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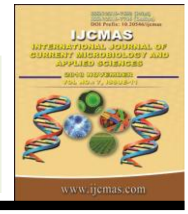

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Combined Effect of Chemical Treatment and Modified Atmosphere Packaging on Physicochemical Properties of Fresh-Cut Pear

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A B S T R A C T

The effect of modified atmosphere packaging (MAP) with chemical treatment on physicochemical quality fresh-cut pears was investigated. Cut-pears were subjected to the following conditions: (1) MAP + Treated - (1% citric acid + 1% $CaCl_2$) and stored in MAP at 8 ºC, (2) Treated - (1% citric acid + 1% $CaCl_2$) and stored at room temperature and regular atmosphere, (3) MAP + Untreated - No chemical treatment and stored in MAP at 8 ºC, (4) Untreated - No chemical treatment and stored at room temperature and regular atmosphere. Changes in physiological loss of weight (PLW), firmness, pH, total soluble solids (TSS), titratable acidity, color, scanning electron microscope-energy dispersive X-ray (SEM-EDX) and sensory characteristics were evaluated at 8ºC for 8 days. Firmness and titratable acidity continuously decreased while PLW, pH, and TSS continuously increased from their initial values for all conditions. 'L' values decreased, 'a' and 'b' values increased during storage. Firmness and color were better maintained in MAP + Treated pear among all other samples. SEM-EDX analysis revealed that the surface of chemically treated sample was smoother than untreated sample. In the sensory test the panellists could not find any significant difference between freshly cut-pear and MAP + treated cut-pears at the end of storage period. These results suggested that fresh-cut pears could be stored maintaining its original quality for long time by chemical treatment of 1% citric acid + 1% $CaCl_2$ in combination with MAP.

Introduction

Pear (*Pyrus communis* L.) is a highly valued fruit for its flavor and nutritional quality. It contains large amount of dietary fiber, vitamins, protein, minerals. According to the USDA National Nutrient Database for Standard Reference Legacy Release (2018), 100 g of pear contains 57 kcal energy, 15.23 g Carbohydrate, 3.1 g Fiber,0.36 g Protein, 4.3 mg Vitamin C, 4.4 mg Vitamin K, 116 mg Potassium, 12 mg Phosphorus, 9 mg Calcium, 7 mg Magnesium, and 1 mg Sodium. It is packed with immense health benefits such as anti-inflammatory, sedative, anti-pyretic, anti-oxidants, hypolipidemic, hypoglycaemic, anti-aging, anti-tussive, anti-diarrheal, and hepato-protective (Parle and Arzoo, 2016). The shelf-life of freshly cut pear is very less and it undergoes frequent browning and texture loss in ambient condition. Browning in sliced fruits is caused by the oxidative reactions of phenolic substrates catalyzed by polyphenol oxidase (PPO) in the presence of atmospheric oxygen (Del Valle *et al.,* 1998), and the fruit softening is due to enzyme-mediated alterations in the structure and composition of cell wall, partial or complete solubilization of cell wall polysaccharides triggered by ethylene (Tuckerand Grierson, 1987). Modified atmosphere packaging (MAP) is a technique used for prolonging the shelf-life of fresh or processed foods by modifying the air surrounding the food in the package to a different composition. Inside packages, O_2 concentration is reduced while CO_2 concentration is increased, causing a reduction in product's respiration rate and a consequent slowing down of senescence and decay phenomena (Das *et al.,* 2006). However, modified atmosphere packaging (MAP) alone cannot completely control the post-cutting enzymatic browning and softening of fresh-cut fruits. There are numerous chemical preservation strategies used to reduce enzymatic browning and fruit softening such as citric acid, acetylcysteine-glutathione solution, and ascorbic acid as browning inhibitors (Park *et al.,* 2010; Oms-Oliu *et al.,* 2008; Soliva-Fortuny *et al.,* 2007), and calcium chloride and lactateas firmness-maintaining agent (Alandes *et al.,* 2006). Combinations of modified atmosphere packaging (MAP) and chemical treatment have been successfully studied to increase the shelf-life of various fruits such as strawberry (Aguayo *et al.,* 2006), banana (Vilas- Boas and Kader, 2006), apple (Rocculi *et al.,* 2004) and fresh-cut pear (Sapers and Miller, 1998). Waghmare *et al.,* (2013) found that chemical solution (1% calcium chloride and 2% citric acid) and MAP was very effective in maintaining the quality of fresh-cut papaya for 25 days at ºC. Bico *et al.,* (2009) reported that dipping into chemical solution (0.5% ascorbic acid, 2% calcium chloride and 0.75% cysteine) combined with carrageenan coating plus storage under controlled atmosphere (3% O_2 and 10% CO_2) could be a good method to preserve fresh-cut bananas for 5 days at 5 ºC.

The main aim of this study was to evaluate the combined effect of chemical treatment and MAP on the physicochemical properties and shelf life of freshly cut pear.

Materials and Methods

Sample preparation

The fresh William Bartlett variety pears were purchased from the local fruit market in Kharagpur. The pears were stored in refrigerator for 3 hours at 0ºC to assure its freshness. The selected quantity of pears were washed by running tap water, dried by cotton and peeled by peeler manually. Each fruit was cut into 6-8 uniform wedges using sharp knife. The cut pears were dipped in water to avoid frequent surface browning by contact of air, then dried with tissue paper. The pear wedges were dipped in a premade chemical solution of 1% citric acid and 1% calcium chloride for 5 minutes. Calcium chloride and citric acid have FDA GRAS status for use as browning inhibitors and firming agent (Code of Federal Regulations 21: 184.1193 and 21: 184.1033, respectively). The samples were removed from the container and put in a glass plate. Excess water was drained off and approximately 100 g portions of pear cubes were packaged in polypropylene bags under modified atmospheric conditions. The size of polypropylene bags was 12 × 20 cm from inside and 0.025 mm thickness having gas permeability of 2660 cc μm m^{-2} h^{-1} for O_2 and 14958 cc μm m^{-2} h^{-1} for CO_2 at 1 atm. The bags were sealed using a Continuous Band Sealer (MS Horizontal 770 Type FR 900-A, Apple Automation and Sensor, Maharashtra, India). Pear slices were subjected to four different treatments: (1) Map + Treated - (1% citric acid + 1% $CaCl_2$) and stored in MAP at 8 ºC, (2) Treated - (1% citric acid + 1% $CaCl_2$) and stored at room temperature and regular atmosphere, (3) MAP + Untreated - No chemical treatment and stored in MAP at 8 ºC, (4) Untreated - No chemical treatment and stored at room temperature and regular atmosphere. The samples of all groups were replicated three times and stored for 8 days.

Measurement of physicochemical properties

Physiological loss in weight (PLW)

Physiological loss in weight (PLW) of cut fruit was calculated as percentage loss in weight based on the initial weight (before storage) and final weight (recorded at the time of periodical analysis during storage) (Shankar *et al.,* 2009).

$$\%PLW = \frac{\text{Initial weight - Final weight}}{\text{Initial weight}} \times 100 \quad (1)$$

Firmness

The texture characteristic of cut fruit in terms of firmness was measured using a texture analyzer (TA-XT2i, Stable Micro System Ltd., UK). The analyser was linked to a computer that recorded data. The studies were conducted at a pre-test speed of 1.0 mm/s, test speed of 0.5 mm/s, distance of 30 mm, and load cell of 50.0 kg (Sirisomboon *et al.,* 2000). Firmness value was considered as mean peak cutting force and expressed in N.

pH-value

pH-value of pear fruit was measured with a digital pH/mV/ºC Analyzer (µpHCal$_5$, Analab Scientific Instruments Pvt. Ltd., Gujarat, India) according to AOAC (2005) procedure.

Total soluble solids (TSS)

Total soluble solids (TSS) in the pear fruit was determined using a digital refractometer (PAL-3, Atago Company Ltd., Japan)

At 20 ºC and expressed as ºBrix following the method prescribed by AOAC (2005).

Titratable acidity

Titratable acidity of pear cut-fruit was determined by titrating against 0.1N sodium hydroxide (NaOH) using phenolphthalein as indicator (AOAC, 2005). Titratable acidity as mg of malic acid per 100 ml of pear juice was calculated by using following formula:

$$\%\ Acidity = \frac{\text{Titre} \times \text{Normality of NaOH} \times \text{Vol. made up} \times \text{eq. wt. of acid} \times 100}{\text{Vol. of sample taken for estimation} \times \text{Vol. of sample taken} \times 1000} \quad (2)$$

Color

The colour of fruit was measured using Chromameter Minolta CR-400 (Konica Minolta sensing Inc., Japan) and the results were expressed in accordance with the Hunter L, a, b color measuring system (AOAC, 2005). Hunter value 'L' varies from 0 to 100 where '100' indicates white and '0' indicates black, 'a' varies from '−' value indicating greenness to '+' value indicating redness, and 'b' varies from '−' value indicating blueness to '+' value indicating yellowness.

Scanning electron microscope-Energy dispersive X-ray (SEM-EDX) Analysis

The SEM-EDX Analysis for microstructural and elemental studies of the samples was done using a scanning electron microscope with energy dispersive X-ray (Sigma 300 VP, Carl Zeiss Ltd., UK).

Sensory evaluation

Sensory analyses of treated and untreated pear wedges stored with and without MAP were carried out at end of storage period to evaluate consumer acceptability (Ranganna, 2001). Ten consumers, between 20 and 30 years old, were recruited among students and personnel of the Department of Agricultural and food engineering, IIT-Kharagpur.

The panelists evaluated the acceptability of the samples from the point of view of odor, color, taste, and firmness using a 9-point Hedonic scale where 1 indicated extreme dislike and 9 indicated extreme like. Results were compared with those obtained for freshly processed samples.

Results and Discussion

Physiological loss of weight (PLW)

The physiological loss of weight (PLW) increased sharply for both the untreated and treated pear (Fig. 1). The maximum PLW was found to be 31.5% in untreated pear and the minimum PLW was found to be 7.2% in MAP with treated pear at the end of 8th days.

This could be mainly due to continuous loss of moisture due to transpiration from the fruit and respiration. Similar results were found by Bico *et al.,* (2009) for banana.

Firmness

The maximum firmness observed was 29 N in MAP with treated sample and the minimum firmness observed was 11 N in untreated sample after 8th days (Fig. 2). The firmness is directly related to loss of water i.e. weight loss. The reason for decrease in firmness during storage of pear fruits might be due to break down of enzymes, loss of water and degradation of pectic substances present in the fruits. Galvis-Sanchez *et al.,* (2003) and Drake *et al.,* (2004) reported similar findings in pear fruits during storage.

pH-value

pH-value was observed to be increased in all four types of sample stored in different conditions. pH-value of the untreated pear without MAP showed the maximum variation, while MAP + treated pear showed the lowest variation during storage (Fig. 3). The pH-value of fruit represents maturity and ripening level of commodity.

Total soluble solids (TSS)

It was observed that total soluble solids (TSS) increased in all samples with storage period (Fig. 4). The minimum variation in TSS was observed in both the MAP + treated and MAP + untreated samples. The maximum TSS (23.6 ^{o}Brix) was observed in untreated sample stored in ambient air at end of storage period. Increase in TSS during storage might be associated with the transformation of pectic substances and starch hydrolysis and also with dehydration of fruits (Carrillo *et al.,* 2003).

Slow increment in TSS during storage in packed sample was due to production of higher levels of CO_2, which may lead to less physiological processes of fruits for slow ripening.

Titratable acidity

The titratable acidity of the samples irrespective of treatment decreased linearly throughout the storage period (Fig. 5). Decrease in acidity indicates the increase in ripening level of commodity. There was little variation in total titratable acidity between treated and untreated sample stored in MAP-technique. Similar, pattern was observed in sample stored in ambient condition.

Fig.1 Variation in physiological loss of weight of cut-pear during storage period

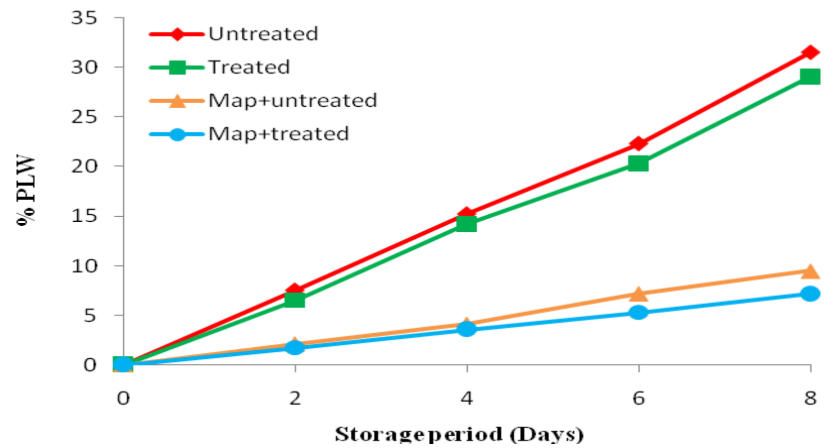


Fig.2 Variation in firmness of cut-pear during storage period

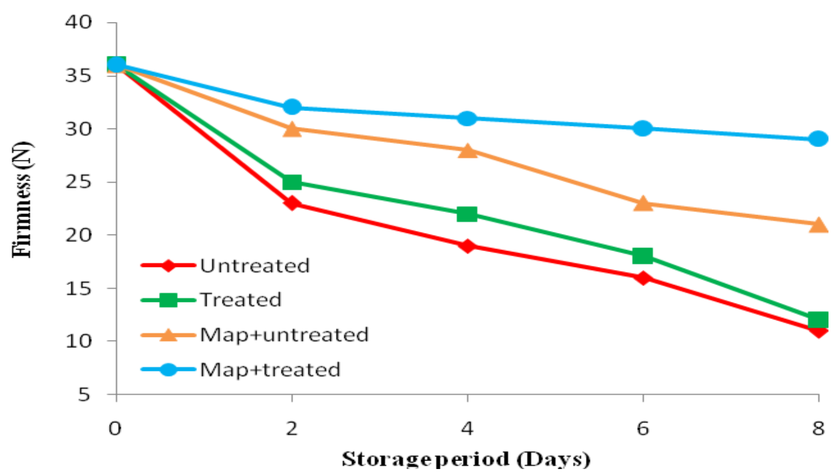


Fig.3 Variation in pH-value of cut-pear during storage period

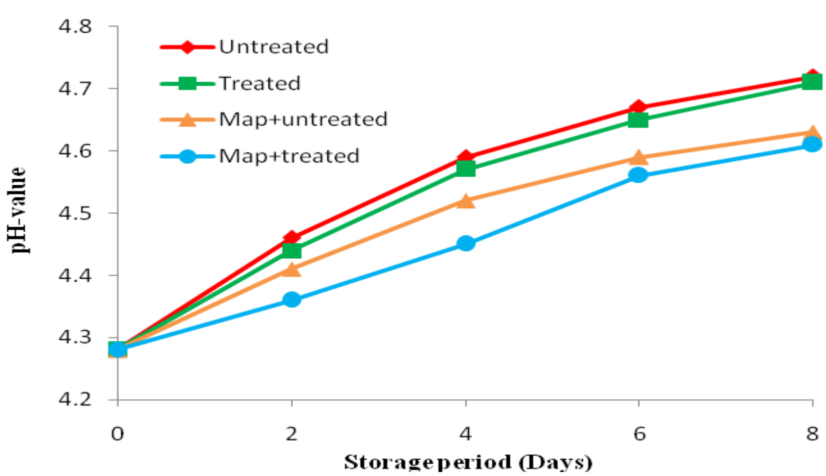


Fig.4 Variation in TSS juice during storage period

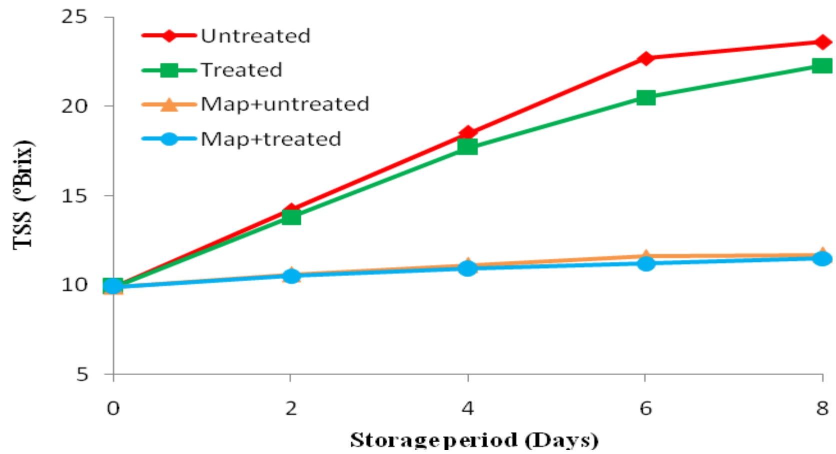


Fig.5 Variation in Titratable acidity juice during storage period

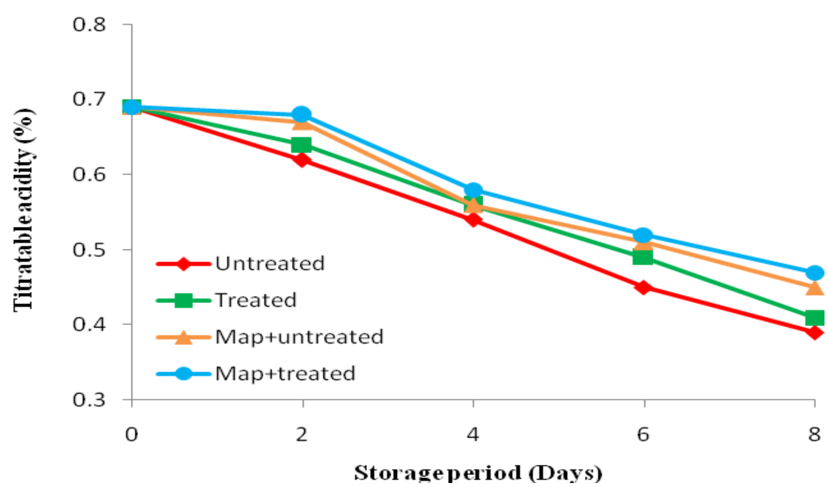


Fig.6 Variation in color of cut pear during storage period

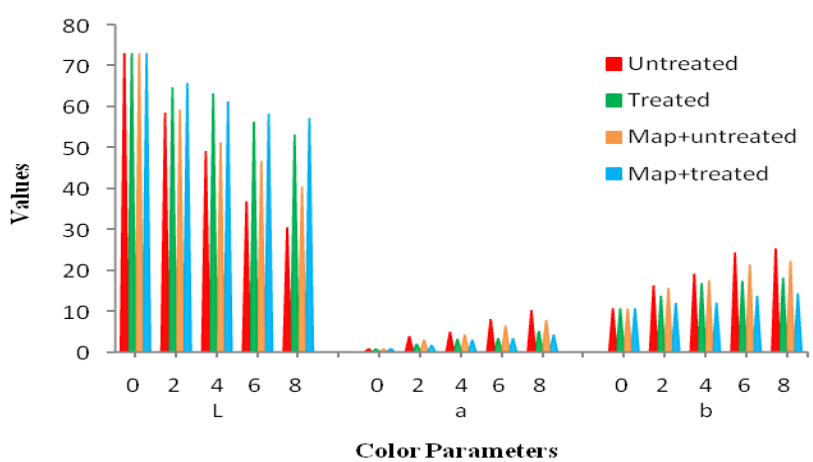


Fig.7 Results of SEM and EDX analysis

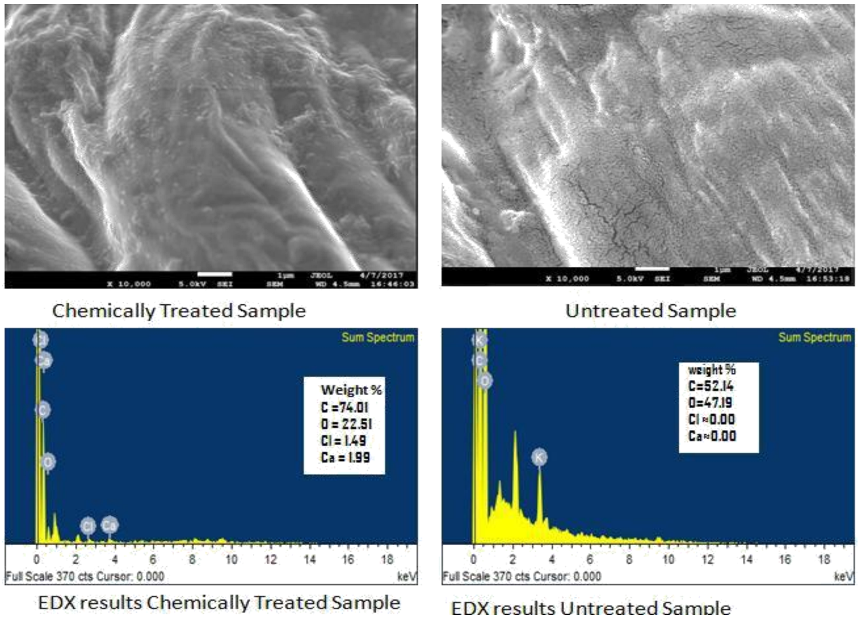
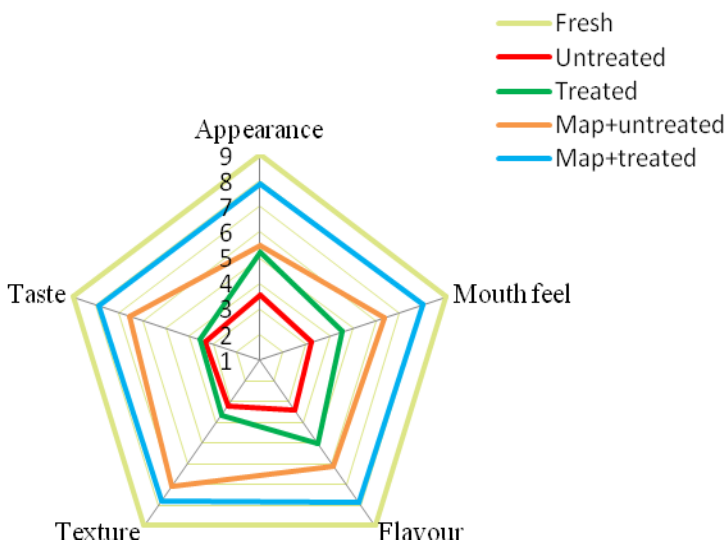


Fig.8 Sensory analysis of cut-pear at the end of storage period



The minimum titratable acidity of 0.37% was recorded in untreated pear stored in ambient air. The reduction in acidity during storage might be associated with the conversion of organic acids into sugars and their derivatives or their utilization in respiration (Zerbini, 2002).

Color

The change in color of cut-pear samples during storage is shown in Figure 6. The maximum color change was observed in untreated pear without MAP which may be due to direct of contact of surplus amount of air, resulting enzymatic browning took place. The minimum color change was found in MAP plus chemically treated samples. The values of 'L' (brightness) were observed to be decreased for all treatments during storage time. The minimum values of 'L' were found to be 30.51 and 40.5 for untreated pear without and with MAP, respectively; while the maximum values of 'L' were found to be 53.21 and 57.26 for treated pear without and with MAP, respectively. It shows that MAP-technique alone is not effective for reducing the browning. The values of 'a' (redness) and 'b' (yellowness) in terms of brownness increased in all samples during storage time. The maximum value of 'a' was 10.23 for untreated sample (without MAP) and the minimum value was 4.27 for MAP with treated sample. The maximum value of 'b' was 24.32 for untreated without MAP while the minimum value was 4.27 for MAP with treated sample.

SEM-EDX analysis

The microstructural and elemental characteristics of both treated and untreated samples are shown in Figure 7. The surface of chemically treated sample was smoother than untreated sample. It was mainly due to treatment with calcium chloride (firming agent) which was also identified in EDX result. More oxygen (47.19%) and less carbon (52.14%) were observed in untreated sample than treated one (O=22.51% and C=74.01%) which may be due to oxidation in untreated sample during storage period.

Sensory evaluations

On 8th day of storage period, chemically treated cut-pear along with MAP scored higher (>7.8) than the other samples for overall sensory attributes (Fig. 8). Sensory evaluation results revealed that there was no discernible between fresh and MAP + Treated samples at the end of storage period. The lowest score (<3.5) was obtained for untreated sample in overall acceptability which was not acceptable by the panel largely due to significant shrivelling and browning.

According to the results obtained in this study MAP alone did not effectively prevent cut surface browning or firmness loss in fresh-cut pear slices. A post-cutting dips of 1% $CaCl_2$ + 1% citric acid and MAP treatment, significantly extended shelf-life of the slices by inhibiting loss of firmness and cut surface browning. Overall, this treatment was found effective in maintaining physicochemical and sensory characteristics of fresh-cut pear during 8-day storage at 8 ºC compared with other treatments. Sensory analysis of the MAP + chemical treated slices showed no objectionable unpleasant attributes for the panelistson 8th day of storage. Use of this combination to inhibit enzymatic browning and deterioration of fresh-cut fruits may help fresh-cut processors to overcome the significant hurdles that currently impede the commercial development of fresh-cut fruit products.

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