Extension of Shelf Life of Plum by Formulation Developed from Oligomer Isolated From Lac

Anjali Bishnoi, H.M. Chawla, and Gita Rani

***Abstract*—**Plums (Prunus domestica L.) were coated with a formulation developed from an oligomer (P-104) isolated from lac and stored at room temperature (36±2 °C). Fruit quality was evaluated by measuring weight loss, color, texture, total soluble solids, pH and microbiological evaluation at a regular interval of four days. Dipping the plums in the formulation has been determined to have a significant positive effect on the retention of firmness and reduction in weight loss. Microbiological evaluation compared to the uncoated plums revealed that the formulation can be used to inhibit any loss in edibility of fruits. The results revealed that coated plums have shelf life of 16 days in comparison to uncoated plums which were edible till 8 days while store at room temperature.

***Keywords*—** Plums, Firmness, Color, Storage, Microbiological evaluation**.**

I. Introduction

PLUM (*Prunus domestica* L.) is considered as climacteric fruit in which ethylene is believed to trigger physico-chemical changes associated with ripening, color, aroma, texture, and flavour. Storage of plums is limited to few days due to the appearance of physiological disorders such as internal browning and gel breakdown [1] while internal browning manifests itself as a browning of the flesh due to the enzymatic oxidation of polyphenols and tannins, gel breakdown results in a gelatinous appearance of the flesh occurring near the fruit pit. Due to unbalanced activity of cell wall hydrolytic enzymes leading to accumulation of unmethylated high molecular weight pectins capable of binding extracellular juice [2]. Some of the strategies used to minimize the undesirable changes in plum include the use of 1-Methylcyclopropene [3-7] and putrescine [8]. Cold storage (at 0ºC) has also been found to be useful for increasing the shelf life of plums but its benefits are limited by the development of physiological disorders and brown rot caused by *Monilinia laxa* [1,3,9]. We have been examining the effect of natural formulations developed from a non toxic and edible terpinoidal oligomer P-104 is isolated from a resin secreted by insect *Laccifera lacca* on certain varieties of tree native to India (10-13). We describe herein the effect of dipping plums in the formulation with an aim to observe its postharvest application for storage at ambient high temperature (36±2 °C).

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II. Materials and Methods

A. Plant material and treatment

Plums (Prunus domestica) used for the present study were purchased from authentic Agricultural Produce Marketing Cooperatives (APMCs). Experiments were done in the month of June during the last three years. The fruits were coated with a coating solution prepared from P-104 and were stored at room temperature in trays.

B. Preparation of coating and fruit treatment

Active ingredient P-104 was obtained from lac resin as per the patented process [12,13]. The purity of P-104 was determined by FTIR, UV and gel permeation chromatography (GPC). 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, final volume was made up to 100 ml with double distilled water [10,11]. Uniformity of formulation was ensured at different intervals by following recommended protocols [14]. Half fruits were kept uncoated while the on other half coating was applied by dip coating method and stored at room temperature (36±2 °C).

C. Weight loss

Six fruits of each treatment (the same fruit during all the storage time) were weighed at the beginning of the experiment and after 4, 8, 12, and 16 days of storage. The results were expressed as percentage loss of initial weight.

D. Colour

Colour was determined using the Hunter Lab CFLX-45-2 Spectrocolorimeter (Hunter Associates Laboratory, Virginia, USA) which recorded the spectrum of reflected light and converted it into a set of colour coordinates (L , a and b values). Colour coordinates range from L = 0 (black) to L =100 (white), -a (greenness) to +a (redness), and –b (blueness) to +b (yellowness). A standard white plate (X =78.45,Y =83.16,Z =88.81) and a black plate were used to standardize the instruments. Hue angle (hº), was calculated as $\tan^{-1}$ (b*/a*).

E. Firmness

For each fruit, texture was determined using a 2mm diameter probe coupled on a TA.XT plus Texture Analyzer

(Stable Micro Systems, Surrey, UK) interfaced to a personal computer. Penetration rate was 2 mm sec^{-1} for 5 mm after contacting the flesh and results were expressed in N.

F. Total soluble solids content (TSS) and pH

The concentration of total soluble solids (TSS) was determined in each fruit with digital refractometer (Advance Research Instruments Company, New Delhi, India) at room temperature and expressed as ºBrix. pH was measured directly with a pH meter (Toshniwal Inst. Mfg. Pvt. Ltd., Ajmer, India).

G. Microbiological evaluation

The fruits were washed with water and then coated with coating solution 'B' by immersing the fruits in a solution for one minute. The fruits were then air dried and stored at room temperature in trays. 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 15 lb/ $inches^2$ pressure for 20 minutes. The medium was then poured into petriplates. 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 35º C for 2 days. All the 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.

H. Statistical analysis

The data were subjected to a one-way analysis of variance (ANOVA) and the differences among means were compared by high-range statistical domain (HSD) using Tukey's test.

III. Results and Discussion

A. Weight loss

Weight loss during storage due to transpiration was observed for all treatments. Though very few reports describe the issue of loss of weight, it is one of the most important causes responsible for fruit quality deterioration. The transpiration rate has been determined to be accelerated by cellular breakdown [15] and it is known that loss of weight in fruit during storage is caused by water exchange between the internal and external atmosphere. Plums coated with formulations developed from P-104 showed significantly ($p< 0.05$) lower weight loss as compared to uncoated plums. As shown in Fig 1, the weight loss detected over the 16 days of storage of coated plums was 20.83% of their initial weight with statistical differences at 4 days interval. A similar effect was observed in plums when treated with putrescine [8]. Valero et al [4] also observed the reduction in weight loss in 'President' plum treated with 1-MCP.

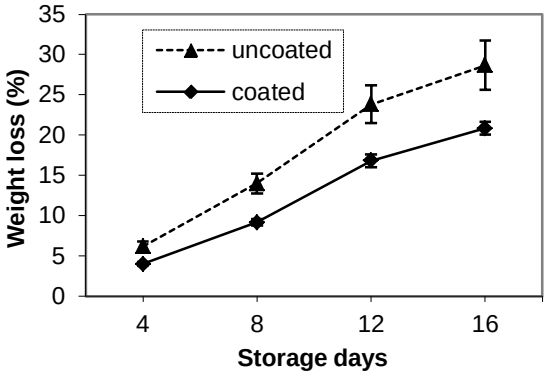

Fig.1 Percentage of weight loss during storage at room temperature in coated and uncoated plum

B. Colour

Colour did not significantly change ($p< 0.05$) in both coated and uncoated plums. The hue angle is known to decrease with increase in storage time in both the cases but no significant difference could be observed among the values (Fig 2). In the present case of application of P-104 dip on plums, the coated fruits have a hue angle of 17.33° which was reduced to 12.77° after 16 days of storage but the differences were not significant. Uncoated plums also showed a similar pattern of color change. A similar kind of behavior in colour was observed in plums by Serrano et al [8]. On the contrary there were reports where the treated plums showed a significant difference in the hue angle or chroma. Menniti et al [6] showed that the hue angle was higher in the 1-MCP treated plums as compare to control.

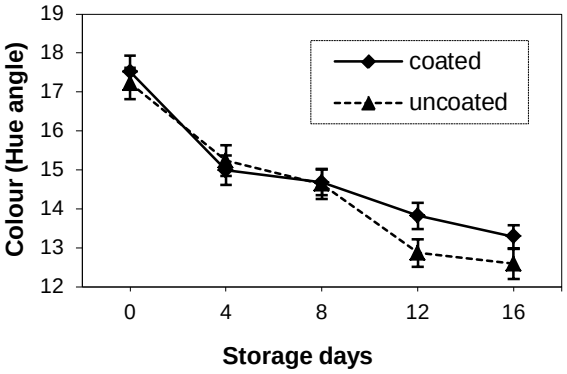

Fig.2 Skin colour changes (Hue angle) during storage at room temperature in coated and uncoated plum

C. Texture

One of the main factors used to determine fruit quality and post harvest shelf life is the rate and extent of loss of firmness during storage. On application of dip in formulation developed from P-104, there was no significant difference in firmness of uncoated and coated plums till 8 days of storage at ambient high temperatures but coated plums remained significantly firmer even after 16 days of storage as compared to uncoated plums (Fig 3). Uncoated plums lost most of their firmness at 8 days of ripening probably due to increased ethylene

production. A similar observation was reported previously by Menniti et al [6] when plums were treated with 1-MCP. Treatment with putrescine treated plums also maintained significantly higher flesh firmness than that found in control fruit during storage [8].

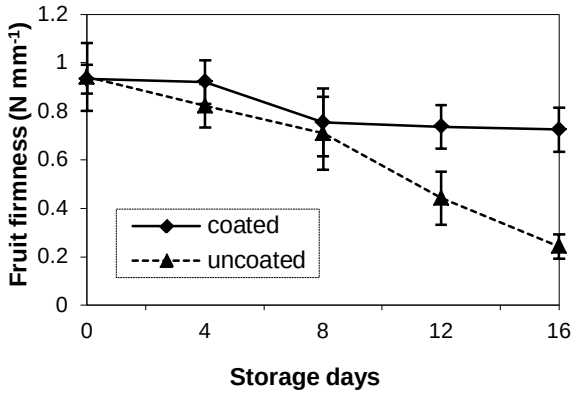

Fig. 3 Fruit firmness (N mm^{-1}) during storage at room temperature in coated and uncoated plum

D. Total soluble solids content and pH

P-104 was found to have no effects on TSS and pH when dipped in the formulation developed from P-104. There were no significant differences between coated and uncoated plums (Table 1, 2). The results are similar to those of Menniti et al [6] who found similar results in plums when treated with 1-MCP. On the contrary Serrano et al [8] reported the SSC slightly increased in plums after treatment with putrescine.

TABLE I
CHANGES IN TOTAL SOLUBLE SOLIDS CONTENT (TSS) DURING STORAGE AT AMBIEN TEMPERATURE IN COATED AND UNCOATED PLUM

Storage days	Total soluble solids (TSS)	
	Uncoated	**Coated**
0	1.351 ± 0.0005 aA	1.349 ± 0.001 aA
4	1.351 ± 0.0005 aA	1.351 ± 0.001 aA
8	1.352 ± 0.001 aA	1.350 ± 0.001 aA
12	1.353 ± 0.002 aA	1.351 ± 0.001 aA
16	1.354 ± 0.0005 aA	1.353 ± 0.0005 aA

Values are mean (n=3) ± standard error. Means for the same column (a-e) or in the same line (a-b) with same letters are not significantly different ($p< 0.05$) and the Tukey's test.

TABLE II
CHANGES IN PH DURING STORAGE AT AMBIENT TEMPERATURE IN COATED AND UNCOATED PLUM

Storage days	pH	
	Uncoated	Coated
0	3.17 ± 0.07 bA	3.22 ± 0.03 bcA
4	3.25 ± 0.20 bA	3.49 ± 0.15 bcA
8	3.74 ± 0.15 abA	3.53 ± 0.08 abA
12	3.83 ± 0.07 aA	3.74 ± 0.15 aA
16	4.42 ± 0.16 aA	4.09 ± 0.06 aA

Values are mean (n=3) ± standard error. Means for the same column (a-e) or in the same line (a-b) with same letters are not significantly different ($p< 0.05$) and the Tukey's test.

E. Microbiological evaluation

Coating with a formulation developed from P-104 was found to be effective in reducing microbial colony forming units (CFU) on PCA medium at ambient high temperature in plums. It has been documented that 7 log cfu g^{-1} as maximum limit for aerobic bacteria. Uncoated plums crossed the limit after 8 days. On the contrary coated plums crossed this limit after 16 days and the microbial populations were significantly reduced in coated plums with total viable counts of 5.36 ± 0.05 log cfu g^{-1} for mesophilic aerobics (Fig.4). Taking this limit into consideration for microbiological evaluation the coated fruits showed an enhanced shelf life of 16 days as compare to the 8 days in uncoated plums.

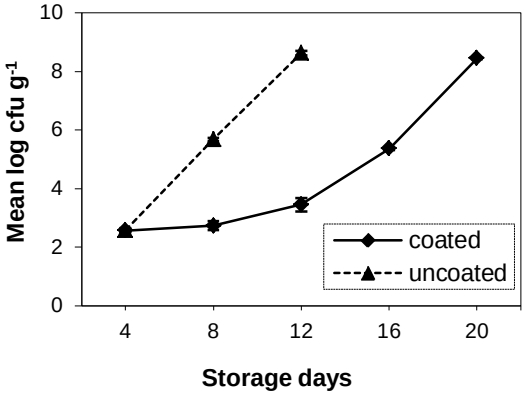

Fig.4 Microbial counts of plum during storage at room temperature in coated and uncoated plum

IV. CONCLUSION

In conclusion, a dip in the formulation developed from terpinoidal oligomer P-104 is an effective method to prolong storability and shelf life extension of plums at room temperatures (36±2 °C).

V. ACKNOWLEDGMENTS

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