Research Article

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

1De Paula Claudia D., 1Simanca Mónica M. and 2Causil Diana P.
1Departamento de Ingeniería de Alimentos, Facultad de Ingeniería, Universidad de Córdoba, Montería Postcode 230002, Colombia
2Alico S.A., Bogotá D.C., Postcode11121, Colombia

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 (BOP/LDPE and EVA) with 2 gaseous mixtures (5% CO₂ and 7% O₂, 4% CO₂ and 6% O₂) 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% CO₂ and 7% O₂ in the BOP/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 (Jacomin 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).
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 (Dominguez 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% CO₂ and 7% O₂, 4% CO₂ and 6% O₂) 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% CO₂ and 7% O₂ plastic film BOPP/LDPE; treatment two: 5% CO₂ and 7% O₂ plastic film EDA; treatment three: 4% CO₂ and 6% O₂ plastic film BOPP/LDPE and treatment four: 4% CO₂ and 6% O₂ 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 CO₂ and O₂ inside the package were observed with a gas analyzer from the brand Dansensor; and soluble solids by means of the °Brix determination using a 1-30 scale refractometer.

**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.

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.

**Table 1: Selection of storage temperature**

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

*: 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.
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≤0.05) for the variables pH, CO₂ and O₂.

For the variables of O₂ concentration, a significant difference was found with a 95% confidence level on days 0 and 10, while the one of CO₂ a significant difference was found on the whole period of observation.

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 CO₂ 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 CO₂ 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 CO₂ is 5% CO₂ and 7% O₂.

Figure 6 is evident that the highest percentage of O₂ is reached for treatment 1 (26), so this film is the one that allows greater input of O₂ 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 CO₂ and allowed greater input of O₂, managing to stop the degradation processes of the fruit.

The best combination of packing material-gas mixture was treatment one (5% CO₂ and 7% O₂ 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.

REFERENCES


