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Effect of surface coatings on postharvest quality of Kinnow mandarin

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ABSTRACT

The study was conducted to observe the effect of surface coatings such as lac based wax, Citrashine®, P-104® and Niprofresh™ on Kinnow mandarin with the objective to extend its shelf-life. For this, Kinnow fruit were treated with different surface coatings and stored at 5º ± 1ºC temperature and 85-90% RH. Our results indicated that all surface coatings maintained a very good profile of quality parameters, but the surface coating of lac based wax was the best followed by Citrashine®, P-104® and Niprofresh™. All surface coatings influenced all the studied attributes significantly but lac based wax was the most effective in maintaining lowest physiological loss in weight (9.7%), fruit firmness (6.5 N), respiration rate (1.3 ml CO_2 kg^{-1} h^{-1}), and ethylene evolution rate (1.5 µl kg^{-1} h^{-1}). Similarly, all the surface coatings used could retain quality attributes (souble solids content, titratable acidity and ascorbic acid content) of the fruits without any adverse effect. Results suggested that surface coatings have potential to enhance shelf-life of Kinnow mandarin as its fruits could be successfully stored for 60 days under cold storage conditions with highly acceptable sensory quality. The non-coated fruits, on the other hand, maintained postharvest shelf-life of 45 days in cold storage. The surface coatings of indigenous origin (lac-based wax & P-104) can also recommended owning to their cheaper cost and reasonable effect on storage life.

Key words: Kinnow mandarin, surface coatings, respiration rate, ethylene evolution rate, storage life.

INTRODUCTION

During 1935, Kinnow mandarin (*Citrus nobilis* × *C. deliciosa*) was developed by H.B. Frost at California, USA. This mandarin was not very successful in the USA but it revolutionized citrus industry in India, Pakistan and Bangladesh (Sharma and Saxena, 12). Presently, it now occupies major share in area and production of citrus grown in India. It has become a major table citrus fruit in India because of attractive orange colour, high juice content and better quality than other citrus fruits. Kinnow is becoming popular all over the country due to its high juice and rich vitamin C content. However, the major problem with Kinnow mandarin is its availability only for a limited period, and during peak production season, there is a glut of fruits in the market. As a result, farmers get very poor price of their valuable produce. To extend its availability, producers store it in cold stores for some period, but postharvest losses are enormous in 'Kinnow' mandarin, ranging from 25 to 35%. Kinnow fruits when they are harvested have dirt, dust, mould, spray residues and sooty blotch. These are usually washed off using detergents or brushes, washing remove the natural waxes and increased rind permeability (Kaplan, 5). Kinnow fruits can be stored at low temperature (5 ± 1°C, RH: 80-90%) for comparatively longer periods (Singh *et al*., 15) but such a facility is limited in our country. Wax coating is a easier and cheaper technique for extending the shelf life of fruits and vegetables. Application of a physical barrier, such as a wax coating, slows down the permeability of water vapour and other gases (Mahajan *et al*., 7), retards ripening and also checks the microbial infection. Role of peel coating for extending the shelf-life of the fruits has been reported by several workers (Giri *et al*., 3) in various fruits.

The coating also increases the mechanical strength to peel and improves gloss, *i.e*. cosmetic appearance. Commercial waxes, containing food grade shellac, are normally used to coat a diverse range of fruits like mandarins. Similarly, lac-based formulations increase the gloss and mechanical strength of the coated produce, besides retarding early ripening and prevention of pathogenic attacks (Singh *et al*., 15). Shellac is used as an ingredient in edible fruit coatings to limit water loss, desiccation and weight loss and to prevent entry of pathogen. Shellac waxes are also added to provide high gloss finishes to fruit for cosmetic purposes and also as bioagent (Kaplan, 5). Since such studies are lacking in India, hence we studied the effect of wax coatings for extending shelf-life of Kinnow under cold storage.

MATERIALS AND METHODS

This study was conducted in the Division of Post Harvest Technology, IARI, New Delhi during 2010-12

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in the fruiting season (December-February) of Kinnow mandarin. Four different surface coatings were used such as lac based wax, Citrashine®, P-104® and Niprofresh™. The mature and fresh Kinnow fruits were procured from a experimental orchard, sorted and graded before giving any treatment in the laboratory. The fruits were thoroughly washed with running tap water. They were air-dried and wax-coated. Subsequently, the fruits were dipped for 30 sec in the emulsion of 20% of 4 different waxes [TIC, MIDC, Thane, Navi Mumbai). After coating, the fruits were air-dried and then packed in CFB box (5 ply) having 0.5% ventilation and kept in cold store condition (5 ± 1°C and 80-90% RH). Thirty fruits were packed in each box in three replications. The observations on the fruit weight loss and physico-chemical characters were recorded at 15-day intervals. Fruit firmness was determined using a texture analyser (Model TA+Di; Stable Microsystems, Godalming, UK). Each fruit sample (n = 5) was compressed using a cutting probe as well as a puncture probe at a pre-test speed of 5 mms^{-1}, a test speed of 0.5 mms^{-1}, and a post-test speed of 10 mms^{-1}, and expressed in Newton (N). Total soluble solids content was determined by a hand refractometer (0-32°Brix). Titrable acidity was determined by direct titration with 0.1 N NaOH and ascorbic acid content were determined as per standard procedure (Ranganna, 11).

Ethylene production and respiration rates were measured using the static headspace technique (Jhalegar *et al*., 4; Sharma *et al*., 13). Two fruits from each replication were selected at random and enclosed in a hermetically sealed container (1,000 ml), fitted with a silicon rubber septum, for 1 h or less. The concentrations of O_2 and CO_2 were recorded in the headspace of the container using auto gas analyzer (Model: Checkmate 9900 O_2/ CO_2, PBI Dan sensor, Denmark) and expressed as ml CO_2/kg/h. To determine ethylene, 1 ml of the head space atmosphere of the container was withdrawn with a gas-tight syringe and injected into a gas chromatograph (Model HP 5890, Hewlett Packard, USA) which was calibrated using standard ethylene gas (Laser Gases, New Delhi). The gas chromatograph was equipped with Porapak-N (80-100 mesh) column and a flame ionization detector (FID). Nitrogen was used as the carrier gas at a flow rate of 30 ml/min, while hydrogen and air were fuel gases had flow rates of 25 and 250 ml min^{-1}, respectively. The temperatures in injector, column and detector were maintained at 110, 60 and 275°C, respectively and the rate of ethylene evolution was expressed as µl kg^{-1} h^{-1}. Physiological loss in weight (WL) was measured by subtracting the initial fruit weight from the final weight and was expressed as a percentage. It was determined in 20 fruits per treatment at each storage interval.

The experiments were laid out in factorial CRD design with each treatment consisting of 30 fruits having 3 replications. The data obtained from the experiments were analysed as per design and the results were compared from ANOVA (Panse and Sukhatme, 11).

RESULTS AND DISCUSSION

Physiological loss in weight is one of the basic areas, wherein postharvest physiologist is interested in or targeting to contain or maintain, it being such an important parameter to be emphasised on, which directly is linked to the shelf-life of any produce. Our studies revealed a steady increase in physiological loss in weight (PLW) with the increase in storage period from 15-day to 60th day (Fig. 1a). However, our observations are in accordance with the studies of Ladaniya (6) and Singh *et al.* (15), who reported progressive loss in weight in different fruits following storage. Similarly, the surface coated Kinnow fruits showed lesser loss in weight in comparison to untreated fruits, which indicates that surface coated fruits, can be stored for a longer time than untreated fruits. The fruits which were treated with lac based wax showed significantly lesser weight loss than those coated with Citrashine, P-104 or Niprofresh (Fig. 1a). The positive effects of surface coatings on decreasing the weight loss could be attributed to lesser respiration rate and ethylene production rate, which might have inhibited the water loss from fruits. Water loss prevention is not only beneficial to consumers, but also to growers and retail stores due to the fact most citrus is sold on a weight basis. Waxes also provide a modified atmosphere within the fruit, which decreases respiration and delays ripening (Bayindirli *et al*., 1). The mechanism for these positive effects is based on their hygroscopic properties, which enable formation of a barrier to water diffusion between fruit and environment, thus avoiding its external transference (Morillon *et al.*, 8).

Fruit softening is attributed to the degradation of cell wall components, mainly pectin, due to action of specific enzymes such as polygalacturonase. Our results showed that the surface coatings excelled in retention of firmness as surface coatings are known to retain the firmness of many fruits due to its activity against cell wall degrading enzymes such as polygalacturonase, pectinmethylesterase and β-galactosidase. Irrespective of storage period, surface coated fruits had better firmness than untreated ones. Among different treatments, fruits treated with lac based wax had the best firmness significantly followed by Citrashine, P-104 and Niprofresh treated fruits (Fig. 1b). Similarly, fruit firmness decreased with

the increase in storage period from 15 to 60th day of storage (Fig. 1b). The retention of fruit firmness may be because the coatings slowed down metabolism and caused breakdown of insoluble protopectins into soluble pectin thus prolonging the shelf life. The waxes improved the appearance of fruit by providing an enhanced shine on the outer surface, overall appearance and quality of the fruit to the consumer by reducing water loss and preventing shrinkage (Petracek *et al*., 10).

Ethylene evolution is major deterent for postharvest life of any fruit. In Kinnow mandarin, irrespective of storage period, the fruits treated with the different surface coatings showed lesser ethylene evolution than the untreated fruits with best being the lac based wax coated fruits which evolved lesser ethylene (Fig. 2a). Hence, higher production rate of ethylene by untreated Kinnow fruits might be due to higher respiration metabolism rates (Jhalegar *et al*., 4; Sharma *et al*., 13). Application of wax coating slows down the permeability of water vapour and other gases, which retards the ripening and also checks the microbial infection. Role of peel coating for extending the shelf life of the fruits has been reported by several workers (Giri *et al*., 3) in various fruits. Interestingly, ethylene production rate was quite steady from 15th day onwards but surface coatings (lac based wax, Citrashine®, P-104® and Niprofresh™) treated fruits showed very meagre evolution up till 30th day of storage (Fig. 2a). Similarly, ethylene production rate increased with progressive increase in storage period from 15th to 60th day. The effect of coatings on ethylene evolution in Kinnow fruits might be attributed to the delaying of the metabolic and respiratory activities of fruit. These results are in agreement with the findings of Sidhu *et al*. (14) for wax-coated pear fruits.

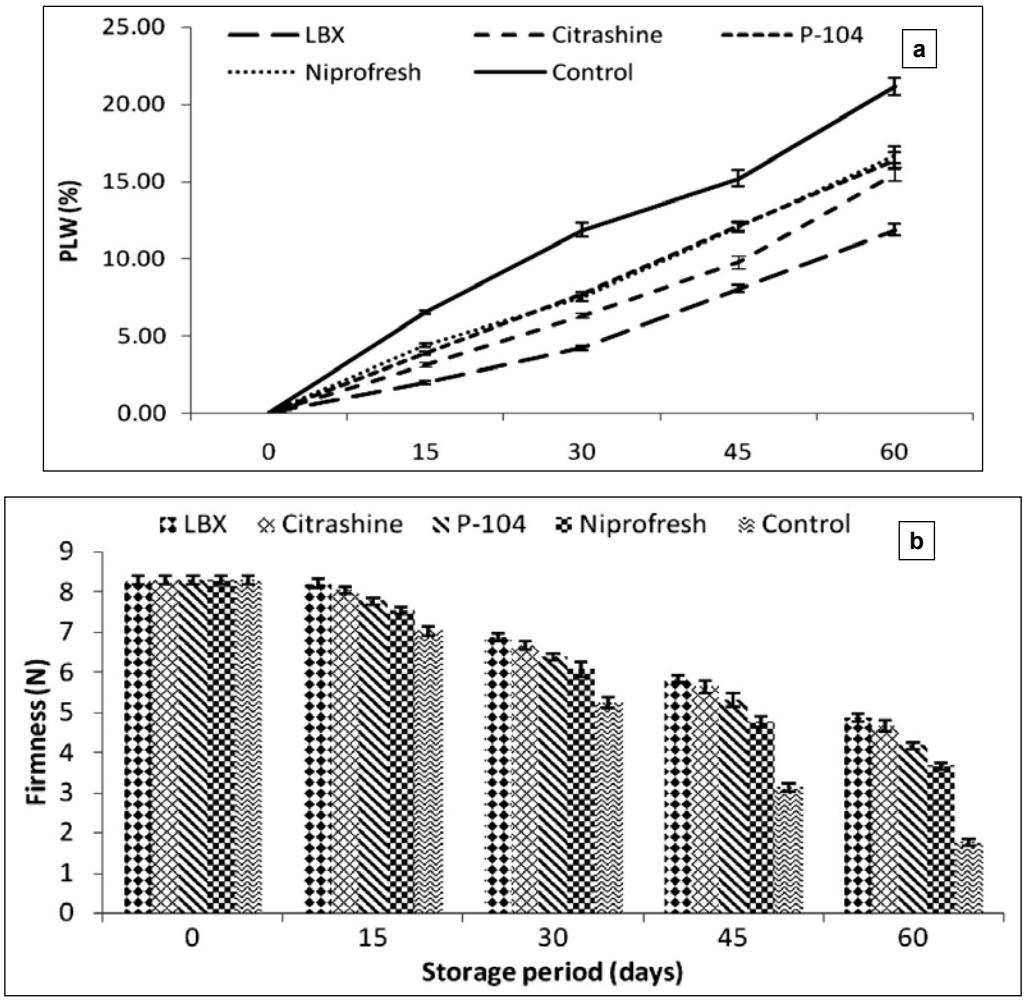

Fig. 1. Effect of surface coatings on physiological loss in weight (%) (a) and fruit firmness (N) (b) in Kinnow mandarin fruits. Fruits were stored at 5 ± 1ºC and 85-90% RH for 60 days.

The respiration rate of Kinnow fruits treated with surface coatings was lesser than untreated fruits. Among different surface coatings, fruits that received lac based wax showed least respiration rate (Fig. 2b) than other coatings, which could be related to the lac-based waxs more successful retarding action of the ripening process by creation of modified atmosphere around the fruit surface. Furthermore, the effect of coatings might be attributed to the delaying of the metabolic and respiratory activities of fruit and hence might have retarded the fruit ripening and senescence processes. Our results agreed with the results of Ladaniya (6) who observed that the influence of fungicidal wax coating during storage of 'Nagpur' mandarins.

In Kinnow mandarin, titratable acidity was significantly higher in the surface coated fruits than the uncoated ones. Kinnow fruits receiving treatment of lac based wax showed highest retention, significantly followed by Citrashine®, P-104® and Niprofresh™ treatments. Similarly, TA decreased with progressive increase in storage period from 15th day to 60th day (Fig. 3a). The coatings helped in better retention of acidity as compared to control, which might be due to the positive role of coatings in delaying the fruit ripening process (Ladamiya, 6). The reduction in titratable acidity of fruits may be due to the utilization of organic acids for respiration. The decrease in titratable acids during storage may also be attributed to utilization of organic acid in pyruvate decarboxylation reaction occurring during the ripening process of fruits. However, our results confirm the findings of Dal and Gozen (2), who

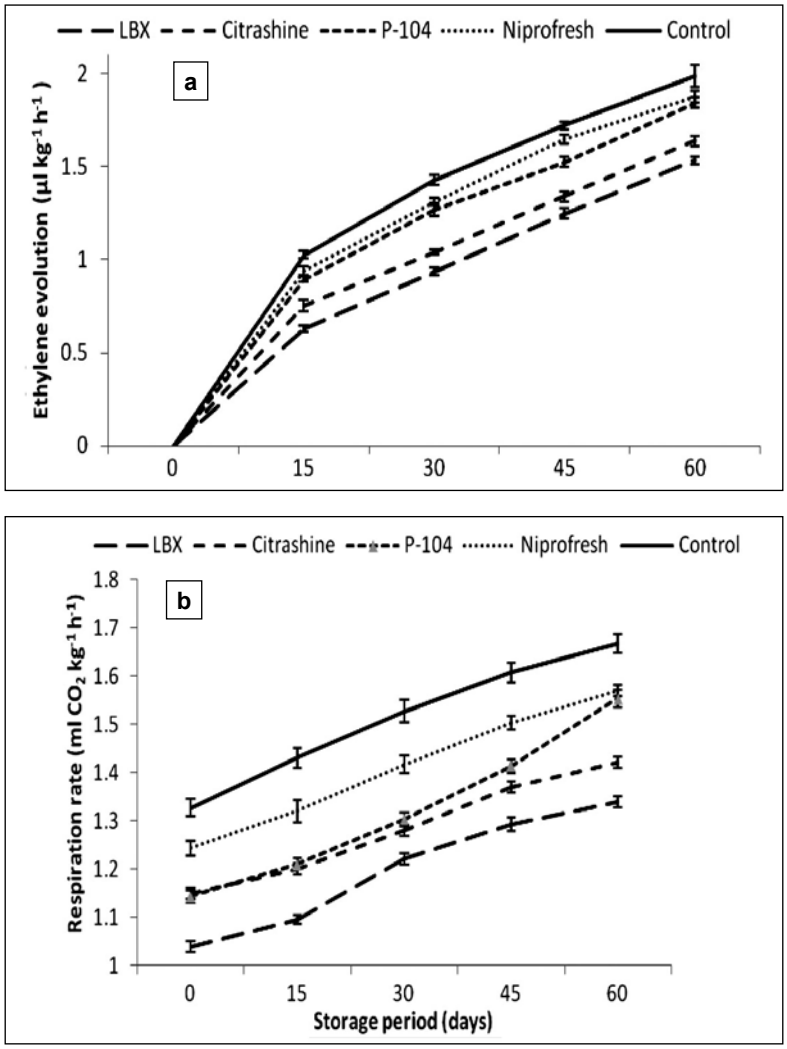

Fig. 2. Ethylene evolution rate (a) ethylene evolution rate, and (b) respiration rate of Kinnow mandarin fruits as affected by different surface coatings. The coated and non-coated Kinnow fruits were stored at 5 ± 1ºC and 85-90% RH for 60 days.

reported that the post-harvest waxing applied on different Satsuma mandarin types. During storage period of 10 days, percentage weight loss and parameters such as titratable acid amount, fruit juice amount and total soluble solids amount had appreciative results.

Soluble solids content (SSC) of a fruit give an account of its sweetness. Our study has revealed a steady increase in SSC with the increase in storage period from 15th to 60th day (Fig. 3b). Surface coatings treated Kinnow fruits showed steady increase in SSC in comparison to untreated fruits. This increase in SSC was lesser in fruits which were lac based wax treated, significantly followed by Citrashine®, P-104® and Niprofresh™ coated fruits (Fig. 3b). The positive effects of surface coatings on maintaining the SSC could be attributed to lesser respiration and low ethylene production rate, which might have inhibited the water loss from fruits. Although, the effects of surface coatings on the quality of fresh horticultural perishables are also affected by factors related to the type of wax and its concentrations etc., produce (*e.g.* species, cultivar, fruit physical and physiological condition) and the postharvest handling (*e.g.* postharvest treatments, length and environmental conditions of storage). The initial increase in TSS and sugars may be due to hydrolysis of starch into mono and disaccharides, and on complete hydrolysis of starch. Our results confirm the findings of Dal and Gozen (2), who reported that the post-harvest waxing applied on different Satsuma mandarin types enhanced the shelf life to 10 days, while maintaining quality.

Ascorbic acid content was significantly higher in the surface coated fruits than the uncoated ones (Fig. 3c). Among different surface coatings, fruits coated with lac based wax showed the highest ascorbic acid content significantly followed by Citrashine®, P-104® and Niprofresh™ coatings (Fig. 3c). Such differences in retention of ascorbic acid content among different surface coatings could be due their differential influence of initiation of decay rot, which might have helped in maintaining fruit quality and prolonging shelf-life or storage life. Earlier,

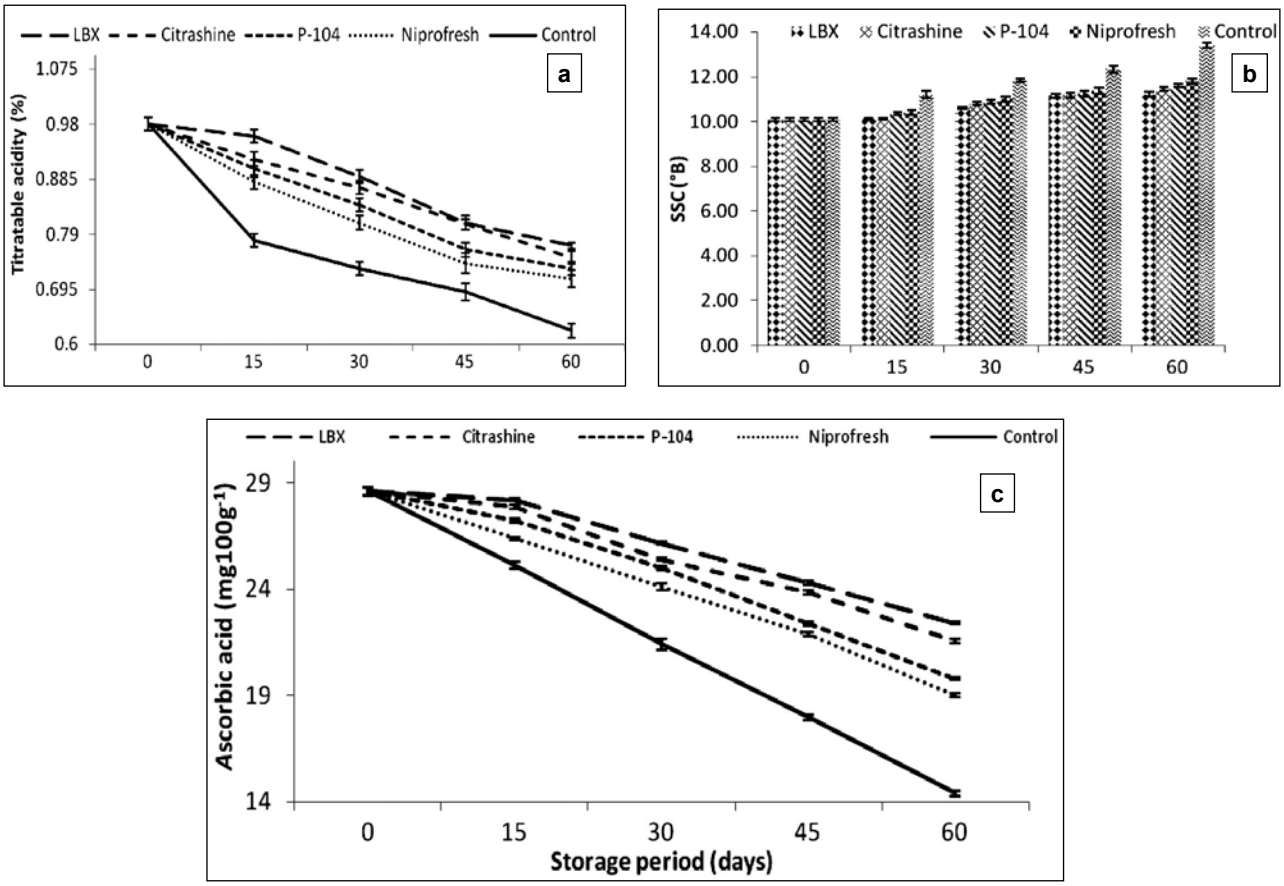

Fig. 3. Effect of surface coatings on titratable acidity (a) soluble solids content (b) and ascorbic acid content (c) in Kinnow mandarin fruits. The coated and non-coated fruits were stored at 5 ± 1ºC and 85-90% RH for 60 days.

Ladaniya (6) evaluated the influence of fungicidal wax coating on storage of 'Nagpur' mandarins. The fruit juice content, titratable acidity and ascorbic acid contents were not much though storage life of 'Nagpur' mandarin could be extended up to 75 days at 3.5°C with fungicidal wax-coating. The retention of higher quantity of ascorbic acid in wax-coated fruits might be due to reduced respiration rate or oxidation of ascorbic acid. Similarly, Mahajan *et al*. (7) have reported higher ascorbic acid content in Kinnow fruits coated with shellac.

In conclusion, surface coatings have the potential to extend shelf-life and maintaining the quality of Kinnow mandarin. Lac based wax was found by far the best in maintaining quality.

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