

The effect of carboxymethylcellulose coating on the temperature-controlled storage of mangoes

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ABSTRACT. Mango is a highly perishable tropical fruit with intense post-harvest metabolism, limiting its marketing period to distant regions. The application of edible coatings is an efficient way to preserve the quality of a fresh product during post-harvest storage. In the present research, the impact of a 3% carboxymethylcellulose (CMC) coating was studied on mangoes during storage at 20° C for 10 days. Results showed that treatment with 3% CMC delayed fruit maturation, suppressed the increase in total soluble solids, decreased firmness, and showed substantially higher titratable acidity, along with maintenance of skin color, in contrast to uncoated fruits. In conclusion, 3% CMC coating can be an effective approach for maintaining fruit quality of harvested mangoes during storage at 20°C.

Keywords: Packaging, Filmogenic Solution, Shelf life, Biodegradable.

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INTRODUCTION

Mangoes (*Mangifera indica* L.) are known for attractive appearance, aroma and flavor, with high nutritional value (Ribeiro and Schieber, 2010). However, they are climacteric, highly perishable fruits whose postharvest life is limited (Cárdenas-Coronel et al., 2012).

One of the main problems faced by the mango industry is its postharvest management that, coupled with the short shelf life of the fruit, restricts its transport in distant markets. The use of low temperature storage is one of the most effective ways to maintain the quality of mango post-harvest, and extend its shelf life (Alvarez et al., 2020). However, mango fruits are extremely sensitive to cold injury at temperatures below 13 °C (Zhang et al., 2017).

Several techniques have been used to reduce postharvest losses, one of them is the use of edible coatings (Singh and Singh, 2012), which can be applied directly to the product, and is one of the main practices to preserve the quality of fresh fruits (Valencia-Chamorro et al., 2010; Dhall, R. K., 2013), moreover, they have the additional advantage of

reducing the use of non- biodegradable packaging (Hassan, et al., 2018).

Carboxymethyl cellulose (CMC) is a cellulose derivative, widely studied as an edible coating (Arnon et al., 2014), has great potential to form a transparent and flexible layer and adhere to the surface of the treated product (Ali et al., 2021). CMC is tasteless, odorless, non- toxic, biodegradable, as well as having low cost and being soluble in cold and hot water (Dehsheikh & Dinani, 2019).

OBJECTIVE

Investigate the benefit of 3% CMC edible coating on color, firmness, acidity, brix and overall appearance of mango fruit stored at 20 °C.

MATERIALS AND METHODS

The experiment was carried out in the Laboratory of Fruits and Vegetables of IF Goiano, Rio Verde-GO Campus and the experimental design was entirely randomized.

Mangoes

The fruits were harvested from the orchard of the IF Goiano farm, Campus Rio Verde- GO, at the physiological maturity stage, transported to the Fruits and Vegetables Laboratory, where they were classified and then disinfected in a sodium hypochlorite solution for 10 min.

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Treatment preparation and application (CMC 3%)

CMC powder was dissolved in water at 60 °C and homogenized until complete dissolution in a magnetic stirrer (Duhoranimana et al., 2017). There were two treatments, i.e., C = control and T = CMC (3%). Mangoes were dipped in the coating solution for 3 min and control fruits were dipped in distilled water (also for 3 min). The fruits were then dried at room temperature, kept at 20 °C and sampled at times 0, 5 and 10 days.

Fruit firmness

Determined by using a pedestal flattener (Calbo & Nery, 1995), on which rested the glass vat of known weight (1.107 kg), and made by measuring the length and width of the spot, with the aid of a digital caliper (Digimess):

$$FZ (Kgf\ cm^2) = \frac{P}{A}$$

where: FZ = flesh firmness (Kgf cm²); P = weight of glass vat (kg); A = 0.784 * longer length * shorter length (cm²).

Soluble solids content

Measured in an analog refractometer (model Kruss Optronic Germany - DR301-95) previously calibrated with distilled water, and the values were expressed in °Brix. The measurement was made by depositing a small amount of the homogenized fruit juice on the prism surface and reading the values directly (Malli et al., 2003).

Titrateable acidity

Five g of the fruit were dissolved in 50 mL of distilled water. Acidity analysis was done by titration with 0.1 M sodium hydroxide and 3 drops of phenolphthalein (Adolfo Lutz Institute, 1985). Acidity expressed as a percentage of citric acid:

$$AT = V \times N \times \frac{0.064}{6} \times 100$$

where: AT = titrateable acidity (% citric acid); V = spent volume of NaOH (ml); N = normality of NaOH.

Skin color

It was measured in four equidistant regions of each fruit, and the results expressed by CIE color space L*, a* and b*, where L* indicates the luminosity and the

coordinates a* and b*, are the chromaticity coordinates. L* (100 = white; 0 = black), a* (positive = red; negative = green), b* (positive = yellow; negative = blue) (Konica Minolta, 2003).

The L*, a*, b*, C* and H* values were measured after calibration of the chromameter (CR-400, Konica Minolta, Japan) with a standard white plate (Cardoso et al., 2007).

Data analysis

Relative data were analyzed and the results were expressed as percent (P%), according to rate of change (value at later time ÷ value at earlier time) - 1] × 100.

RESULTS AND DISCUSSION

Fruit firmness

Retention of fruit firmness was associated with suppression of softening enzyme activities (Fagundes et al., 2015). Edible mulch treatment shows a positive impact on retaining firmer fruit (Hussain et al., 2010) due to suppressed softening enzyme activity (Ali et al., 2020). Fruit firmness decreased over the course of storage time for all fruits, but at differential rates, as per data in Table 1, which shows a 7.65% decrease in firmness of coated fruits on day 10 of storage, contrasting with the 14.28% decrease in firmness of control mangoes.

Soluble solids content and titrateable acidity

The application of the 3% CMC coating significantly delayed the increase in total soluble solids and exhibited higher titrateable acidity concentration, substantially suppressing the increase in ripening index. Generally, control fruits exhibited a remarkably higher (1.22-fold) increase in total soluble solids after 10 days of storage compared to the 3% CMC treatment. With regard to titrateable acidity, the 3% CMC coating retained a significantly higher concentration of titrateable acidity throughout storage, according to Table 1.

Table 1 - Average reading of Brix and Titrateable Acidity values at time zero, five and ten days of storage

Time	3% CMC coated mangoes			Control mango		
	Brix	%Acidity	Firmness	Brix	%Acidity	Firmness
T0	3.53	1.177	0.915	3.26	1.188	1.04
T5	3.41	0.967	0.910	3.53	0.818	0.970
T10	9.16	0.708	0.85	11.2	0.242	0.91

Table 2 - Results of color attributes - L*, a*, b*, Chroma (C*) and hue angle (H) - of mango peel treated with CMC 3% and control, evaluated up to 10 days of controlled storage (20°C)

	T0					T5					T10				
	L*	a*	b*	C*	H*	L*	a*	b*	C*	H*	L*	a*	b*	C*	H*
CMC 3%	47.5	-15.5	27.7	31.8	119.2	50	-15.4	28.5	32.5	118.6	48	15.9	29.07	33.1	118.8
Control	46.9	-15.8	27.2	31.5	120.3	46.3	-15.9	26.7	31.3	120.8	61.6	3.9	55.65	55.8	85.3

Skin color

The L*, a* and b* values changed significantly from day 5 to day 10 of the storage period (Table 2). The L* value increased progressively and significantly as time progressed in the control fruit, in contrast, it showed a significantly smaller change in the peel of the 3% CMC coated mango. Similar to L*, the a* and b* values also showed an increasing trend from day-5 to day-10. On day 10, the L*, a* and b* values were 0.277, 1.235 and 0.881% higher respectively in the control mangoes compared to the group coated with CMC 3%. The variations in brightness values, internationally recognized by the abbreviation L*, were suppressed during storage time, except for those fruits subjected to CMC 3%, whose values increased from 47.542 at the beginning of storage to 48.093 at the end of storage. In contradiction to the control that presented L* 49.977 at the zero time and 61.462 at the last day of the experiment. The lower values of L*, a* and b* in mangoes coated with CMC 3% can be attributed to the delay in the development of the peel color due to the reduced accumulation of carotenoids. In our case, the 3% CMC coating probably delayed the breakdown and degradation of chlorophyll contents and reduced the accumulation of carotenoids, therefore, resulted in delayed yellow color development of the coated mango fruits.

CONCLUSION

The 3% CMC-based edible coating was efficient to delay ripening and maintain the quality of mango for 10 days in storage at 20°C. The pre-storage treatment with CMC positively influenced firmness, Brix, titratable acidity and delayed the skin coloration changes of mango fruits. Mangoes treated with 3% CMC had reduced softness, decreased total soluble solids, along with markedly higher titratable acidity retention. Thus, CMC 3% coating can be considered a potential postharvest treatment for delaying ripening and preserving the eating quality of harvested mango fruits.

CONFLICT OF INTEREST DECLARATION

The authors declare no potential conflict of interest in connection with the research, authorship, and/or publication of this article.

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