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Research Article

Conservation of Papaya (*Carica papaya L.*) of the Sunrise Variety Through Modified Atmospheres

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Abstract: The aim of this study was to determine the shelf life of papaya of the Sunrise variety, packed in two plastic films, Bi-Oriented Polypropylene/Low-Density Polyethylene (BOPP/PEBD) and Ethylene Vinyl Acetate (EVA), packed with two gas mixtures (5% CO_2 and 7% O_2; 4% CO_2 and 6% O_2). The changes in the fruit were determined by a microbiological analysis of aerobic mesophilic count, fungi, total and fecal coliforms and clostridium sulfite reducer, as well as its sensory characteristics like flavor and hardness, during 26 days of storage. The obtained results on aerobic mesophilic counts, fungi, taste and hardness attributes didn't reveal statistically significant differences with a 95% confidence level between treatments. The treatment that presented the longest shelf life was the one with the gaseous composition of 5% CO_2 and 7% O_2, with BOPP/PEBD packaging material during 23 days of storage, on which the microbiological and sensory parameters of the fruit were preserved; demonstrated that the atmosphere modification is a good alternative to increase the shelf life of fruits.

Keywords: *Carica papaya L.*, modified atmospheres, packaging, plastic film, shelf life

INTRODUCTION

Papaya (*Carica papaya* L.) is a native plant of central and south America which cultivation extends up to 32° latitude south and north of Ecuador, this fruit is cultivated in almost all tropical countries of Central and South America, several Asian countries, as well as in the Antilles and Africa (Chan and Paull, 2008). Brazil stands out as the world's largest producer (Donadio and Zaccaro, 2016); and in Colombia, it is mainly cultivated in the departments of Meta, Córdoba, Valle del Cauca and Nariño; with an area of 7255 ha planted in 2015 throughout the national territory (DANE, 2015).

This exotic fruit is classified as a climacteric fruit because its ripening occurs quickly after harvest, characterized by being a quick perishable fruit (Paull, 1993; Fuggate *et al*., 2010).

During storage of papaya, physiological changes occur that diminish its quality and reduce its shelf life (De Olivira and Vitoria, 2011). The main postharvest factors influencing the shelf life of the product are temperature, relative humidity, surrounding gas concentration and hygienic conditions on the fruit handling (Jacomino *et al*., 2002; Albertini *et al*., 2016).

To extend the shelf life of tropical fruits, there are several available methods, such as refrigeration (Aghdam and Bodbodak, 2013; Pan *et al*., 2017), the use of controlled atmospheres and/or modified atmospheres (Oliveira *et al*., 2015; Ochoa-Velasco and Guerrero-Beltran, 2016; Bodbodak and Moshfeghifar, 2016), the use of films such as wax and starch (Almeida *et al*., 2011; Mistriotis *et al*., 2016; Obi Reddy *et al*., 2017), among others.

Nowadays, there is a continuous demand for fruits and vegetables that are minimally processed and refrigerated, consumer prefers fresh, convenient, high quality and safe products; papaya lists among the exotic desirable fruits on international markets for its nutritional value, sensory characteristics and digestive effects (Ali *et al*., 2014; Paes *et al*., 2015).

Research on papaya storage systems has increased in recent years, such as the study on its conservation (*Carica papaya* L.) associated with the application of edible films (Almeida *et al*., 2011); the study of the cold injury effect due to low temperatures in relation to the energy status of papaya during storage (Calvache *et al*., 2016; Zhang *et al*., 2017); the antioxidant properties of the antioxidant characterization of new dietary fiber concentrates of papaya pulp and peel (*Carica papaya* L.); and life extension studies, such as the use of chitosan solutions for microbiological

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prolongation of the shelf life of papaya during storage at room temperature (Dotto *et al*., 2015).

The conservation by modified atmospheres method uses plastic films that limit the gas exchange and the loss of water, which has an effect on the prolongation of the fruit's shelf life (Reis *et al*., 2016; Rubio *et al*., 2016). There are multiple researches among the modified atmospheres application on fresh fruits and vegetables, some of them are, strawberry (Jouki and Khazaei, 2014), melon (Silveira *et al*., 2015), apple (Cortellino *et al*., 2017), pear (Suchanek *et al*., 2017), sweet corn (Hussein *et al*., 2015) and tomato (Domínguez *et al*., 2016); and the application of this method for the conservation of minimally processed fruits such as pitahaya (Vargas *et al*., 2010), watermelon (Rojas *et al*., 2008), among others.

The present study aims to investigate the behavior of papaya (*Carica papaya* L.) of the Sunrise variety packaged in modified atmospheres, to determine the combination of the optimal gas mixture and plastic packaging that increases the shelf life of the product, based on its microbiological and sensorial characteristics.

MATERIALS AND METHODS

This research was carried out in the Pilot Plant and Laboratories of the University of Cordoba, using papaya of the Sunrise variety, with a physiological maturity state between 60 and 80%, obtained from producers of the municipality of Valencia-Cordoba (Colombia); reagents and culture media of excellent quality and high purity were used.

The fruits were classified based on size and weight, then packed in two plastic films of Bi-Oriented Polypropylene/low-Density Polyethylene (BOPP/PEBD) and Ethylene Vinyl Acetate (EVA) and two gas mixtures (5% CO_2 and 7% O_2; 4% CO_2 and 6% O_2) and stored at a temperature of 13±1°C. The following treatments were evaluated: treatment one: 5% CO_2 and 7% O_2 plastic film BOPP/PEBD; treatment two: 5% CO_2 and 7% O_2 plastic film EDA; treatment three: 4% CO_2 and 6% O_2 plastic film BOPP/PEBD and treatment four: 4% CO_2 and 6% O_2 plastic film EDA.

The counting of viable aerobic and facultative mesophiles of fungi, total and fecal coliforms and clostridium sulfite reducing spores was performed using microbiological analysis techniques established in the Compendium of methods for the microbiological examination of foods (Vanderzant and Splittstoesser, 1992). The Sensory analysis included taste and hardness measurement through a triangular test of ordering by attribute, using trained judges for two months (Minim, 2006); Microbiological and sensory parameters were determined in triplicate during storage days 0, 10, 20 and 26, respectively.

To determinate the best packaging and gaseous mixture combination in order to extend the shelf life of papaya based on its microbiological and sensorial characteristics, a block statistical design divided through time with three replications was applied, using a 3×4×4 factorial arrangement (3 replicates ×4 times ×4 treatments).

Table 1: Medium tables of microbiological variables

Source of variation	Time 0	10	20	26
Mesophiles	0	2186.1	9133.3	174316.7
Fungus	0	0	1875	10

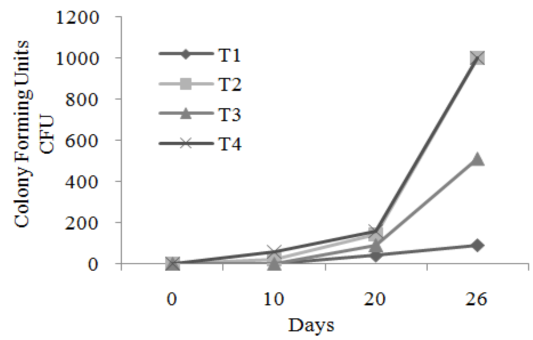

Fig. 1: Aerobic mesophil count

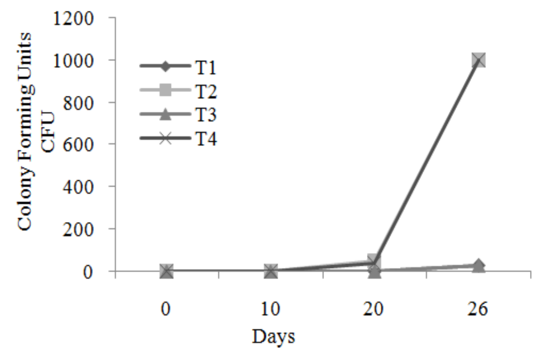

Fig. 2: Fungus count

RESULTS AND DISCUSSION

Table 1 presents the analysis of variance of microbiological variables of papaya packed in different plastic films, which shows no statistically significant differences with a 95% confidence level ($p \geq 0.05$). For the four treatments, Clostridium sulfite reducer spore counts of less than ten Colony Forming Units (CFU) and less than three total and fecal coliforms were reported during the 26 days of observation, so no variance analysis was performed for these variables.

Figure 1 and 2 shows the microbiological variables behavior, where it can be seen that treatments 2 and 4 registered the highest count of aerobic mesophiles and fungi; it is worth noting that treatment one (5% of CO_2 and 7% of O_2 with BOPP/PEBD film) had the lowest mesophilic and fungus counts, therefore at a microbiological level, it can be considered as the best treatment.

Table 2: Sensory ordering test results-Friedman test preference

		Treatment			
Repetition	Atribute	1	2	3	4
1	Flavor	17a	15a	9a	18a
	Hardness	8b	20a	22a	10b
2	Flavor	14a	16a	17a	13a
	Hardness	14ab	19a	18ab	7b
3	Flavor	13a	15a	15a	16a
	Hardness	16a	19a	16a	9a

*: Means with the same letter in the same line do not differ from each other at the 5% probability level for the Friedman test (dms = 12)

Ochoa-Velasco and Guerrero-Beltran (2016) indicated that microbial growth increases in fruit packaged in modified atmosphere; however, at low temperatures the microbial growth decreased. On the other hand the effect of Modified Atmosphere Packaging (MAP) on microorganisms can vary, depending mainly on the storage conditions and the type of packaged product (Oliveira *et al*., 2015).

Table 2 presents the statistical analysis of sensory variables using the sorting test attribute, which reveals no statistically significant differences with a 95% confidence level ($p \geq 0.05$), except in the hardness measurement for the first test; it also indicates that treatment one obtained higher ratings in sensory attributes.

Based on the results presented, treatment 1 (5% CO_2 and 7% O_2 with BOPP/LDPE film) was selected because of its better preservation of microbiological and sensorial characteristics; prolonging the shelf life of papaya in a modified atmosphere for 20 days.

CONCLUSION

The aerobic and fungal mesophiles counts showed no statistically significant differences, while the total and fecal coliform and clostridia counts did not grow during the observation days.

Flavor and hardness attributes were not statistically significant at the 5% level for the treatments.

The shelf life of papaya (*Carica papaya* L.) can be prolonged, using the combination of packaging and gas mixture selected for treatment one (5% CO_2 and 7% O_2 with BOPP/PEBD film), reaching an average shelf life of 20 days, selected for its microbiological and sensory characteristics.

CONFLICT OF INTEREST

Authors declare no conflict of interests of any nature.

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