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Post-Harvest Conservation of Papaya "Formosa Tainung 01" Conditioned Under Different Packaging Systems

Josália Liberato Rebouças[1], Francisca Lígia de Castro Machado[2], Marcos Rodrigues Amorim Afonso[3], José Maria Correia da Costa[4]✎

[1] Department of Food Technology, Federal University of Ceará, Brazil
[2] Federal Institute of Education, Science and Technology - Ceará
[3] Department of Food Technology, Federal University of Ceará, Brazil
[4]Department of Food Technology, Federal University of Ceará, Av. Mister Hull. 2977, CEP: 60356-000, Fortaleza, Ceará, Brazil

Abstract: This study aimed at evaluating the efficiency of different storage conditions on lengthening the post-harvest useful life of papaya "Formosa Tainung 01". The fruits were harvested at ripening stage 2, pre-cooled, conditioned in nylon/polyethylene bags, polyamide bags and in polyamide bags with sachets of $KMnO_4$. They were later stored under a refrigerated condition (10 ± 1ºC and 90 ± 5% R.U.) for a period of 20 days and evaluated every 5 days of refrigeration, followed by 24 hours under room conditions. The analyses included mass loss and firmness, peel coloration and chlorophyll amount, titratable acidity, pH, total soluble solids, total soluble sugars, reducing sugars, ascorbic acid and carotenoids in the pulp. We used a fully randomized design and sub-divided parcels. The results suggest that the modified atmosphere, caused by polyamide films in association with ethylene absorber, preserved the fruits better and retarded metabolic processes, increasing post-harvest useful life.

Keywords: Carica papaya L., refrigeration, modified atmosphere

Introduction

Papaya is a highly consumed fruit in Brazil and in other countries. However, it has a very limited post-harvest useful life, due to its sensitivity to mechanical damages, pests and microorganisms. Because it is a climacteric fruit, transformations resulting from ripening occur fast, triggered by ethylene production and by an increase in respiratory rate [1]. Thus, it is necessary to handle it carefully, from cultivation to commercialization, aiming at increasing post-harvest useful life and reducing losses. Refrigeration is the most used method in long storage of fruits. Other methods, such as the use of modified atmosphere or atmosphere control and the use of coverings on the product surface, have been used, but their efficiency is conditioned to the use of low temperatures [2].

Atmosphere modification associated to refrigeration is one of the storage alternatives used for reducing respiratory rate in fruits, minimizing water loss, growth of pathogenic microorganisms and enzymatic reactions, bestowing these fruits with greater quality and longer useful life. Modified atmosphere can be obtained by using plastic films or coverings based on carnauba wax, polysaccharides, proteins, lipids and others. When properly used, coverings can increase post-harvest useful life of fruits, by retarding metabolic processes linked to ripening, and better the fruit's appearance by providing them with a superficial glow [3].

During ripening, the fruit goes through biochemical, physiological and structural changes; specific taste and scent are created together with an increase in sweetness, pulp softening and change in coloration, making the fruit proper for consumption. In this stage, respiratory rate and ethylene production are high [2], [4].The respiratory speed is a good time index used for evaluating post-harvest conservation. Respiratory intensity indicated the speed in which metabolism occurs, i.e., high respiratory rates are, in general, associated to short life in storage [5]. Temperature control in storage of garden products is fundamentally important, because increases in temperature stimulate respiration and ethylene production [6]. Choosing temperature during storage depends, among other factors, on the ripening stage

✎ José Maria Correia da Costa (Correspondence)
✉ correiacostaufc@gmail.com
☎ +55-085-91040416

of the fruits. Higher temperatures may reduce post-harvest useful life, while lower temperatures may cause damages.

This study aimed at evaluating the post-harvest useful life of papaya “Formosa Tainung 01”, regarding the physicochemical parameters of fruits harvested in ripening stage 2, and conditioned in polyethylene/nylon (partial vacuum) bags, polyamide bags (modified atmosphere) and polyamide bags with sachets of $KMnO_4$ (modified atmosphere with ethylene absorber) during refrigerated storage (10 ± 1ºC and 90 ± 5% R.U.).

Material and Methods

Papayas from variety “Formosa Tainung 01” were harvested in September 2009, in a commercial orchard located in the Irrigated Perimeter Jaguaribe-Apodi, Limoeiro do Norte, Ceará, which is an area located under coordinates 5º 20’ S and 38º 5’ W, with climate type BSw’h’ and average temperature of 28.5º, irregular precipitation of 772mm, relative humidity of 62% and insolation of 3,030 hours [7]. The fruits were harvested at a maturation stage “M2”, which corresponds to 25% of the peel showing a yellow coloration, in accordance to the Program for Exportation of Brazilian Papaya - APHIS/USDA - IS - SDA / Ministry of Agriculture, Livestock and Supply.

After harvest, the fruits were washed, covered with carnauba-based wax (Aruá Tropical®), dried under forced ventilation, surrounded in a polyethylene net, conditioned in carton boxes and transported to the Center for Agricultural Sciences in the Federal University of Ceará, Fortaleza. After arriving at the laboratory, the fruits were immediately cooled at the temperature they would be stored in (10 ± 1ºC and 90 ± 5% R.U.). After cooling, the fruits were divided into four parcels, in accordance with the following conditioning conditions: fruits without packaging, packaging under partial vacuum (polyethylene/nylon bags with 30cm x 40cm and thickness of 0.12µm), packages with modified atmosphere (polyamide bags) and packages with modified atmosphere and ethylene absorber (polyamide bags with sachets of $KMnO_4$).

The fruits were stored under refrigeration (10 ± 1ºC and 90 ± 5% R.U.) for a period of 20 days. During this period, samples were taken randomly every five days, and transferred to room atmosphere (24 ± 2ºC and 48 ± 5% R.U.) where they remained for 24 hours prior to the analyses of mass loss, firmness, peel coloration, chlorophyll amount in the peel, titratable acidity, pH, soluble solids, total soluble sugars, reducing sugars, ascorbic acid and carotenoids in the pulp.

Mass loss was determined according to Sanino [8]; firmness was determined using a digital penetrometer, brand SOIL CONTROL, by inserting a cylindrical 8-mm- needle into the fruit with peel; peel coloration was analyzed according to luminosity, chromaticity and hue angle parameters, by means of reflectometry in a colorimeter brand KONICA MINOLTA and according to McGuire [9]; chlorophyll content was determined by spectrophotometric analysis, according to the methodology described by Engel & Poggiani [10]; titratable acidity and pH were determined according to analytical norms from Instituto Adolfo Lutz [11]; soluble solids, according to recommendations made by AOAC [12]; soluble sugars, according to the methodology described by Yemn & Willis [13]; reducing sugars, according to the methodology described by Miller [14]; ascorbic acid was analyzed in accordance with the methodology described by Strohecker & Henning [15] and carotenoids, by means of an adapted methodology from Nagata & Yamashita [16].

We used a fully randomized design with three repetitions and sub-divided parcels, being that the main parcel concerns the treatments and the sub-parcels concern storage times. The data were submitted to analysis of variance and regression, by Tukey Test at 5% of significance to compare the averages. We used software SISVAR, version 5.3, for the statistical analysis of the results.

Results and Discussion

In all treatments, the fruits mass loss increased together with storage time. The biggest losses occurred in control fruits, probably due to higher water loss by transpiration, when compared to the other fruits that were protected by films (Table 1). The papayas that were conditioned under vacuum, showed the lowest mass loss during storage and there were significant differences at the rate of 5%, between the latter and the other treatments with films. These results corroborate those obtained by Galvão *et al.* [17] and they can be explained by low temperatures of fruit storage and the use of wax in association with plastic films that reduce the percentage of fresh mass loss, due to the environment saturated with moisture within the package. Therefore it reduces the gradient of steam pressure between the fruit and the air, and diminishes and controls the transpiration in the fruit, as well as its metabolism.

Table 1. Mass loss evolution (%) and average values of firmness (N) in papayas ‘Tainung 01’ conditioned without package, under vacuum, under modified atmosphere plus ethylene absorber and under modified atmosphere at refrigeration (10 ± 1ºC and 90 ± 5% of RU). Averages followed by the same letter in the columns do not differ statistically by

Tukey Test at the level of 5% of probability.

Treatments	Mass loss (%)				
	Days of storage after harvest				
	1	5	10	15	20
Without packaging	0.00 a	0.29 a	1.14 b	1.36 c	1.66 c
Under vacuum	0.00 a	0.08 a	0.08 a	0.11 a	0.13 a
Modified atmosphere plus ethylene absorber	0.00 a	0.09 a	0.22 a	0.47 b	0.70 b
Modified atmosphere	0.00 a	0.14 a	0.26 a	0.29 ab	0.40 ab
	Firmness (N)				
Without packaging	161.31 a	121.47 a	137.22 a	138.60 a	144.92 ab
Under vacuum	161.31 a	134.13 b	141.55 a	142.93 a	15.58 c
Modified atmosphere plus ethylene absorber	161.31 a	137.12 b	138.55 a	143.18 a	149.44 b
Modified atmosphere	161.31 a	126.47 a	136.40 a	138.13 a	142.68 a

Fruit's firmness, regardless of treatment, decreased on the first five days of storage (Table 1). It probably happened because of the evolution of maturation on the first days after harvest, as well as the water loss through transpiration. Santos *et al.* [18] observed the existence of a relation between mass loss and fruit firmness, that is, whenever there is an increase in percentage of mass loss, there is also a reduction in firmness.

It was possible to observe an increase in firmness from the tenth to the twentieth day of storage, in all treatments. In fruits under refrigeration and without film, it was possible to detect a slight wrinkling of the peel, which bestowed an "elastic" effect to the peel, associated to the difficulty in breaking through the same, during the tests of perforation. On this occasion, the fruits showed firmness of 144.92 N and a slight yellowish coloration.

The fruits conditioned under vacuum remained very firm at the end of the storage time, with firmness equals to 157.58 N (Table 1). This increase in average values of firmness may have been triggered by the retard in ripening processes, caused by low temperatures. A similar fact was reported by Rocha *et al.* [19], while researching papayas 'Formosa', where the fruits that were kept at low temperatures (8 and 10ºC) showed more firmness and slower ripening; these symptoms were considered as injuries occasioned by cold. These authors still report that such symptoms were more severe in papayas stored at the coldest temperatures (8ºC).

Luminosity in papaya peel was influenced by the interaction between the treatments and storage periods (Table 2). The control fruits, as well as the fruits conditioned under modified atmosphere plus ethylene absorber did not show any significant difference at 5% of probability, by Tukey Test, at the end of storage. The papayas conditioned under modified atmosphere showed, at the end of storage, the lowest luminosity values. It suggests that the association of a modified atmosphere (polyamide films) under refrigeration would be, possible, responsible for the reduction in the process of yellow color development on papaya peels, i.e., it shows less maturation. However, it was possible to check that fruits conditioned with the ethylene absorber showed lower luminosity variations, pointing out higher a stability of this variable during storage.

Chromaticity values on papaya peels were influenced by the interaction between the treatments and storage times (Table 2). In general, the yellow coloration of the peel became more intense in all treatments at the end of the storage period. Nevertheless, the changes for fruits submitted to a modified atmosphere and ethylene absorber were not explained by the independent variable "storage time", considering the coefficient of determination of the third degree polynomial expression [$Y = 11.437 + 0.208(x) + 0.059(x)^2 - 0.003(x)^3$], $R^2 < 0.70$, i.e., they were not adjustable, pointing out that the slight changes occurred in chromaticity could not be explained by the storage periods. According to Toebe *et al.* [20], chromaticity represents the color intensity or saturation and the closer to zero it is, the lower is the differentiation in tonality from green to yellow, which represents lower ripening degrees.

Table 2. Luminosity, chromaticity, hue angle and chlorophyll in the peel (mg/100g) of papayas 'Tainung 01' conditioned without package, under vacuum, under modified atmosphere plus ethylene absorber and under modified atmosphere at refrigeration (10 ± 1ºC and 90 ± 5% of RU). Averages followed by the same letter in the columns do not differ statistically by Tukey Test at the level of 5% of probability.

Treatments	Luminosity				
	Days of storage after harvest				
	1	5	10	15	20
Without packaging	29.50 a	36.43 c	40.73 c	42.46 d	35.96 c
Under vacuum	29.50 a	28.27 a	36.86 a	37.12 a	31.31 b
Modified atmosphere plus ethylene absorber	29.50 a	31.05 b	39.82 b	38.65 b	35.96 c
Modified atmosphere	29.50 a	28.26 a	43.50 d	39.88 c	29.50 a
	Chromaticity				
Without packaging	11.85 a	17.50 d	18.81 b	19.99 c	16.76 d
Under vacuum	11.85 a	11.07 a	16.35 a	16.31 a	11.83 b
Modified atmosphere plus ethylene absorber	11.85 a	11.92 c	18.98 c	16.30 a	16.24 c
Modified atmosphere	11.85 a	11.31 b	22.64 d	16.65 b	10.03 a
	Hue angle (^{o} H)				
Without packaging	126.72 a	123.76 a	118.81 a	123.26 b	118.25 c
Under vacuum	126.72a	125.05 b	123.96 c	124.98 d	120.21 d
Modified atmosphere plus ethylene absorber	126.72 a	125.13 b	120.74 b	124.56 c	115.89 b
Modified atmosphere	126.72 a	123.64 a	120.77 b	119.25 a	115.23 a
	Chlorophyll in the peel (mg/100g)				
Without packaging	86.94 a	71.71 b	65.19 c	62.09 b	48.89 b
Under vacuum	86.94 a	74.16 b	55.31 a	55.46 a	47.78 b
Modified atmosphere plus ethylene absorber	86.94 a	73.73 b	59.00 b	56.52 a	56.12 c
Modified atmosphere	86.94 a	64.32 a	53.45 a	54.78 a	36.15 a

The change in peel coloration was more evident in fruits stored at refrigeration without films, representing higher values of chromaticity, while papayas wrapped in films showed little alterations in this parameter.

Although fruits conserved in modified atmospheres, without the use of sachets of ethylene absorber, showed lower values of chromaticity than the other treatments at the end of 20 days of storage, it was possible to observe that the use of ethylene absorber caused just slight changes during the storage period, which may indicate that the maintenance of chromaticity is because of a retard in the ripening processes.

Through Hunter's Chromatic Space, hue angle indicates color tonality. The higher these values are in papayas, the greener their peel it. The average initial values of hue angle were 126.72º, indicating that the peels were green. After 20 days of storage, it was possible to observe a decrease, reaching the average values of 118.25º, 120.21º, 115.89º and 115.23º for the fruits stored without film, under vacuum, under modified atmosphere plus ethylene absorber and under modified atmosphere, respectively (Table 2). However, it was observed that this variation was not enough to change perceptively the peel color. Fonseca *et al.* [21] affirm that the variation in the peel color as a reference of maturation stage is not a proper characteristic to classify papayas 'Golden', because of the reduced relation between chlorophyll and carotenoids, being also necessary to evaluate the other features. In addition to the alteration in the peel color, changes in size, weight, soluble solids and acidity also indicate the harvesting moment and the ripening stage of fruits [22].

The chlorophyll values by the time of harvest was 86.94mg/100g of peel, indicating that in all treatments, there was a decrease in chlorophyll contents in the peel, during the storage period (Table 2). There was a decrease in chlorophyll content according to the treatment used, being that the averages, at the twentieth day of storage, differed statistically ($p<0.05$). However the treatments under refrigeration without film and under vacuum were equally efficient to keep the green color in the fruits. The papayas stored under modified atmosphere plus ethylene absorber showed, on this date, the highest percentages of chlorophyll.

Tendency to ripening, verified by the development of yellow color on papaya peels, can be evaluated through the tendencies presented by luminosity, chromaticity, hue angle and chlorophyll values. The increase in values of chromaticity and luminosity indicate, together with the decrease in average values of hue angle and chlorophyll content, a tendency to ripening. Thus, the variations presented by the variables suggest that the fruits stored under modified atmosphere plus ethylene absorber, with average luminosity values of 35.96, chromaticity of 16.24, hue angle of 115.89º and chlorophyll equals to 56.12mg/100g, conserved better the green color.

The average values of titratable acidity showed an initial increase on the fifth day of storage in fruits stored without film, under vacuum and under modified atmosphere; however, a decrease was observed on the tenth day in fruits under vacuum and on the fifteenth day of storage in fruits under refrigeration, without film, and under modified atmosphere (Table 3).

Table 3. Titratable acidity (% of citric acid) and pH in papayas 'Tainung 01' conditioned without package, under vacuum, under modified atmosphere plus ethylene absorber and under modified atmosphere at refrigeration (10 ± 1ºC and 90 ± 5% of RU). Averages followed by the same letter in the columns do not differ statistically by Tukey Test at the level of 5% of probability.

Treatments	Titratable acidity (% of citric acid)				
	Days of storage after harvest				
	1	5	10	15	20
Without packaging	0.06 a	0.12 b	0.12 b	0.09 b	0.06 a
Under vacuum	0.06 a	0.13 c	0.06 a	0.06 a	0.12 b
Modified atmosphere plus ethylene absorber	0.06 a	0.06 a	0.06 a	0.06 a	0.06 a
Modified atmosphere	0.06 a	0.12 b	0.13 c	0.06 a	0.06 a
	pH				
Without packaging	5.85 a	5.78 bc	5.75 b	5.91 d	5.93 c
Under vacuum	5.85 a	5.73 a	5.86 c	5.89 c	5.62 a
Modified atmosphere plus ethylene absorber	5.85 a	5.79 c	5.77 b	5.70 a	5.72 b
Modified atmosphere	5.85 a	5.76 b	5.72 a	5.86 b	5.92 c

The increase in acidity can be justified by the formation of organic acids produced by enzymes, such as pectinamethylesterase and polygalacturonase that degrade the cell wall during the ripening of papaya. [23]. As for the decrease, it can be explained by a reduction in respiratory activity [24] caused by the use of films in association with refrigeration.

For fruits stored under a modified atmosphere plus ethylene absorber, it was observed that there was no significant increase in titratable acidity, during the 20 days of cooled storage. The apparent stability observed in this treatment may be an indicator of metabolic stability, because the same serve as substrate for such reactions as respiration and production of volatiles during ripening. Pinto *et al*. [25] observed a similar fact while storing papayas 'Golden' and assigned this lower tendency to acidification to a reduced accumulation of CO_2, caused by a lower metabolic activity of fruits stored in polyamide films.

The pH behavior was inversed to the behavior of titratable acidity. The values of pH fund in the analyzed fruits ranged between 5.62 and 5.93 (Table 3). These values were superior to the ones found by Castro *et al*. [26] who, while studying papayas covered with starch pellicles and stored at 8ºC, found variations between 5.03 and 5.50. In fruits stored under modified atmosphere and under refrigeration without film, it was observed an increase in pH values by the end of the cooled storage, revealing a possible maturation. It was a result of a higher consumption of organic acids as substrate for respiratory processes. As for the fruits under modified atmosphere with ethylene absorber and the ones under vacuum, it was observed a reduction in pH values on the fifteenth and twentieth days of storage, respectively (Table 3). Pinto *et al.* [25] reported something similar in their research with papayas 'Golden' kept under refrigeration at 10ºC; in such case, the values of titratable acidity showed a tendency to increment in the beginning of storage period and to an evident reduction (increasing pH) between the 8^{th} and the 16^{th} day of storage, mainly in fruits wrapped with PEBD films. This fact was assigned to higher concentrations of CO_2, proceeding from respiration, where some acids are used in the Krebs cycle. These authors also reported increases in acidity and reductions in pH values between the sixteenth and the twentieth days of storage and concluded that it might be due to intensification of metabolic activity, which is characteristic to a climacteric peek, leading to the synthesis of organic acids.

Soluble solids in the fruits conditioned in films were kept lower than the ones found in papayas stored without coverings (Table 4), probably due to the retard in the ripening process of these fruits. A similar behavior was observed by Neves *et al*. [27] who, while studying mangos 'Tommy Atkins', observed that plastic films retard the development of metabolic processes in these fruits. According to Pinto *et al.* [25], the modified atmosphere created by plastic films alters the metabolic activity of papaya and decreases the increment of soluble solids.

In fruits stored under refrigeration without packages, the increase in soluble solids can be related both to ripening and to water loss, and to a consequent wilting of the fruit. According to Silva *et al.* [28], the increase in mass loss promotes higher concentrations of sugars per gram of tissue.

The content of total soluble sugars in papayas was influenced by the treatments and the storage times, but it was not observed any significant interaction between these factors (Table 4). According to Oliveira Júnior *et al*. [29], fruits with low concentrations of starch, such as papaya, do not show great variations in the content of soluble sugars after harvest, since little starch is hydrolyzed during the ripening process and converted into simple sugars. Chitarra & Chitarra [2] affirm that low temperatures of storage retard metabolic activities, reducing synthesis and degradation of polysaccharides and carbohydrates. Therefore, it was possible to check that, in this study, temperature conditions were also important for the maintenance of the content of total sugars.

The fruits wrapped in plastic films had their average values of soluble sugars lower than in fruits stored under refrigeration and without film. It confirms the effect of metabolic reduction in fruits stored under modified atmosphere, as reported by Pinto *et al*. [25], who noticed that modified atmosphere reduces the metabolic activity in papaya, retards ripening and, as a consequence, diminishes the synthesis of sugars.

Table 4. Content of soluble solids (ºBrix), total soluble sugars (% of fresh mass) and reducing sugars (% of fresh mass) in papayas 'Tainung 01' conditioned without package, under vacuum, under modified atmosphere plus ethylene absorber and under modified atmosphere at refrigeration (10 ± 1ºC and 90 ± 5% of RU). Averages followed by the same letter in the columns do not differ statistically by Tukey Test at the level of 5% of probability.

Treatments	Soluble solids (°Brix)				
	Days of storage after harvest				
	1	5	10	15	20
Without packaging	11.2 a	11.8 c	11.8 d	11.9 c	12.0 d
Under vacuum	11.2 a	11.3 a	11.3 a	11.3 a	11.3 a
Modified atmosphere plus ethylene absorber	11.2 a	11.3 a	11.5 b	11.6 b	11.4 b
Modified atmosphere	11.2 a	11.5 b	11.6 c	11.6 b	11.7 c
	Total soluble sugars (% of fresh mass)				
Without packaging	11.45 a	12.21a	12.54 a	12.67 a	12.49 a
Under vacuum	11.45 a	11.98 a	12.08 a	12.20 a	12.13 a
Modified atmosphere plus ethylene absorber	11.45 a	12.03 a	12.12 a	12.35 a	12.21 a
Modified atmosphere	11.45 a	12.08 a	12.25 a	12.51 a	12.18a
	Reducing sugars (% of fresh mass)				
Without packaging	11.34 a	11.61 a	11.75 a	12.20 a	11.86 a
Under vacuum	11.34 a	11.68 a	11.71 a	11.78 a	11.51 a
Modified atmosphere plus ethylene absorber	11.34 a	11.71 a	11.63 a	11.85 a	11.64 a
Modified atmosphere	11.34 a	11.79 a	11.88 a	11.94a	11.71 a

There was an increase in average values of reducing sugars, when compared to the values obtained in the beginning of the storage, in all treatments. Nevertheless, the results found during storage of papayas under refrigeration without package, under vacuum, under modified atmosphere and under modified atmosphere plus ethylene absorber were not significant during storage period. At the end of 20 days of storage, these fruits did not show statistic differences at the level of 5%, by Tukey Test (Table 4).

The contents of ascorbic acid raised in all treatments, with a maximum value on the tenth day of storage and decreasing afterwards, as a probable consequence of losing this organic compound, during storage (Table5). This behavior is similar to the one observed by Fernandes *et al*. [30], who observed an increase in ascorbic acid on the twentieth day of storage, with further decrease after this period. According to Santos *et al*. [18], the content of ascorbic acid in papayas increases during ripening.

Table 5. Content of ascorbic acid (mg of ascorbic acid / 100g of pulp) and total carotenoids (mg/100g) in papayas 'Tainung 01' conditioned without package, under vacuum, under modified atmosphere plus ethylene absorber and under modified atmosphere at refrigeration (10 ± 1ºC and 90 ± 5% of RU). Averages followed by the same letter in the columns do not differ statistically by Tukey Test at the level of 5% of probability.

Treatments	Ascorbic acid (mg /100g)				
	Days of storage post-harvest				
	1	5	10	15	20
Without packaging	44.53 a	54.72 d	59.64 c	57.19 c	53.60 c
Under vacuum	44.53 a	46.22 a	49.19 a	45.74 a	41.34 a
Modified atmosphere plus ethylene absorber	44.53 a	50.68 b	57.21 b	56.17 b	50.22 b
Modified atmosphere	44.53 a	52.36 c	57.90 b	56.98 c	50.06 b
	Total carotenoids (mg/100g)				
Without packaging	0.74 a	0.79 a	0.82 a	1.18 b	1.24 b
Under vacuum	0.74 a	0.76 a	0.84 a	0.99 a	1.03 a
Modified atmosphere plus ethylene absorber	0.74 a	0.75 a	0.94 a	0.99 a	1.07 a
Modified atmosphere	0.74 a	0.77 a	0.91 a	1.05 ab	1.19ab

The content of carotenoids by the time of harvest was 0.74mg/100g of pulp, while at the end of 20 days of storage, these values were: 1,24; 1.03; 1.07 and 1.19mg/100g of pulp for fruits stored under refrigeration without packaging, under vacuum, under modified atmosphere and under modified atmosphere plus ethylene absorber, respectively (Table 5). It was observed that all treatments showed an increase in carotenoid content in papaya pulp, on the twentieth day of storage, which means that refrigeration with or without modified atmosphere retards, but does not cease, the metabolic processes that promote ripening and the synthesis of this compound.

Conclusions

1. payas in ripening stage 2 (with 25% of yellow peel), stored in a cooled chamber at 10 ± 1ºC and 90 ± 5% of RU, developed symptoms of damage by cold.
2. The modified atmosphere provoked by polyamide films in association with ethylene absorber and cooled storage (10 ± 1ºC and 90 ± 5% of RU) showed to be the most efficient treatment to conserve the post-harvest quality of papayas, during the storage for 20 days under cooled atmosphere and after 24 hours of exposition to room conditions.

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