Research article

Effect of 1-Metylciclopropene application on some physicochemical and organoleptic properties of sweet passion fruit

Efecto de la aplicación de 1-Metilciclopropeno sobre algunas propiedades físico-químicas y organolépticas del fruto de la granadilla

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Abstract

Shelf life extension of the sweet passion fruit is helpful for its marketing, since it is positioned in the international market as a gourmet fruit. In this work the effect of applying an antagonistic agent to the ethylene action was evaluated, 1- methylcyclopropene (1-MCP) was used to prolonged shelf life of sweet passion fruit, stored of 27 ± 2 °C and 76 ± 2% RH. Physical properties as weight loss, firmness loss and color changes were evaluated, together with chemical properties such as pH, acidity and soluble solids and sensory analysis. Three concentrations of 1-MCP: 200, 400 and 600 mg/l with three exposure times: 15, 30 and 60 seconds were applied. The results suggest that application of 600 mg/l of 1-MCP for 60 seconds of exposure preserves the fruit during 15 days at 27 ± 2°C and 76 ± 2% of HR.

Key words: Controlled maturation, ethylene, 1-MCP, *Passiflora ligularis*, postharvest physiology, storage.

Resumen

Se evaluó el efecto de la aplicación de 1-metilciclopropeno (1-MCP), un agente antagonista a la acción del etileno -el 1-metilciclopropeno es utilizado para prolongar la vida útil del fruto de granadilla común-, almacenado a 27 ± 2°C y 76 ± 2% de HR. Se evaluaron propiedades físicas como pérdidas de peso, cambios de dureza de la corteza; propiedades químicas como pH, acidez titulable y sólidos solubles; y propiedades organolépticas como cambios de color. Se aplicaron tres concentraciones de 1-MCP: 200, 400 y 600 mg/lt y tres tiempos de exposición: 15, 30 y 60 segundos. Los resultados sugieren que la aplicación de 600 µg/lt de 1-MCP y 60 segundos de exposición conserva la granadilla común durante 15 días a 27 ± 2°C y 76 ± 2% de HR.

Palabras clave: Almacenamiento, etileno, fisiología poscosecha, maduración controlada, 1-MCP, *Passiflora ligularis*.

Introduction

Sweet passion fruit (*Passiflora ligularis* Juss) is an exotic fruit plant, found among the new preferences of customers looking for convenient, innocuous and highly nutritious fruits. Colombia is the main producer in the world with a production of 43885 ton in 2007 and 52305 ton in 2008. The region of Huila is the largest producer with 46.5% of the national production in 2008. Also, Colombia is the main world exporter of this fruit. In 2008, exportations were about 2444 ton, being one of the most attractive agribusinesses in Colombia (Parra-Morera *et al.*, 2011).

One of the widely used strategies to prolong fruit shelf life is the use of 1-metylciclopropene (1-MCP) as an ethylene antagonist (ethylene is a hormone involved in the ripening process). This inhibitory property of 1-MCP was disco–vered and patented in USA by Sisler y Blan–kenship (1996). The first works and commercial developments of the product were done in flowers, in which the natural senescence was delayed (Sisler *et al.*, 1996; Chitarra y Chitarra, 2005).

1-MCP is a product used at low concentrations, it is commercialized in solid or gaseous state and shows variable results depending on the treated fruit, its morphological and physiological characteristics and storage conditions and time (Grichko *et al.*, 2006). Such variabi–lity on results using 1-MCP has motivated diverse studies aimed to evaluate its effect on ripening, senescence delay, and post harves–ting conservation of fruits such as banana, (Jiang *et al.*, 1999), apple (Fan *et al.,* 1999), mango (Hofman *et al.*, 2001), avocado (Kluge *et al.*, 2002), passion fruit (Andrade, 2004), soursop, guava, papaya, tomato (Beno-Moualem *et al.*, 2004), melon (Dussán-Sarria *et al.*, 2005; Alves *et al.*, 2005), and kiwi (Mao *et al.*, 2007).

Nonetheless the excellent quality of the sweet passion fruit, it is a perishable product. Due to its high water content its storage time is relatively short, and this complicates its commercialization. This study aimed to eva–luate the effect of 200, 400 and 600 µg/l aplications of 1-MCP on sweet passion fruits for 15, 30 and 60 sec on some physical traits such as, weight and hardness loss; chemical traits as pH, acidity and soluble solids; and organoleptic characteristics such as color and flavor.

Materials and methods

Plant material. Sweet passion fruits from a common cultivar were harvested in 2008 from Calima-Darien (1485 ma.s.l, 18°C) in Valle del Cauca, Colombia. Fruits were harvested in a ripening grade of 3 according to regulation ICONTEC NTC 4101 (1997), which is the adequate grade to export. Fruits without any external damage such as cuts, pest or diseases, were selected for further treatment. Selected fruits were washed and disinfected by immersion in water with chlorine (200ml/l), followed by a wash with distilled water to eliminate chlorine traces.

1-MCP preparation and application. The product was prepared following provider´s (AgroFresh INC.) instructions. 40 l. 1-MCP solutions were prepared in 200, 400 and 600 mg/l concentrations in distilled water. 8 kg. of fruits, previously cleaned, were immersed in the respective solutions and time according to the applied treatments (Table 1).

Once the exposition time passed, fruits were extracted from the solution and submerged on drinking water for 5 min. to clean excess product. After that, they were dispose

Table 1. Applied treatments on the evaluation of 1-MCP as a ripening delaying treatment on common sweet passion fruit.

Treatment	1-MCP concentration (µg/lt)	Exposition time (sec)
T1	200	15
T2	200	30
T3	200	60
T4	400	15
T5	400	30
T6	400	60
T7	600	15
T8	600	30
T9	600	60
T10	Control	0

on plastic baskets (30 cm x 40cm x 60cm) in three layers of fruit separated by cardboard panels, and were storage at 27 ± 2 °C and 76 ± 2 % RH. Physical, chemical and organoleptic evaluations were done every 3 days.

Weight loss. 10 fruits of each treatment were taken for this measurement. Fruits were weighted every 3 days on a precision balance. This trait was calculated by the following equation.

$$\%Wl = \left({}^{Wi - Wf}/_{Wi}\right) * 100$$

where, $\%Wl$ is water loss percentage (%), Wi is the fruit sample initial weight (g), Wf is the fruit sample final weight (g).

Hardness. It was determined with a penetrometer of maximum reading of 196.06 kPa and 6 mm cylindrical tip. Measurement was done by triplicate, applying a constant force in the equatorial area directly on the fruit skin. Results are expressed in force units (Newton).

Titratable acidity, pH and total soluble solids. To determine titratable acidity, pH and total soluble solids three fruits per treatment were used, their pulp was extracted and the content was homogenized. The titratable acidity (TA) was determined according to the method proposed by the Regulation AOAC 942.15 (2005) and was expressed as citric acid percentage. pH values were directly determined on the homogenized pulp using a potentiometer, and the total soluble solids (TSS) by refractometer (Reichert, Germany) directly on the homogenized pulp.

Organoleptic analysis. This analysis was done every 3 days by 20 persons that acted like no-trained judges and judge the external appearance by using a nine points hedonic scale, being 1= Like Extremely and 9= Dislike Extremely. Changes in ripening stage were measured by means of fruit coloration through time according to ICONTEC Regulation NTC 4101 (1997) which described stages form 0 to 6, O dark green color and well developed fruit, and 6 an orange or reddish fruit.

Experimental design and statistical analysis. To evaluate 1-MCP effect a 3 x 3 factorial design with two factors: 1-MCP concentration factor in three levels: 200 mg/l, 400 mg/l and 600 mg/l, and time factor with three levels 15 sec, 30 sec and 60 sec. Treatments were done in triplicate and a control without 1-MCP aplication was used. Treatments are depicted in Table 2. Results were analyzed by analysis of variance (Anova) using the software for statistical analysis ESTAT version 2.0 (1993), and the mean comparison was done with a ´t´ Tukey´s test ($P < 0.05$).

Table 2. Ripening stage on common sweet passion fruit according to legislation NTC 4101, treated with different 1-MCP concentrations and exposition times.

Day	Treatments (1-MCP -µg/l)									
	200			400			600			Control
	T1*	T2	T3	T4	T5	T6	T7	T8	T9	T10
0	3	3	3	3	3	3	3	3	3	3
3	5	4	5	4	5	4	5	4	4	4
6	5	5	5	5	5	5	4	5	6	6
9	6	6	6	6	6	6	5	5	5	6
12	5	5	5	6	5	6	5	5	5	6
15	6	6	6	6	6	6	6	5	5	6
18	—	—	—	—	—	—	—	6	6	—
21	—	—	—	—	—	—	—	—	—	—

(—) = Fruits lost their commercial value. Ripening stage values unequal are statistically different ($P < 0.05$). * treatment correspondences are on Table 1.

Results and discussion

Fruit weight. Figure 1 shows the absolute weight percentages and the relative accumulated weight loss for each treatment. A progressive weight loss through time is observed ($P < 0.05$). This loss is affected by the physiological processes of transpiration and respiration (Kader, 1992). e.g., in the day 15 of storage, the accumulated weight loss in water

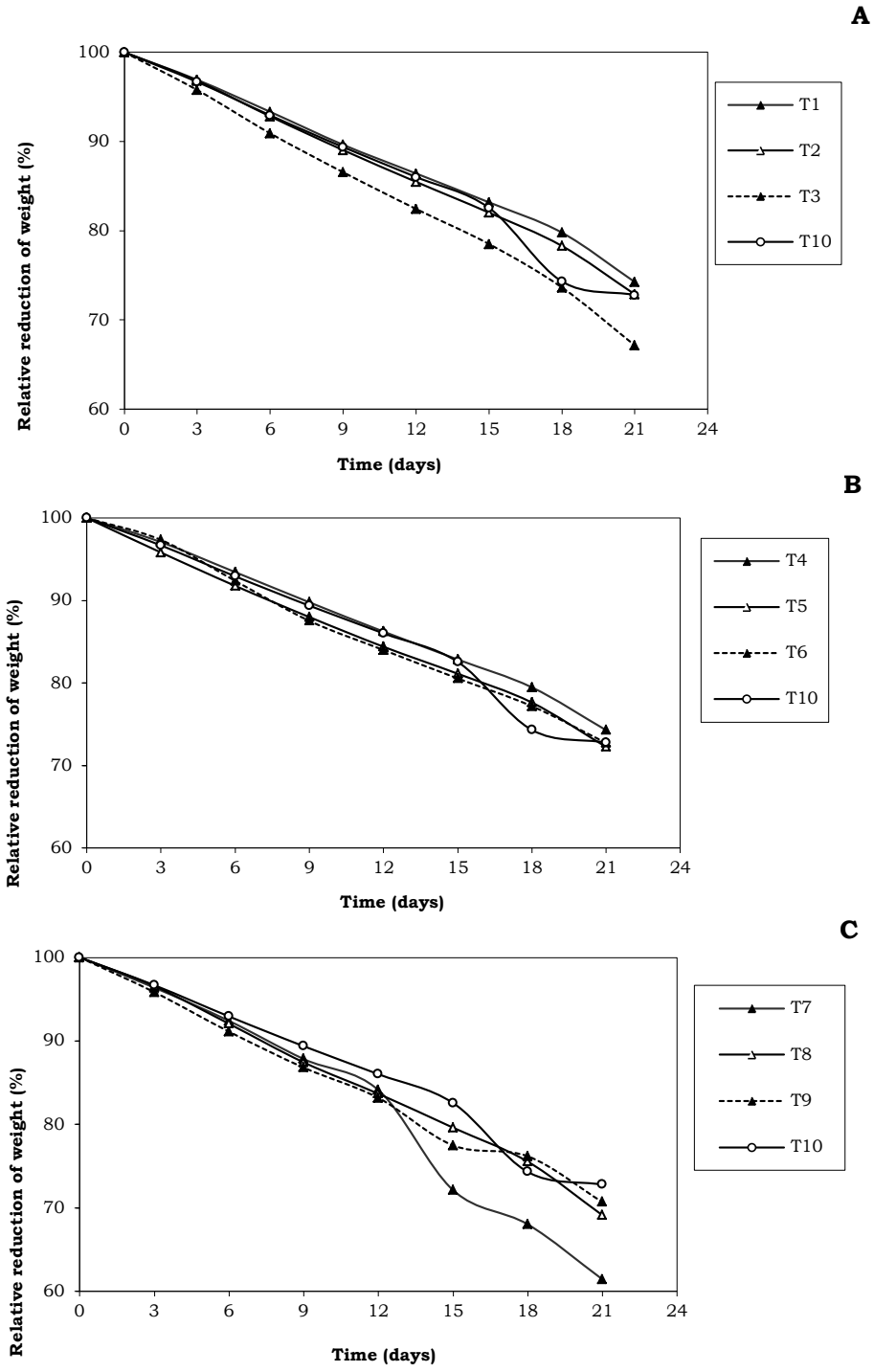

Figure 1. Relative reduction (loss) of weight during sweet passion fruit storage time treated with different 1-MCP concentrations and exposition times **(A)** 200 μg/l and 30 sec. **(B)** 400 μg/l and 15 sec. **(C)** 600 μg/l and 60 sec. Treatment correspondence is on Table 1

varied between 175 and 23% in all the treatments. In general, during 21 days of storage the treatment showing higher loss value was the control (T10). Considering the storage day 15, the average loss values during this period were not significantly different (P > 0.05).

Hardness. Figure 2 shows hardness reduction among sweet passion fruits during the storage time. During the first 3 days the

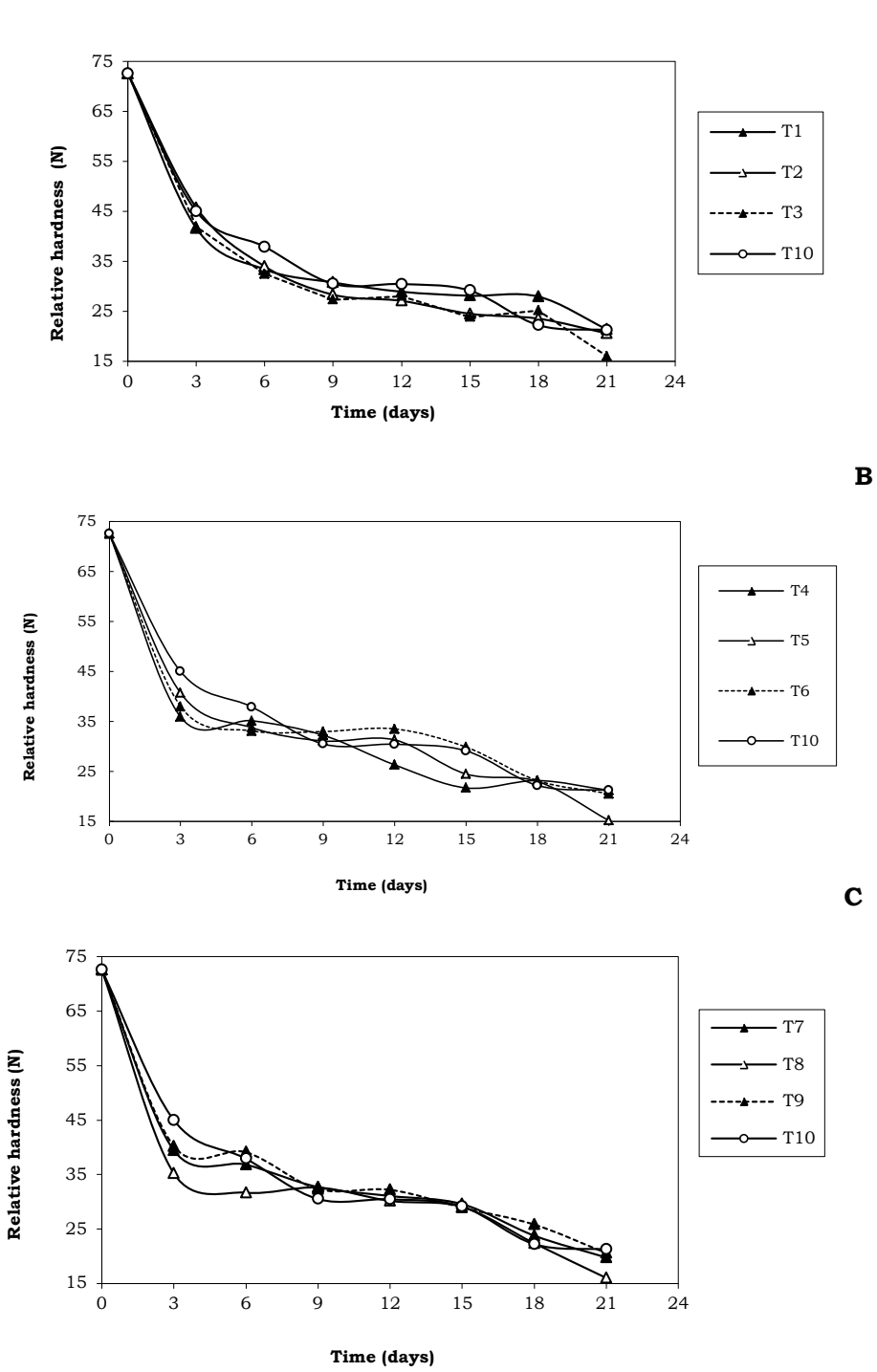

Figure 2. Relative hardness loss on common sweet passion fruit, expressed in Newton (N), treated with different 1-MCP concentrations and exposition times **(A)** 200 μg/l and 30 sec. **(B)** 400 μg/l and 15 sec. **(C)** 600 μg/l and 60 sec. Treatment correspondence is on Table 1.

fruits both untreated and treated had reduced the hardness of the skin; they varied from 73 N to 37 N. In the day 15 there were no statistically significant differences ($P > 0.05$) in the hardness value of the treatments. During this period sweet passion fruits of the T9 treatment showed a fruit hardness close to 29 N. Salda–rriaga (1998) found similar results on sweet passion fruits stared at 17 °C for 11 days. Hardness loss is attributed to pectin and cellulose degradation on fruits (Gallo, 1996).

Tritatable acidity and pH. Tritatable acidity values decreased during the storage time, they were 0.53% in average and ended at day 21 in 0.29%.

In general, pH values remained constant during the storage time, 4.81 was the starting value and it was 4.66 on day 21. In this period of time treatment 9 showed a pH 4.72 and tritatable acidity 0.59%. Normally pH values on post harvested fruits tend to increment and tritatable acidity tends to diminish, in this work with sweet passion fruit only the last phenomena was recorded.

Total soluble solids. Total soluble solids presented slight variations during storage (Table 3). Those fluctuations are due to the difficulty to select fruits on a sequential ripening stage for a periodic sampling. Similar results were found by Chitarra y Chitarra (2005) on different storage fruits.

Between days 0 and 15 there was a slight increase in total soluble solids value: from 13 °brix to 14.5 °brix. Those results are similar to the ones found by Saldarriaga (1998). In the day 15 fruits treated with 600 mg/l 1-MCP for 60 sec. (T9) showed the lowest total soluble solids value (12.5 °brix) in comparison to the other treatments ($P < 0.05$). After day 15 a reduction on the °brix was observed, which reflects the normal behavior of fruits in the senescence phase (Chitarra y Chitarra, 2005).

Organoleptic properties. In the day 3 of storage, sweet passion fruits still remain green. In this stage the judges assigned an average value of 6 (like slightly). In the day 15, fruits in all the treatments were around 6 and 9 values. Between day 18 and 21 dark spots appeared on fruits skin.

On day 15 of storage, treatments T8 and T9 showed a ripening stage lower than the other treatments (Table 2), which indicates that 1-MCP had an effect on delaying ripening of sweet passion fruit. 5 and 6 ripening stages are statistically different ($P < 0.05$), confirming the results of Valero *et al.* (2003) who found that 300mg/l and 500mg/l concentrations of 1-MCP had an effect on the fruit color storage on refrigerated conditions. These analysis allow the affirmation that a 15 days period of time is the limit for fruit conservation.

Table 3. Total soluble solids evolution on sweet passion fruit treated with different 1-MCP concentrations and exposition times.

Day	Treatment (1-MCP -µg/l)									
	200			400			600			Control
	T1*	T2	T3	T4	T5	T6	T7	T8	T9	T10
0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
3	13.7	12.4	13.3	13.3	11.7	13.5	13.7	14.3	12.8	12.1
6	13.7	14.5	13.3	13.0	13.3	13.3	12.7	13.8	13.5	13.3
9	13.4	13.0	12.9	12.3	13.2	13.0	14.0	13.0	13.3	13.5
12	13.8	14.7	14.1	14.4	14.0	13.3	13.6	13.3	14.5	14.2
15	13.4	13.9	13.3	13.8	13.3	13.7	14.5	13.4	12.5	14.4
18	12.1	11.9	11.1	12.7	12.8	13.2	11.8	13.1	13.5	11.7
21	13.6	13.5	12.9	12.7	12.3	13.0	13.5	13.5	13.4	14.1

* Treatment correspondences are on Table 1.

Conclusions

- Application of 1-MCP at different concentrations and exposition times showed a low incidence of the ripening process in sweet passion fruit while stored at 27 ± 2 °C and 76 ± 2% RH. Nevertheless, high concentrations of 1-MCP and longer exposition times improved shelf life quality, favoring soluble solids and organoleptic characteristics (color and flavor).
- 1-MCP treatment of 600 mg/l during 60 sec. was the best preserving the common sweet passion fruit and gave a 15 days shelf life under the conditions mentioned before.

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