Advance Journal of Food Science and Technology 16(SPL): 255-259, 2018
DOI:10.19026/ajfst.16.5964
ISSN: 2042-4868; e-ISSN: 2042-4876

Submitted: September 14, 2017 Accepted: January 25, 2018 Published: November 10, 2018

Research Article

Physicochemical Characteristics of Papaya (*Carica papaya L.*) Preserved in Modified Atmospheres

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Abstract: The aim of this study was to determine the physicochemical characteristics of papaya fruit (*Carica papaya L.*) from the Sunrise variety, packed in 2 plastic films (Bi-oriented Polypropylene/Low-Density Polyethylene and Ethylene Vinyl Acetate) and 2 gaseous mixtures of oxygen and carbon dioxide. Papaya produced in Valencia-Córdoba (Colombia) was packed in 2 plastic films (BOPP/LDPE and EVA) with 2 gaseous mixtures (5% CO_2 and 7% O_2, 4% CO_2 and 6% O_2) were packed and stored for 1 month at temperature of 13±1°C; physicochemical analyzes of pH, acidity, weight loss and oxygen and carbon dioxide concentrations were carried out inside the package during storage. The results indicate that the physicochemical parameters do not have a linear behavior and do not show a statistically significant difference between the samples at a 95% confidence level; while for the case of oxygen and carbon dioxide concentrations, significant differences are found at a 95% confidence level between treatments. The treatment with a gaseous composition of 5% CO_2 and 7% O_2 in the BOPP/LDPE film preserved the physicochemical characteristics of the fruit better, being recommended for its conservation under the conditions of this study.

Keywords: *Carica papaya L.*, conservation, modified atmospheres, packaging, physicochemical characteristics, post-harvest losses

INTRODUCTION

Papaya (*Carica papaya L.*) is an exotic and very popular fruit in the international market (Ali *et al.*, 2014), its cultivation in Colombia registered 7255 ha planted in 2015 (0.5% of the area cultivated in the country), which were concentrated on the departments of Meta, Córdoba, Valle del Cauca and Nariño (DANE, 2015). It is cultivated in almost all the tropical countries of central and South America, also in Hawaii, Sri Lanka, several Asian countries, as well as on the Antilles and tropical Africa (Chan and Paull, 2008); Brazil highlighted as the largest producer of papaya that supplies 25% of world demand (Donadio and Zaccaro, 2016).

Papaya is a climacteric fruit that grows throughout the year, during the postharvest papayas ripen very quickly, so this is why it is considered a perishable fruit (Fuggate *et al.*, 2010); and during its storage, it suffers physiological changes that negatively influence the development of the crop, decreasing the quality of the fruit and reducing its shelf life (De Oliveira and Vitoria, 2011).

Past studies estimate losses between 20-30% of the production, attributable to poor postharvest management, inefficient conservation systems and other types of fruit alterations (Martins and Farias, 2002). Due to the postharvest losses that were registered, it is important to control the ripening process, so the shelf life can increase, thus ensure quality on the domestic market and exports (Jacomino *et al.*, 2002; Albertini *et al.*, 2016).

There are several different procedures to extend the shelf life of tropical fruits, including the use of low temperatures (Aghdam and Bodbodak, 2013; Pan *et al.*, 2017), which is a traditional method and also the cheapest for prolonged storage of fresh fruits and vegetables; the use of controlled atmospheres and/or modified atmospheres, which use has been generalized as a simple process for conservation (Oliveira *et al.*, 2015; Bodbodak and Moshfeghifar, 2016; Ochoa-Velasco and Guerrero-Beltran, 2016); in addition and not less important the use of films of another nature, including wax and starch (Almeida *et al.*, 2011; Mistriotis *et al.*, 2016; Obi Reddy *et al.*, 2017).

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In the conservation of fruits using modified atmospheres procedure, plastic films that limit the gas exchange and the loss of water are used, diminishing the metabolism of the product and prolonging its shelf life (Reis *et al*., 2016; Rubio *et al*., 2016). The range of fresh fruits and vegetables that have been conserved by this technique is very wide, research relates its application to 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). It has also been used in combination with other techniques for the conservation of minimally processed fruits such as pitahaya (Vargas *et al*., 2010), watermelon (Rojas *et al*., 2008), among others.

The present research aims to evaluate the application of modified atmospheres as a method of conservation for the papaya (*Carica papaya L.*) from the Sunrise variety, based on the monitoring during the storage of its physicochemical characteristics.

MATERIALS AND METHODS

We used papaya from the Sunrise variety, provided by producers of the municipality of Valencia (Córdoba); high quality and high purity reagents were used for physicochemical determinations.

In order to select the storage temperature, the mentioned fruit was conserved in three temperature ranges at 13±1, 25±1 and 29±1°C, by measuring in triplicate the weight loss, the soluble solids, the percentage of acidity and pH during the storage days 0, 3, 6 and 10, respectively. In order to determine the best gas-mixture combination, the samples were packed in 2 plastic films (BOPP/LDPE and EDA), with 2 gaseous mixtures (5% CO_2 and 7% O_2, 4% CO_2 and 6% O_2) and stored in the selected temperature range, which corresponds to 13±1°C; measuring in triplicate the physicochemical parameters during days 0, 10, 20 and 26 of the storage, respectively.

The treatments evaluated were as follows, treatment one: 5% CO_2 and 7% O_2 plastic film BOPP/LDPE; treatment two: 5% CO_2 and 7% O_2 plastic film EDA; treatment three: 4% CO_2 and 6% O_2 plastic film BOPP/LDPE and treatment four: 4% CO_2 and 6% O_2 plastic film EDA.

To observe the changes in the fruit, its physicochemical characteristics were determined: pH, according to the adapted method 10.041/84 (Bernal, 1993); titrated acidity, expressed as acetic acid by the adapted method 942.15/90 (Bernal, 1993); weight loss by recording weight on analytical balance with precision of 0.1 g; the percentage of CO_2 and O_2 inside the package were observed with a gas analyzer from the brand Dansensor; and soluble solids by means of the ºBrix determination using a 1-30 scale refractometer.

Table 1: Selection of storage temperature *

Attribute	Day	Storage temperature (°C) 13±1	25±1	29±1
Weight loss (%)	0	0.000	0.000	0.000
	3	2.100	5.800	12.400
	6	2.500	9.300	18.700
	10	3.700	12.800	25.700
Soluble solids (°Brix)	0	14.000	10.000	14.000
	3	14.800	11.500	14.000
	6	14.400	14.000	15.000
	10	13.800	15.500	15.000
pH	0	5.100	5.100	5.100
	3	5.450	5.480	5.490
	6	5.400	5.540	5.540
	10	5.790	5.770	5.770
Acidity (%)	0	0.140	0.140	0.140
	3	0.071	0.054	0.071
	6	0.060	0.087	0.074
	10	0.090	0.072	0.107

*: Mean values of 3 replicates

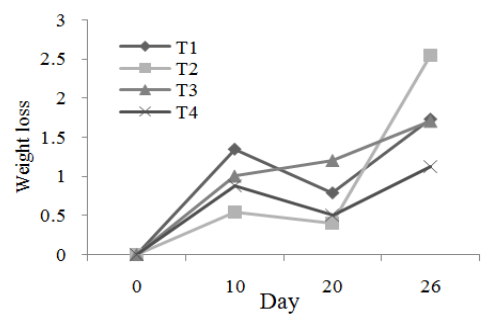

Fig. 1: Weight loss of papaya fruit

In the study, a block design divided through time with 3 replications was applied, using a 3×4×4 factorial arrangement (3 repetitions × 4 times × 4 treatments), for the determination of the combination of gaseous mixture that extended the shelf life of the product without changing its own physicochemical characteristics.

RESULTS AND DISCUSSION

Table 1 presents the results for the determination of the storage temperature, where it is observed that the sample of sunrise papaya stored at a temperature of 13±1°C, preserved in a better way the physicochemical properties; weight loss and soluble solids underwent slight changes, the percentage of acidity decreased until day 6 and increased on day 10; in terms of pH it increases as time goes by, which indicates the progress of the ripening process in stored fruits.

Figure 1 to 4 shows the behavior of the physicochemical parameters, where it can be seen that weight loss, soluble solids, acidity and pH do not have a linear behavior. The 2 treatments stand out because they present the highest values in weight loss, acidity and lower content of soluble solids, and pH.

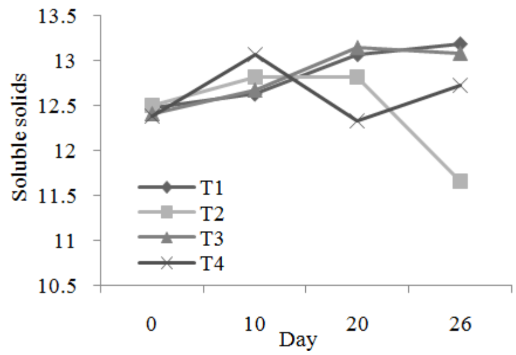

Fig. 2: Soluble solids of papaya fruit

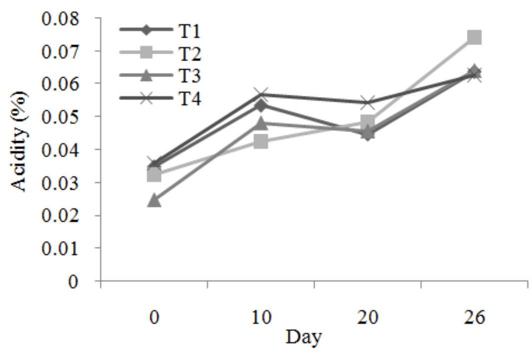

Fig. 3: Acidity of papaya fruit

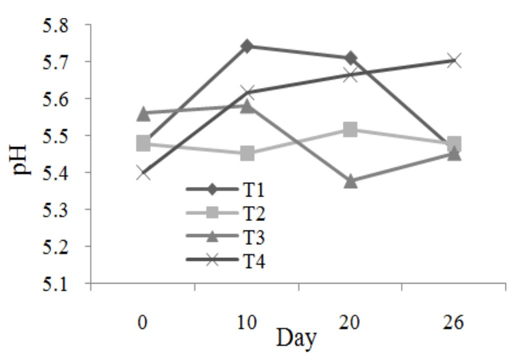

Fig. 4: pH of the papaya fruit

The results obtained by Almeida *et al*. (2011) in the study evaluating the effect of a cassava starch film on papaya stored at room temperature; they show an increasing tendency in the weight loss during the storage, being greater in the samples without film and smaller in the samples with film; increase in acidity, due to the processes of fruit degradation and an increase in soluble solids.

Table 2 shows the analysis of variance of the physicochemical variables, which reveals statistically significant differences with a confidence level of 95% ($p \geq 0.05$) for the variables pH, CO_2 and O_2.

For the variables of O_2 concentration, a significant difference was found with a 95% confidence level on days 0 and 10, while the one of CO_2 a significant difference was found on the whole period of observation.

Table 2: Mean squares of the physicochemical variables*

Variation source	Time (days) 0	10	20	26
Weight loss	0.0000	1.0370	694993.809	2.62600
Soluble solids	0.0512	0.4640	0.40400	2.24200
pH	0.0740	0.0930*	0.12900	0.13900
Acidity	0.0020	0.0002	0.00006	0.00006
CO_2 (%)	2.6570*	348.5760*	620.28300*	64.81900*
O_2 (%)	3.8740*	0.9020*	0.49400	0.86400

*: Mean values

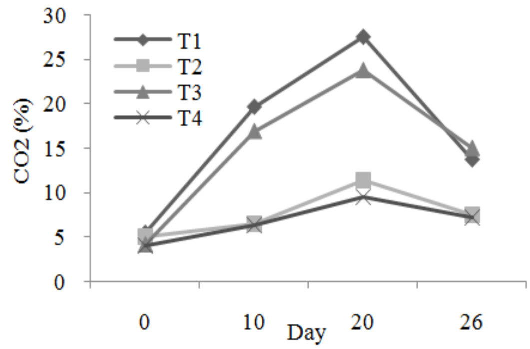

Fig. 5: Percentage of CO_2 in papaya fruit

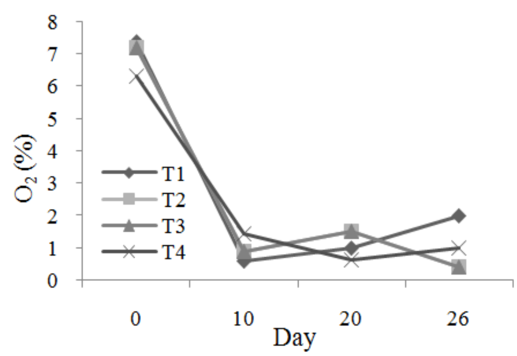

Fig. 6: Percentage of O_2 in papaya fruit

Figure 5 and 6 show the percentages of oxygen and carbon dioxide determined in the papaya samples; being observed that for all the treatments the concentration of CO_2 increases by the own processes of degradation of the fruit and then there is a decrease of the values because the transfer of this compound starts outwardly through the film.

The results were analyzed through a Duncan test, with the highest percentages of CO_2 in treatment 1 (day 20) and treatment 3 (day 26); and the lowest percentages in treatment 4 (day 20 and 26); these results indicate that the film most impermeable to this gas is that containing BOPP/LDPE and the mixture that favors the production of CO_2 is 5% CO_2 and 7% O_2.

Figure 6 is evident that the highest percentage of O_2 is reached for treatment 1 (26), so this film is the one that allows greater input of O_2 from the atmosphere surrounding the fruit, thus not allowing the incipience of anaerobic processes that will accelerate the degradation processes of the fruit.

CONCLUSION

The shelf life of papaya (*Carica papaya L.*) can be extended using the packaging in modified atmospheres. The BOPP/LDPE film was the most impermeable to CO_2 and allowed greater input of O_2, managing to stop the degradation processes of the fruit.

The best combination of packing material-gas mixture was treatment one (5% CO_2 and 7% O_2 with BOPP/LDPE film), reaching a shelf life of 20-23 days, in which the physicochemical attributes of papaya were conserved.

CONFLICT OF INTEREST

Authors declare no conflict of interests of any nature.

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