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Organic versus conventional: a comparative study on the shelf life of passion fruit (*Passiflora edulis* Sims) crops

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Abstract

Yellow passion fruit (*Passiflora edulis* Sims) is one of the most appetising fruits worldwide due to its intense flavour. There have been few published studies comparing the evolution of storage quality parameters and shelf life of organic and conventional tropical fruit crops. The aim of the present work was therefore to compare the temporal changes in various physicochemical parameters and commercial shelf life of fresh organic passion fruit (OPF) and conventional passion fruit (CPF), under the same storage (20.0 ± 1.0°C, 85.0 ± 2.0% relative humidity) and initial maturity conditions. Colour measurements and total soluble solid contents showed significant differences between OPF and CPF. Increasing colour difference (ΔE) and decreasing hue angle values were observed during the storage in both crops. Nonetheless, the rate of growth of ΔE in CPF was higher than that in OPF. In contrast, the initial temporal rate of reduction in the hue angle was more rapid in CPF. Total solid soluble content remained almost unaltered during the observation period, and there were insignificant differences in the measured values between OPF and CPF. Firmness and active acidity did not manifest significant differences between the crops. The same loss of weight (30.0% ± 1.0%) was observed in both crops at the end of the storage period.

Introduction

Passion fruit (*Passiflora edulis* Sims), which is a fruit native to the Amazonian region of Brazil and cultivated in Colombia since 1963, belongs to family Passifloraceae. Other species of the family include curuba (*P. mollisima*), badea (*P. quadrangularis*) and granadilla (*P. ligularis*) (López-vargas *et al*., 2013). Passion fruit has a spherical shape (5.5 to 6.8 cm in diameter, 70 to 150 g in weight) with gelatinous yellow pulp (Vielma *et al*., 2012). It is one of the most desirable fruits worldwide due to its particularly intense flavour. It is also one of the most important fruit crops in Colombia, especially in 2015, when the productivity was 14.6 tons per hectare and 4,351 tons were exported (Fernández *et al*., 2015).

The current food market has a tendency for healthy and functional products (free of carcinogenic substances and synthetic compounds) at affordable prices. This trend is strongly associated with the increase in organic agriculture farming in the world during the past 20 years (Secretariat of the Codex Alimentarius Commission, 1999).

Organic agriculture is a production management system that eliminates (from cultivation of crops) the use of synthetic supplies, such as synthetic fertilisers and pesticides, veterinary drugs, genetically modified seeds and breeds, preservatives, additives, and irradiation (Brandt and Mølgaard, 2001). The comparisons of product quality and product durability between conventional and organic crops have been carried out for vegetable and fruit crops, such as tomatoes (Mitchell *et al*., 2007), apples (Notarnicola *et al*., 2017), and blueberries (Strik and Vance, 2015), showing differences in quality parameters depending on the type of fruit or vegetable.

Properties of fruits are unpredictable; they depend on many variables, such as agroecological conditions of cultivation, time between planting and harvesting, maturity of the product, and transport conditions (Kader, 2002). Alterations in fruits postharvest can generate losses in quality parameters during the life

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cycle, resulting in high levels of generated waste and a loss of commercial value throughout all stages of the fruit supply chain (Gil *et al*., 2006).

Measurements of quality changes during postharvest and storage periods can be used to monitor the fruit evolution; however, the best evolution prediction is reached when a combination of methods is used to measure multiple fruit characteristics (external appearance, bioactive compounds, and sensorial analysis).

Therefore, the aim of the present work was to measure and compare the evolution of quality parameters of conventional passion fruit (CPF) and organic passion fruit (OPF) during 10 days storage under identical storage conditions 20.0 ± 1.0°C and 85.0 ± 2.0% relative humidity.

Materials and methods

Passion fruits

OPF and CPF were manually harvested [fruit colour scale 1–2 according to the Colombian maturity standard (ICONTEC, 1979)] and provided by a local producer (Frugy S.A. Manizales, Colombia). Fruits were washed with chlorinated water (0.01%) prepared from 5.0% sodium hypochlorite. After tap water rinsing, the fruits were placed in a cold room according to the Colombian storage standard (ICONTEC, 2000) at 20.0 ± 1.0°C and 85.0 ± 2.0% relative humidity. These conditions simulated the storage process in supermarkets in the city of Manizales, Colombia.

Shelf life analysis

The physicochemical characteristics (weight loss, firmness, colour, active acidity, and total soluble solids [TSS]) were evaluated in 10 CPF and 10 OPF fruits during 10 days storage. The end of shelf life was defined as the storage time point at which average weight loss was 20% or when samples started to show damages/deterioration (Cecon and Finger, 2000).

Weight loss

Following the methodology developed by Maniwara *et al*. (2015), 10 fruits of each crop type were separated from the initial batch and weighed each day by means of a digital balance (AX324, Parsippany, USA). The weight loss of each fruit was expressed as a percentage reduction according to Equation 1.

$$\%W_L = \frac{(W_o - W_i)}{W_o} \times 100\% \qquad \text{(Eq. 1)}$$

where $\%W_L$ = percentage of weight loss, W_O = initial weight, W_i = final weight.

Firmness

The firmness was measured using a texture analyser (Stable MicroSystem TA.XT Plus, Godalming, UK) by a non-invasive compression test with deformation fixed with a 2 x 75 mm probe over a flat plate: the test was carried out with a pre-test speed of 5 mm/s and a speed of 1 mm/s with a 1 N force, following the methodology proposed by Hertog *et al*. (2004). Each fruit was analysed twice on opposite sides of its equatorial zone. The firmness value was calculated as the average of two measurements. Results were expressed as force in Newtons (N).

Active acidity

The active acidity was determined using a pH meter (pH3110, Weilheim, Germany). Measurements were performed in triplicate on all samples and were expressed on a pH scale, ranging from 0 to 14

TSS content

This concentration (sucrose, fructose, among others) was measured using a digital refractometer Brixco (ABBE 3030, Medellín, Colombia). Measurements were performed in triplicate on all samples and were expressed in °Brix.

Colour

The peel colour was measured with a portable spectrophotometer colorimeter Konica Minolta (CR-700, Tokyo, Japan) in the CIELab colour space. Parameters a* (red-green dimension), b* (yellow-blue dimension), and L* (luminosity) were determined. Colour difference (ΔE) and hue angle (h) were calculated using equations (2) and (3). Measurements were taken on two equatorial sides of the fruits, taking the average of the results as the final value (Giné Bordonaba *et al*., 2014).

$$h = \arctan\left(\frac{b^*}{a^*}\right) \qquad \text{(Eq. 2)}$$

$$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \qquad \text{(Eq. 3)}$$

Results and discussions

Weight loss

Fruit weight loss during storage is influenced by the surrounding temperature, humidity, and airflow, and is directly related to transpiration (Pongener *et al*., 2014). In the present work, the weight variation followed a linear decrease for both type of fruit crops (OPF and CPF) during the storage period. It was found that the weight loss percentage did not reach values higher than 30.0% ± 1.0% for both OPF and CPF. The slopes in Figure 1 are the comparative weight loss rates of both fruit crops. According to linear regression for both scopes, weight loss per day for CPF and OPF was 2.67% and 2.49%, respectively, indicating that OPF losses were 7.09% lower than those of CPF. According to the criteria described above, and considering that the purpose was to evaluate commercial variables that a consumer could appreciate; commercial shelf life was therefore defined as when fruit samples started to show damages/deterioration on the peel. For CPF, the shelf life was eight days and for OPF, 10 days.

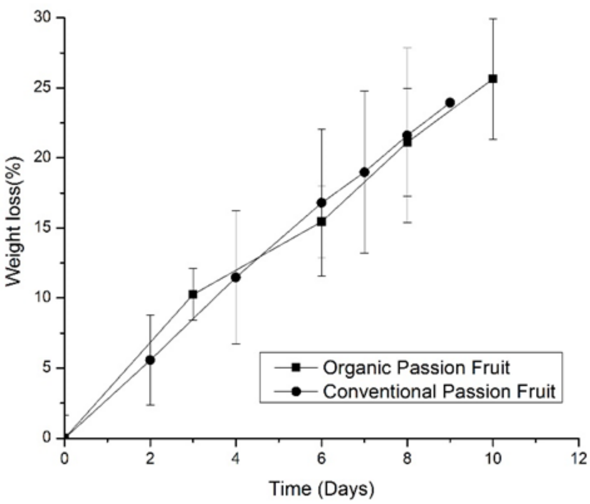

Figure 1. Linear regression curves for weight loss of organic (OPF) and conventional (CPF) passion fruits during 10 days storage.

Thus far, to the best of our knowledge, there has been no study that compared the storage weight evolution of OPF and CPF. Nevertheless, one research group reported similar results on tamarillo weight loss during storage at 5°C for a week, showing 0.49% weight losses per day, at 12°C (Javanmardi and Kubota, 2006). Other researchers also detected linear trends of weight reduction for badea and cassava (Sánchez *et al*., 2014). Other investigators demonstrated a weight loss percentage of 20% for passion fruit stored with Sparcitrus covering (Cecon and Finger, 2000). Similarly, one research group reported a weight loss of 30% for CPF at 24°C for 10 days (Cristina *et al*., 2012). According to these observations, passion fruit loses weight rapidly, which causes shrinkage under conventional storage conditions. Higher moisture loss usually occurs in fruit peels (Bezerra *et al*., 2015). Thus, fruit peels appear visually unacceptable even if the sensory evaluation of the pulp of the fruit indicates satisfaction among consumers (Maniwara *et al*., 2015).

Firmness

Firmness is one of the most influential factors of commercial quality of fruits because consumers tend to analyse freshness and fruit quality via visual appearance and touching (Sánchez *et al*., 2014). The firmness loss presented in Figure 2 correlated with the weight loss due to the loss of water in the outer layer of the fruit. Firmness tendency of both crops were similar, beginning with 32.32 ± 4.94 and 31.19 ± 6.63 N and ending with a value of 8.57 ± 0.60 and 9.59 ± 4.40 N for OPF and CPF, respectively. After six days of storage, there was a noticeable firmness decrease by 73.4% and 69.2% for OPF and CPF, respectively. Some researchers reported similar evolution of firmness for CPF subjected to packaging and storage compared to storage without packaging with values ranging between 6.04 and 8.60 N at 24°C (Espinoza *et al*., 2008). Variation of firmness values could be associated to different initial conditions of maturation; however, the decreasing trend is similar to that found in the present wok.

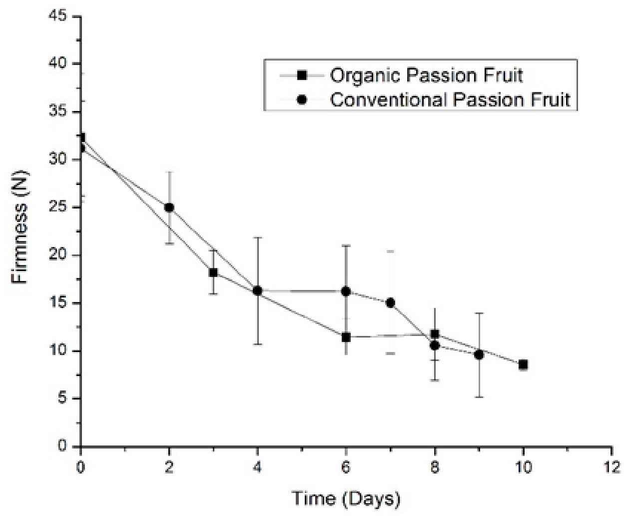

Figure 2. Firmness (N) of organic (OPF) and conventional (CPF) passion fruits during 10 days storage.

Active acidity

Active acidity (pH) remained constant throughout the experiment. Nonetheless, some differences in pH values between OPF and CPF were observed in the first days of storage (0-6 days) (Figure 3). At the end of the storage period, pH values were between 2.80 and 3.00. These values are similar to those reported by other investigators who evaluated the pH variation of fresh pulp (pH: 2.77) and pasteurised pulp at 70°C (pH 2.70) and 90°C (pH 2.70) (Janzantti *et al*., 2014). Similar results were also reported by another research group on yellow, light purple, and dark purple passion fruit, showing the range of pH variation from 2.74 to 3.22 (Araújo *et al*., 2015).

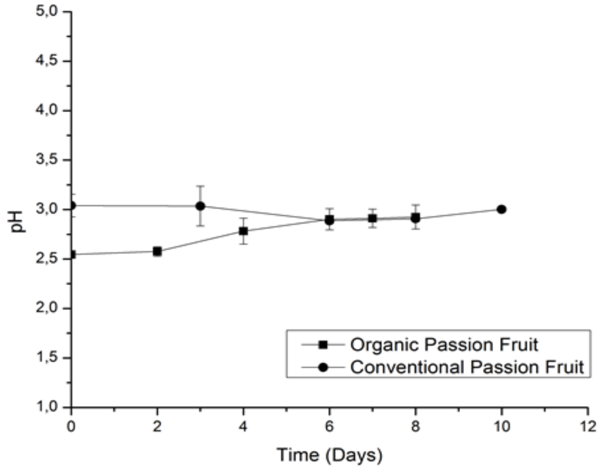

Figure 3. pH of organic (OPF) and conventional (CPF) passion fruits during 10 days storage.

TSS content

TSS content varied slightly (from 8.5 to 10.5 °Brix) in OPF, while no significant changes were observed in CPF during the storage period (Figure 4). Vargas *et al*. (2011) observed similar trend during the ripening of gulupa (*Passiflora edulis* Sims. F. edulis), with an initial value of 13.5 °Brix and a final value of 17.4 °Brix (Jiménez *et al*., 2011). Nonetheless, significant differences between CPF and OPF were detected in TSS, with higher levels of TSS were observed in CPF. Gastol *et al*. (2012) found higher TSS content of organic juices relative to conventional juices for blackcurrant and beetroot; this finding means a better taste of the organic crop. Differences between CPF and OPF could be attributed to the crop conditions.

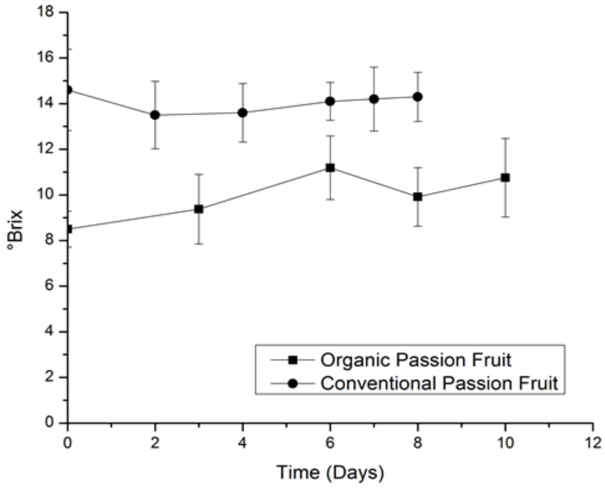

Figure 4. °Brix of organic (OPF) and conventional (CPF) passion fruits during 10 days storage.

Colour measurement

Colour variations in CPF and OPF were analysed in terms of ΔE and h (Figure 5). Colour evolution analysis revealed significant differences between OPF and CPF. Increasing colour differences (ΔE) and decreasing hue angle values were observed during the storage period in both types of fruits. Colour changes were mainly due to the degradation of chlorophyll structure associated with the ripening process of the plant (Della Modesta *et al*., 2005). The temporal rate of ΔE in CPF was higher than that in OPF. In contrast, the initial rate of decrease of the hue angle was more rapid in CPF. One research group evaluated the shelf life of CPF fruits from three different cultivation areas of Mexico, and obtained lower values of the hue angle during an advanced state of ripening (Cruz *et al*., 2010).

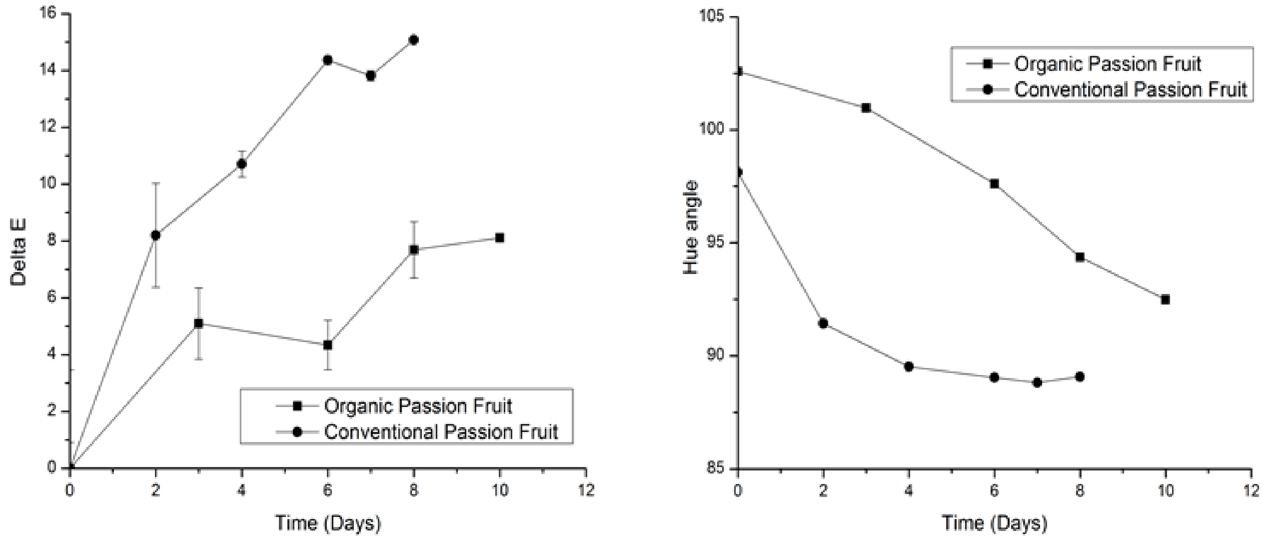

Figure 5. Colour changes (ΔE) of organic (OPF) and conventional (CPF) passion fruits (left). Hue angle of organic (OPF) and conventional (CPF) passion fruits (right), during 10 days storage.

Conclusion

The physicochemical parameters were evaluated to establish the conditions related to the optimal processing and storage of agricultural products for organic versus conventional crops of passion fruits. Two of the measured parameters (pH and °Brix) did not undergo significant variations. Firmness and weight showed a linear decline, while the colour difference (ΔE) increased throughout the storage for the two types of fruits. Nevertheless, the temporal rate of ΔE for CPF was higher than that for OPF. Hue angle decreased for both type of fruits. The obtained results on CPF and OPF fruits during storage are similar to the findings reported in other studies on *Passiflora* fruits. Future work must identify the optimal conditions in terms of the use of refrigeration, packing in special bags, or film covering of fruits, for extending the commercial life of CPF and OPF fruits.

The results obtained in the present work also indicate that organic crops are a sustainable alternative with a positive environmental impact, showing the same potential in terms of storage conditions as do conventional crops; these properties are very useful for the agricultural market.

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