0.53
Mean	**0.00**	**4.03**	**11.66**	**44.31**	**40.12**	**34.66**	**9.58**	**9.99**	**10.26**	**0.71**	**0.70**	**0.60**
CD (p=0.05) for: Storage interval (A) =		0.0028			1.445			0.135			0.0209	
Treatment (B) =		0.0045			1.809			0.214			0.0330	
Interaction (A×B) =		0.0090			3.623			0.428			0.0661	

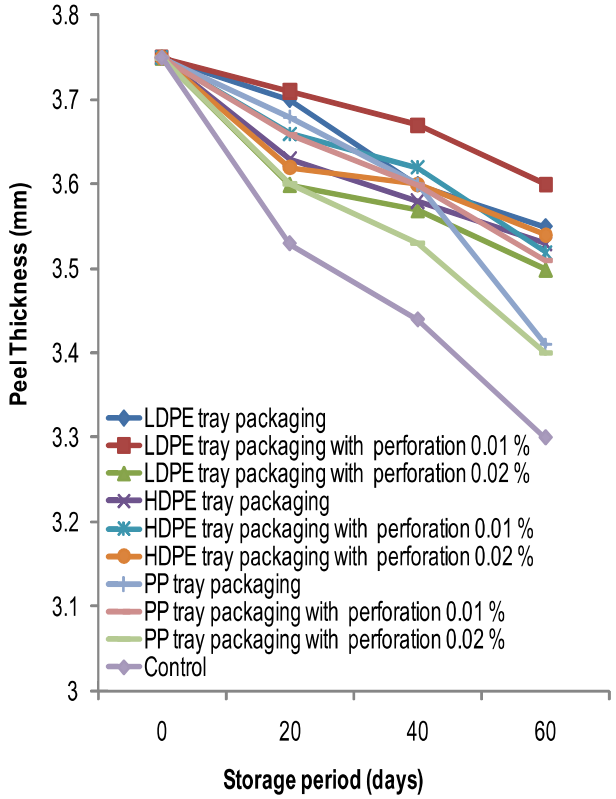

Fig. 1: Effect of different packaging films on the Peel Percentage (%) of tray packed Kinnow fruits stored under cold conditions (4-6°C and 90-95%RH)

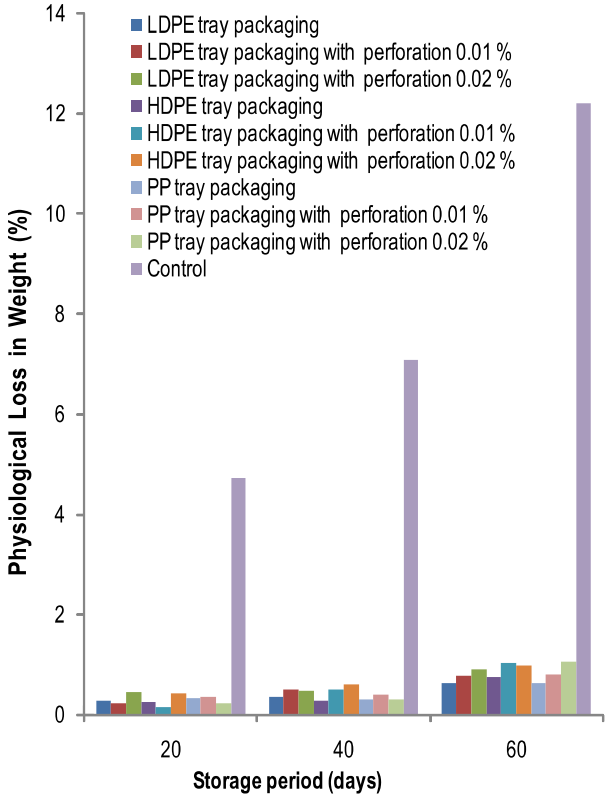

Fig. 2: Effect of different packaging films on Physiological Loss in Weight (%) of tray packed Kinnow fruits under cold conditions (4-6°C and 90-95%RH)

(10.27) followed by control (10.17) and minimum was observed in LDPE without perforation (8.88). On D2 of storage, maximum TSS of (10.42) was observed in LDPE tray packaging with 0.02 % perforation followed by control (10.33) and minimum TSS was obtained in HDPE without perforation (9.60). On D3 the maximum TSS was observed in LDPE tray packaging with 0.02 % perforation (10.87) followed by the control treatment (10.43) and minimum TSS was recorded in HDPE tray packaging without perforation (9.57).

Acidity: The mean acidity value after three different intervals 20, 40 and 60 days of storage are 0.71, 0.70 and 0.60%, respectively there was rapid decrease in acidity with increase in storage time. On 20 days of storage, maximum acidity was observed in PP tray packaging without perforation and same was recorded in PP tray packaging with 0.01% perforation (0.77%) and minimum was obtained in LDPE and HDPE tray packaging with 0.01% perforation (0.69%). On 40 days of storage, maximum acidity was observed in PP tray packaging without perforation (0.89%) followed by PP tray packaging with 0.02% perforation (0.59%) and On 60 days of storage, maximum acidity was obtained again in PP tray packaging without perforation (0.76%) and minimum was observed in control (0.53%). The mean acidity

after all storage intervals was recorded maximum in PP tray packaging without perforation (0.84%) and minimum acidity was observed in PP tray packaging with 0.02% perforation (0.70%). The interaction between storage intervals and treatments were found to be significant. Kinnow fruits individually seal packed in high density polyethylene film and tightly sealed with manual electric sealer showed maximum acidity percentage after 4 weeks of storage but it decreased considerably between 8-12 weeks of storage interval Dhatt *et al* (1991) and the progressive reduction in the acidity with advancement of storage periods may be attributed to utilization of organic acid in pyruvate decarboxylation reaction occurring during the ripening process of fruits (Pool *et al* 1972). Sandhu and Singh (2000) evaluated that 'LeConte' pear fruits packed in HDPE and LDPE bags of different thicknesses and observed delay in decrease in acidity content as compared to non-packed fruits. The decrease in acidity with the storage period might be due to utilization of organic acids in the respiration process. A gradually decrease in acidity has been reported by Josan*et al* (1983) and Aswah *et al* (1975) as compare to control. Kinnow stored at ambient conditions found higher loss may be due to its metabolism rate is higher at this temperature as compare to cold conditions (Bratley 1939).

The physiological loss in weight of Kinnow fruits increased with an advancement of storage intervals irrespective of different treatments. However, tray packed Kinnow in LDPE, HDPE and PP without perforation had lower average PLW (0.43, 0.43 and 0.42 %) under cold storage conditions as compared to control (8.01 %). The peel thickness of packed Kinnow fruit with different films decreased with an increase of storage period. The tray packaging in different films LDPE, HDPE and PP with 0.01 % perforation has better maintained peel thickness (3.68, 3.64 and 3.63 mm), respectively as compared to control (3.51 mm). Rotting percentage of Kinnow increased after each storage interval. The fruits packed with LDPE, HDPE and PP with 0.01% perforation in tray had lower spoilage (1.39 % each) while, the highest mean spoilage (9.72 %) was recorded in control fruits. The tray packed fruits with 0.01 % perforation had retained better juice percentage (47.76, 43.84 and 44.39 %) in comparison to control (39.99 %). Organoleptic rating of Kinnow was observed to be maximum on 20--th day of storage and it decreased continuously thereafter. The fruit was packed with different packaging films LDPE, HDPE and PP with and without perforation. Perforated film packaging had better organoleptic rating (8.20, 8.05 and 7.89) as compare to non-perforated (7.91, 7.93 and 7.77) as per 1-9 Scale. Total Soluble Solid of Kinnow increased with an advancement of storage interval. The tray packed in LDPE, HDPE and PP with 0.02 % perforation had higher TSS value (10.10, 9.80 and 9.53 0B) as compared to the films without perforation (9.54, 9.25 and 9.51 0B).

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