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Influence of coating developed from oligomer isolated from lac resin on post-harvest quality and shelf life of peaches (*Prunuspersica L.*)

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Abstract

Large quantities of fresh fruits are produced that never reach the consumers due to heavy post-harvest losses, lack of storage, transportation care and less acceptable quality. These losses are not only concerned in terms of the revenue but it also concern in terms of health and life style of human being. To fulfill consumer demand and to avoid losses due to environmental variability, several methods are being utilized to increase the shelf life of fruits. Fruit coatings are considered as one of the widely used methods. This work investigates the effect of fruit coating developed from oligomer (P-104), isolated from lac resin on the quality of peach (*Prunuspersica L.*) when stored at room temperature (36-40°C) and at refrigerator temperature (4-8°C) temperature. Fruit quality was evaluated by measuring physiological weight loss, color and textural changes as well as microbiological evaluation at a regular interval of four days. When kept at room temperature, uncoated peaches remained fresh and microbiologically safe for 4 days only while shelf life of coated peaches increased to 12 days. Again the shelf life of coated peaches prolonged to 24 days when stored at refrigerator temperature. These results showed that the combined effect of coating and low storage temperature could improve the shelf life of peaches indicating the potential of this combination for fruits preservation.

Keywords: *Prunuspersica*, Coating, Color, Firmness, Shelf life, Microbiological evaluation

Introduction

It is well known that fruits and vegetables play a vital role in human diet as sources of calories, vitamins, dietary fiber and special nutraceuticals. Many fruits develop a waxy coat on their epidermis as they mature on the plant but this natural waxy coat is not adequate to offer protection against water loss and high respiration rate that follow when they are removed from the living tree leading to the spoilage of these fresh produce. Such post-harvest losses can be reduced to some extent by increasing the wax content on fruit surface [1, 2] utilizing low temperature technologies [3], efficient packaging [4], use of coatings [5-10], nanotechnology [11-13], osmotic dehydration, irradiation [14, 15] and other techniques.

The peach fruit softens quickly after harvest and leads to huge losses in the marketing chain due to over-ripeness. Post-harvest decay due to rapid ripening in peaches is the major factor that limits their shelf-life which poses a serious constraint for efficient handling and transportation [16]. Application of low temperature techniques have been determined to provide delayed fruit degradation by reducing its biological and chemical activity but these methods require refrigerated transport and storage tanks [17-20]. Koukounaras et al. [21] have also investigated the effect of short-term heat treatment on the quality of fresh-cut peach. Intermittent warming has been reported to increase the shelf-life of firm-mature and firm-breaker peaches by 1 and 2 weeks, respectively [17, 18]. Likewise, Zhang et al. [22] have reported that self-defense capability of peach fruit was

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improved by heat treatment. Recently, high pressure processing (HPP) technique has been utilized to achieve enzyme inactivation for preserving texture and color of minimally processed peaches. This research showed that higher pressure levels were more effective to inactivate enzymes and to preserve color for longer times [23].

Fruit coatings are used as carriers of antimicrobial compounds, color or aroma additives, anti-oxidants, or anti-ripening compounds [24]. *Aloe arborescens* and *Aloe vera* gels [25], carboxymethyl cellulose [26, 27], 1-methylcyclopropene [2, 19, 20], sodium alginate [28], edible gum and calcium lactate [29] and other materials have been used for an extension of the shelf-life of peaches. Specific fruit coatings for easily perishable fruits like peaches also provide improvements in arresting physiological weight loss, retardation of ripening, reduction of chilling and mechanical injury, reduced decay and plausible added shine or gloss to the fruits. However, it has been observed that fruit coatings indirectly induce changes in the flavor due to delayed ripening or as a result of anaerobic respiration with increased ethanol concentrations [30] and hence, have to be carefully selected and used so that the original texture, color and flavor of the fruits is retained. The present study was conducted to assess the potential of a coating developed from a naturally occurring terpenoidal oligomer P-104 [5-8, 31, 32]. Experiments on evaluation of effect of coating have been conducted on storage at refrigerator temperature (4-8°C) and at room temperature in the month of June (36-40°C).

Materials and Methods

Fruit source

Peaches (*Prunuspersica L.*) used for the present study were purchased from an authentic Agricultural Produce Marketing Cooperative. Uniform and non-damaged fruits were selected and they were washed with water and shade dried before treatment.

Preparation of coating and fruit treatment

Active ingredient P-104 was obtained from lac resin as per the patented process [31]. Morphology of P-104 was investigated by Scanning electron microscope (SEM) and Atomic force microscopy (AFM). Coating (O/W type emulsion) was developed from P-104 by mechanical stirring of 10 g of P-104 and 2 ml of triethyl amine in 70 ml of 100 mg/l SDS and final volume was made up to 100 ml with double distilled water [5-8]. Uniformity of formulation was ensured at different intervals by following the recommended protocols [33]. Peaches were randomly distributed into two groups. In both the groups, half of fruits were kept uncoated while the other half were treated with the coating solution by dip coating (with 2-3 minutes of contact time) method. Thereafter, the fruits of both the groups were kept at room temperature (36-40°C) in open trays for drying. One group of fruits was stored at room temperature (36-40°C) while the fruits of other group were stored in the refrigerator (4-8°C) for progressive assessments.

Characterization techniques

Scanning electron microscope (SEM)

Glass slides coated with P-104 solution in isopropyl alcohol (by dip coating) was mounted on the stub and coated with silver paste to render a conducting surface to determine the surface topography of films formed by using LEO, 435 VP, SEM operating at 20 kV and a working distance of 12.11 mm.

Atomic force microscopy (AFM)

A glass slide was dipped in a solution of P-104 in isopropyl alcohol and taken out to dry subjected to analysis by AFM (Digital instruments, Nanoscope III-A) to study the variation in surface topography. Since contact mode AFM operates by scanning a tip attached to the end of a cantilever across the sample surface, it could monitor the change in surface which deflects the cantilever with a split photodiode detector.

Quality assessment of coated and uncoated fruits

Physiological weight loss

Six fruits of each treatment (the same fruit during all the storage time) were weighed at the beginning of the experiment and at every fourth day of the storage. The results were expressed as percentage loss of initial weight.

Firmness

For each fruit sample, texture was determined using a 2 mm diameter probe coupled on a TA.XTplus Texture Analyzer (Stable Micro Systems, Surrey, UK) interfaced to a personal computer. Penetration rate was 2 mm sec^{-1} for 5 min after contacting the flesh and results of firmness were expressed in Newton (N).

Color analysis

Color characteristics (L, a and b) were assessed using a ColorQuest Hunter colorimeter (HunterLab, Hunter Associates Laboratories Inc., Virginia, USA) to determine L value (lightness or brightness), a value (redness or greenness) and b value (yellowness or blueness) of peach samples. Twelve readings were obtained for each treatment from 6 replicates with 2 readings for each replicate by changing the position of the peach to get uniform color measurements. Measurements were taken at every fourth day up to 12 days for fruits stored at ambient temperature and up to 24 days for fruits stored in the refrigerator. A standard white plate (X =78.45,Y =83.16, Z =88.81) and a black plate were used to standardize the instruments. Color changes were converted to hue angle (θ) = $\tan^{-1}$ (b/a). Results were expressed as hue angle (θ) and L values.

Microbiological evaluation

Plate count agar (PCA) medium was used for all the experiments. The pH of the medium was adjusted at 7.0±0.2 and autoclaved at 103410 Pa pressure for 20 minutes. The medium was then poured into petri plates. Samples of 10 g of fruit pulp were blended and then added to 100 ml of 1% sterile peptone water at different dilutions (10^{-1}-10^{-8}). Aerobic mesophilic microorganisms were counted by plating 1 ml of the corresponding dilution and the plates were incubated at 35ºC for 48 h [34]. Experiments were done in triplicate and only counts of 30-300 colony forming units (CFU) were considered. Microbial counts were determined by using standard procedure available in the literature.

Statistical analysis

Analysis of variance *(ANOVA*) for each quality parameter with respect to coating and temperature of storage was carried out.

Results and Discussion

Characterization of P-104

Morphology of P-104

The surface topography of P-104 has been evaluated by scanning electron microscopy (SEM) and atomic force microscopy (AFM) (Fig. 1, 2). It has been observed that P-104 particles were assembled uniformly throughout the deposited films on glass together with the spherical agglomerate formation.

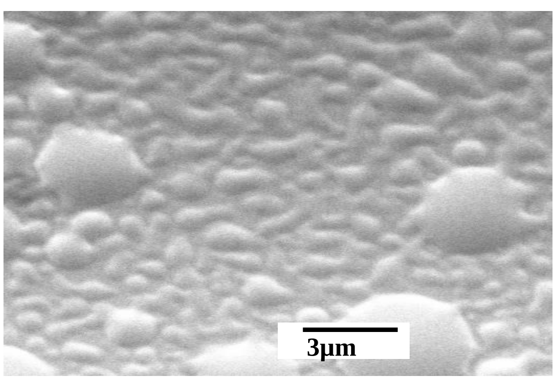

Fig. 1: SEM image of P-104.

Quality assessment of coated and uncoated fruits

Physiological weight loss

In our study, the highest weight loss was determined in control samples of peaches while coated samples suffered a comparatively insignificant loss for both the samples stored at room temperature and in the refrigerator. Coated fruits when stored at room temperature showed 12.2% weight loss after 12 days of storage while the loss was found to be 20.8% for uncoated fruits after 12 days of storage. At the same time when the coated and uncoated peaches were stored in the refrigerator, the fruits remained fresh for a longer period of time. Physiological weight loss reached 11.9% for coated fruits and 35.1% for uncoated fruits at the end of 24 days of storage (Fig. 3). Many researchers have reported weight loss as the most important problem during the storage of peaches and nectarines [35, 36]. The lower weight loss in coated fruits as compared to control is originated from slower rate of water loss in coated fruits due to partial clogging of natural pores with coating developed from P-104.

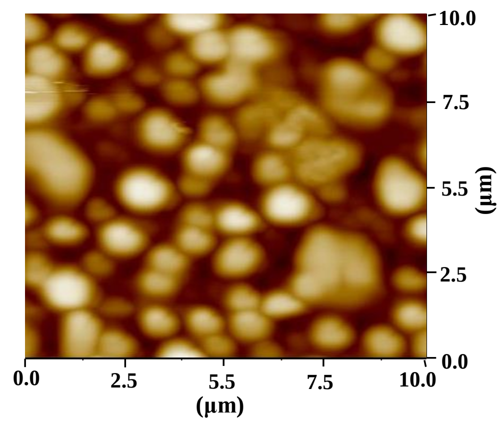

Fig. 2: AFM image of P-104.

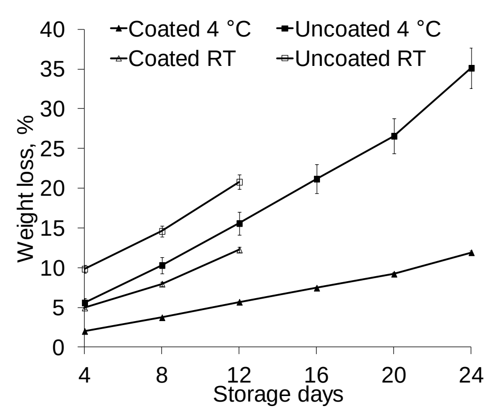

Fig. 3: Changes in weight loss in coated (Δ) and uncoated (□) peach stored at room temperature (36-40°C) and coated (▲) and uncoated (■) peach stored in the refrigerator (4-8°C) (n=6).

Texture Analysis

Firmness is an important quality attribute and the rate of firmness loss during ripening may influence not only the fruit quality but also its storage life. Reduction in fruit firmness on storage is believed to reflect solubilization of pectic substances with conversion of insoluble pectin to soluble pectin causing fruit softening and reduced resistance [37]. In our experiments, it was determined that fruit firmness gets significantly reduced from the first day of storage to the last day probably due to the conditions of fruit storage at room temperature. The reduction in firmness gets attenuated under refrigerated storage conditions. Fig. 4 showed a decrease in firmness under both coated and uncoated peaches but the decrease was found to be less in coated peaches irrespective of storage conditions. Shewfelt et al. [38] have identified maturity at harvest, ripening and temperature as most critical factors in the postharvest life of peaches while firmness as the main limiting quality attribute.

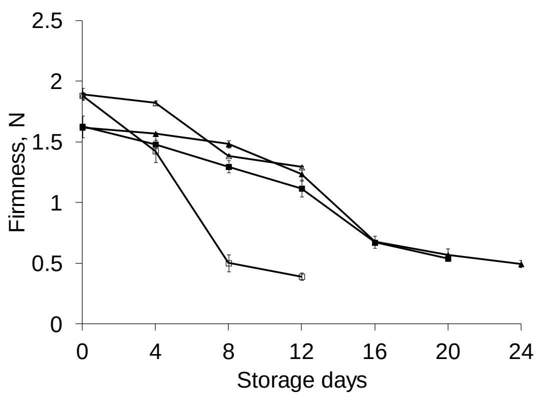

Fig. 4: Changes in Firmness in coated (Δ) and uncoated (□) peach stored at room temperature (36-40°C) and coated (▲) and uncoated (■) peach stored in the refrigerator (4-8°C) (n=6).

Color Analysis

Little changes in lightness (L) and hue angle values were observed when fruits were stored at room temperature (36-40°C) and in the refrigerator (4-8°C) (Fig. 5, 6). These changes in Hunter L values were not significant. Changes associated with the ripening include loss of green color and development of yellow, red and other color characteristics of the variety. Various studies suggested that normal ripening of peaches comprise of the softening process, changes in skin and flesh color (less green with a reduction in Hue angle values), an increase in total soluble solids (TSS), lower titratable acidity (TA) and a higher TSS/TA ratio [36, 38, 39]. Crisosto [40] also emphasized that fruit firmness is an excellent indicator of maximum maturity but the combination of ground color and fruit firmness may be better than a single index to assay stone fruit maturity.

Microbiological evaluation

Coating developed from P-104 was found to be effective in reducing microbial colony forming units (CFU) on plate count agar (PCA) medium in peaches. International Commission on Microbiological Specifications for Food (ICMSF) [41] set a maximum limit of 7 log cfu/g of total aerobic mesophilic bacteria. In the present experiments, it was determined that the room temperature storage is favorable for the microbial growth (Fig. 7). Total plate count (TPC) in uncoated peaches stored at ambient temperature increased drastically from 4.23±0.02 to 8.35±0.02 log cfu/g from 4 to 8 days of storage. Coated peaches stored at room temperature were found to have the TPC value of 9.67±0.06 over a period of 16 days. Coated and uncoated peaches stored at ambient temperature were determined to have the shelf life of 12 and 4 days, respectively which is in concurrence with the earlier findings [3, 42]. It has been determined that the refrigerator temperature significantly ($P < 0.05$) lowered the rate of microbial growth. Our findings showed that the uncoated peaches stored in refrigerator crossed the microbial limit of 7 log cfu/g after 12 days but the fruits were not in marketable conditions after 8 days of storage. On the other hand, the coated peaches remain microbiologically safe even after 24 days when stored in the refrigerator.

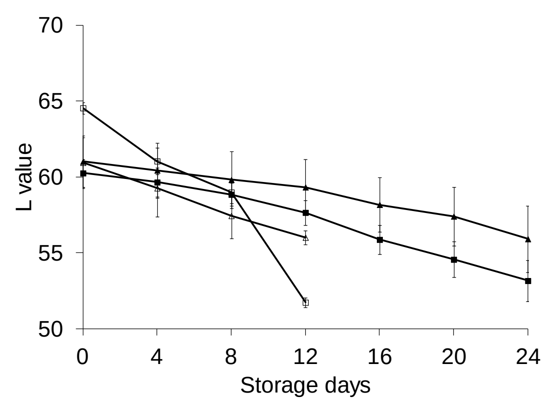

Fig. 5: Changes in Lightness in coated (Δ) and uncoated (□) peach stored at room temperature (36-40°C) and coated (▲) and uncoated (■) peach stored in the refrigerator (4-8°C) (n=6).

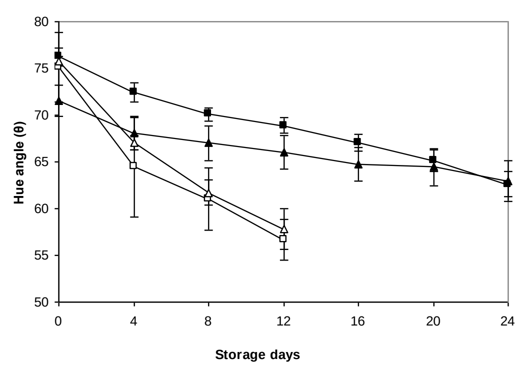

Fig. 6: Changes in Hue angle in coated (Δ) and uncoated (□) peach stored at room temperature (36-40°C) and coated (▲) and uncoated (■) peach stored in the refrigerator (4-8°C) (n=6).

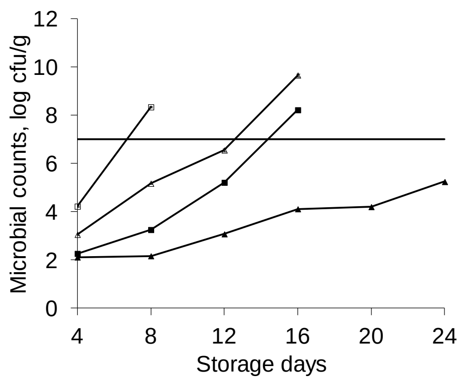

Fig. 7: Changes in aerobic mesophilic microbial counts in coated (Δ) and uncoated (□) peach stored at room temperature (36-40°C) and coated (▲) and uncoated (■) peach stored in the refrigerator (4-8°C) (n=3). The straight horizontal line indicates the maximum microbial limit for total aerobic growth (7 log cfu/g).

Statistical analysis

Results of statistical analysis are presented in Table 1. Differences among means were compared by least significant difference (LSD) test ($P \leq 0.05$).

Conclusion

This research provides an initial specific characterization of the impact of coating treatment on various quality parameters for a longer period of time as compared to untreated peaches. It has been determined that the coating alone or in combination with refrigerated storage has positive effects on enhancement of shelf life of peaches and can be worked out further for commercial applications to significantly reduce post-harvest losses of peaches. Based on the data reported in this paper, the predicted storage life of coated peaches was about 12 days at 36-40°C and 24 days at 4-8°C.

Table 1: ANOVA for various quality parameters of peach.

Source	DF	SS	MS	F	P
Weight loss					
Treatment	5	274.36	54.7	75.26	0.0001
Temperature	1	63.11	63.11	86.56	0.0002
Error	5	3.64	0.72		
Total	11	341.12			
Firmness					
Treatment	7	2.05	0.29	3.17	0.07
Temperature	1	0.04	0.04	0.46	0.51
Error	7	0.64	0.09		
Total	15	2.74			
L value					
Treatment	7	76.4	10.91	2.27	0.15
Temperature	1	3.08	3.08	0.64	0.44
Error	7	33.59	4.78		
Total	15	113.09			
Hue angle					
Treatment	7	345.2	49.32	3.39	0.06
Temperature	1	103.5	103.58	7.11	0.03
Error	7	101.89	14.55		
Total	15	550.71			
Microbial counts					
Treatment	3	11.59	3.86	2.45	0.2
Temperature	1	15.1	15.12	9.60	0.05
Error	3	4.72	1.57		
Total	7	31.4			

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Conflict of Interest

No conflict of interest declared.

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