Agrotrópica 33(3): 187 - 196. 2021.
Centro de Pesquisas do Cacau, Ilhéus, Bahia, Brasil

SHELF-LIFE OF BRS PÉROLA DO CERRADO PASSION FRUIT UNDER DIFFERENT FORMS OF CONSERVATION

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Brazil is the main producer of passion fruit in the world, and this crop has, steadily, grown in importance for brazilian agribusiness. The objective of this study was to evaluate the post-harvest conservation of BRS Pérola do Cerrado (*Passiflora setacea*) passion fruit in 10 µm PVC packages, 30 µm HDPE packages, coated with 12% carnauba wax and without any packaging (control) stored under ambient conditions at 25 ºC and 70% of relative humidity and in refrigerated conditions at 10 °C and 90% relative humidity for 14 days. Parameters such as pH, titratable acidity, soluble solids, fresh weight loss percentage, luminosity, increment in browning, chromaticity, hue angle, texture (via texturometer) and fruit microbiology were analyzed at 0, 7 and 14 days of storage. The concentration of O_2 and CO_2 inside the packages was also analyzed. Refrigerated storage at a temperature of 10 ºC and 90% relative humidity and the use of 10 µm PVC packaging were beneficial for BRS Pérola do Cerrado passion fruit conservation up to 14 days after harvesting. Ambient condition storage was not suitable for long-term fruit conservation.

Key words: *Passiflora setacea*, passion fruit, temperature, packaging, post-harvest, carnauba wax.

Vida útil de frutos de maracujá BRS Pérola do Cerrado sob diferentes formas de conservação. O Brasil é o principal produtor mundial de maracujá sendo esta uma cultura muito importante para o país. Assim o trabalho teve como objetivo estudar a conservação pós-colheita de frutos de maracujá BRS Pérola do Cerrado (*Passiflora setacea*) acondicionados em embalagens de PVC 10 µm, PEAD 30 µm, revestido com cera de carnaúba a 12% e sem embalagem armazenados sob condição ambiente na temperatura de 25 ºC e 70% de umidade relativa e refrigerada a 10 ºC e 90% de umidade relativa por 14 dias. Na matéria-prima e durante o armazenamento foram analisados o pH, acidez titulável e sólidos solúveis na polpa dos frutos, perda de massa fresca, luminosidade, incremento no escurecimento, chroma, ângulo hue, textura (teste normal via texturômetro) e microbiologia dos frutos. Também foi analisada a concentração de O_2 e CO_2 no interior das embalagens contendo os frutos acondicionados. A armazenagem em condição refrigerada na temperatura de 10 ºC e 90% de umidade relativa e a utilização da embalagem PVC de 10 µm são benéficas para a conservação dos frutos por até 14 dias após a colheita. A condição ambiente não apresenta benefícios para a conservação dos frutos em longo prazo.

Palavras-chave: *Passiflora setacea,* maracujá, temperatura, embalagens, pós-colheita, cera de carnaúba.

Received for publication on November 26, 2021. Accepted on December 03, 2021.
DOI: 10.21757/0103-3816.2021v33n3p187-196

Introduction

Brazil is the center of origin of the Passiflora genus, with approximately 150 to 200 different species, with more than 70 species producing edible fruits (Faleiro et al., 2020). Brazil is also the main producer of yellow passion fruit (*Passiflora edulis* Sims) with a cultivated area of 41.584 ha, which in 2019 produced 593.429 tons of fruits corresponding to 14,27 t/ha. The Northeast region is a major producer accounting for 64.5% of the national production, especially in the state of Bahia (IBGE, 2019).

Embrapa Cerrados, located in Planaltina - DF, Brazil, holds one of the largest passion fruit germplasm bank in the world, with more than 70 species and about 200 intraspecific variations (Faleiro et al., 2020). The bank provides genetic resources to Embrapa's Passiflora Breeding Program, which has produced commercial varieties for yellow passion fruit (*Passiflora edulis* Sims), sweet passion fruit (*Passiflora alata* Curtis) and for less known species such as *Passiflora cincinnata* and *P. setacea* (BRS Pérola do Cerrado) (Embrapa, 2015). One of the main problems for passion fruit commercialization is the fruit's short shef-life after harvest (Moura et al., 2012). Several species of the genus present problems such as: wrinkling and bruising of the fruit after harvest, during handling and transportation; a short climacteric cycle; and difficulty to define the harvest period, since in some species the fruit does not turn yellow (Rinaldi et al., 2017). These peculiarities hamper the logistics of production and commercialization of several species of passion fruit, which in turn makes it difficult to introduce and establish new species in the market, such as BRS Pérola do Cerrado (*P. setacea*).

Proper fruit handling during and after harvesting is essential for maintaining quality and reducing post-harvest losses (Campos et al., 2005). Also, the use of plastic packaging for conservation and increase of fruit shelf life has been widely studied. However, the packaging must have adequate characteristics such as good gas permeability, adequate size to the quantity of packed fruit, easy handling and resistance (Santos e Oliveira, 2012). Furthermore, for each species there may be an ideal temperature and relative humidity for postharvest conservation.

The objective of this study was to evaluate the post-harvest conservation of BRS Pérola do Cerrado fruits (*P. setacea*) packed on styrofoam trays wrapped with 10 µm PVC film, in 30 µm HDPE plastic packaging, and coated with 12% carnauba wax. The treatments were stored under environment conditions, at 25 ºC and 70% relative humidity, and in a cold room, at 10 °C and 90% relative humidity, for 14 days.

Materials and Methods

Fruits of cultivar BRS Pérola do Cerrado harvested from the experimental fields of Embrapa Cerrados, located in Brasília - DF - Brazil (Latitude: 15° 35"30"S; Longitude: 47° 42"30"W; Height: 1030m), were used for trial purposes. The fruits were harvested at the maturation point adopted by local producers, where the fruits have a light green coloration with dark green stripes in the longitudinal direction, and pale yellow or creamy pulp; the seeds are oblong lightly reticulated, about 0.5 cm in diameter by 0.3 cm in length. In the laboratory the fruits were selected and washed in running water with subsequent drying on paper towels.

Afterwards, the fruits were packed in trays of expanded polystyrene and coated with a flexible polyvinyl chloride (PVC) film with a thickness of 10 µm. The fruits were also packed in 30 µm thick high-density polyethylene (HDPE) plastic packaging. In another treatment, the fruits were manually coated with carnauba wax in the concentration of 12% supplied by Aruá inc. (São Paulo - SP, Brazil). The control treatment consisted of fruits washed with water and dried on paper towels. All treatments were stored in a cold room at 10 °C and 90% relative humidity and at room temperature at 25 °C and 70% relative humidity for 14 days.

At the beginning of storage (day zero) and at seven and 14 days, pH, titratable acidity, soluble solids and ratio analyses were performed according to Abreu et al. (2009). Color (L*, a*, b*) was determined by HunterLab brand MiniScan® EZ spectrophotometer, with five readings per fruit. The value of L* defines the luminosity (L* = 0 black and L* = 100 white) and a* and b* are responsible for chromaticity (+ a* red and - a* green), b* (+ b* yellow and -b* blue). Using the module L*, a* and b* we are able to calculate the increase in fruit surface darkening (browning) ($[(L^* - L^* 0)^2 + (a^* - a^*0)^2 + (b^* - b^*0)^2]^{1/2}$), chromaticity (color intensity: 0 – impure and 60 – pure) and hue angle (color angle, 0º red, 90º yellow, 180º green, 270º blue and 360º black). Chromaticity was calculated through the formula: chroma $[(a^2 + b^2)^{1/2}]$. Hue angle was calculated using the formula: [tangent arc (b*/a*)] for the a* positive and [tangent arc (b*/a*) (-1) + 90] for the a* negative. For the analysis of texture it was used the Brookfield texture Analyzer, model CT3 4500. The analysis consisted of the perforation resistance test (normal test), with the standards for Trigger (strength) set at 10 g. Deformation set at 10 mm and Speed set at 10 mm/s, using the TA 17 tip with a 30 mm D cone, 45°. The results were presented in Newton (N). Fresh weight loss was also assessed by calculating the difference in weight between the initial fruit mass and the mass at the moment of the evaluation. Also, O_2 and CO_2 concentration was measured inside the packages using CheckPoint II equipment developed by PBI-Dansensor America Inc. Gas concentration measurements were performed directly inside the packages by introducing the equipment´s needle through a silicone septum adapted to the packages containing the fruits (Rinaldi et al., 2009).

Microbiological analyzes were performed according to Silva et al. (2010). The total counts of mesophiles and psychrotrophic microorganisms, mold, yeasts, total coliforms and thermotolerant coliforms were analyzed.

The experimental design was completely randomized, with three replicates per each treatment, and each replicate consisting of six fruits of BRS Pérola do Cerrado. Six fruits per treatment were used for color analyzes, and five readings per fruit were carried out on each day of analysis. For texture analysis, three readings were performed on each of the six fruits. The data were submitted to analysis of variance using the F test and means were compared using Tukey's test at 5% error probability. All the statistical analyzes were performed with the ASSISTAT statistical program (Silva, 2017).

Results and Discussion

The pH values ranged from 2.83 to 3.20 and there was no statistically significant variation throughout the experiment, although the parameter values had a tendency to increase during the 14 days of storage in all treatments (Table 1). Rinaldi et al. (2017) obtained values between 3.19 and 3.46 for this same species stored under ambient and refrigerated conditions at temperatures of 6ºC, 10ºC and 20ºC for 21 days, with no significant variation in the pH of fruits kept at 6ºC and 10ºC. The same authors also observed higher pH values at higher temperatures. The highest values of pH corresponded to the lowest values of titratable acidity, proving that the acids present in the fruits may have been reduced during ripening and were also used in the metabolic processes, in an attempt to maintain fruit integrity after harvest.

Titratable acidity values ranged from 2.21 to 3.15 g of anhydrous citric acid/100ml in ambient condition and between 2.48 and 3.15g of anhydrous citric acid/100ml in refrigerated condition (Table 1). The lowest absolute value was at 14 days of storage in fruits coated with 12% carnauba wax and kept under ambient conditions. There was no statistically significant difference among the treatments in both storage conditions. Generally, packaging should have the function of reducing fruit metabolism in order to maintain acid concentration for longer periods, thus increasing their shelf-life. However, the results do not show such effectiveness for BRS Pérola do Cerrado fruits. The non significant oscillations that occurred were probably due to the intrinsic characteristics of the samples. The maintenance of fruit acidity guarantees flavor and odor to the product (Campos et al., 2013).

The soluble solids showed significant variation during storage, with initial values of 14.93°Brix (Table 1), being significantly superior, during the 14-day analysis period, to the minimum required by the Ministry of Agriculture (11°Brix), for *in natura* juice (MAPA, 2000). At the beginning of storage, the fruits also presented values of soluble

Table 1. Evaluation of the pH, titratable acidity and soluble solids in BRS Pérola do Cerrado passion fruit during storage under two different environmental conditions

Treatments	pH		
	Ambient storage		
	Storage time (days)		
	0	7	14
Without packaging	2.83aA	2.97aA	3.15aA
PVC 10µm	2.83aA	3.04aA	3.20aA
HDPE 30µm	2.83aA	3.01aA	3.18aA
Carnauba wax 12%	2.83aA	3.05aA	3.12aA
	Refrigerated storage (10ºC)		
Without packaging	2.83aA	2.95aA	2.94aA
PVC 10µm	2.83aA	2.85aA	2.99aA
HDPE 30µm	2.83aA	2.93aA	3.09aA
Carnauba wax 12%	2.83aA	2.97aA	2.95aA
	Titratable acidity (g of citric acid/100ml)		
	Ambient storage		
	0	7	14
Without packaging	3.15aA	2.56aA	2.25aA
PVC 10µm	3.15aA	2.43aA	2.46aA
HDPE 30µm	3.15aA	2.35aA	2.24aA
Carnauba wax 12%	3.15aA	2.26aA	2.21aA
	Refrigerated storage (10ºC)		
Without packging	3.15aA	2.79aA	2.92aA
PVC 10µm	3.15aA	2.75aA	2.48aA
HDPE 30µm	3.15aA	2.76aA	2.53aA
Carnauba wax 12%	3.15aA	2.63aA	2.72aA
	Soluble solids (°Brix)		
	Ambient storage		
	0	7	14
Without packging	14.93aA	14.97aA	11.93bB
PVC 10µm	14.93aA	13.30bAB	12.97aB
HDPE 30µm	14.93aA	14.03abA	13.10aB
Carnauba wax 12%	14.93aA	13.77abAB	13.03aB
	Refrigerated storage (10°C)		
Without packaging	14.93aA	13.40abB	13.70aB
PVC 10µm	14.93aA	12.83bB	12.73bB
HDPE 30µm	14.93aA	13.67abB	13.33abB
Carnauba wax 12%	14.93aA	13.87aB	14.43aAB

[1]Same lowercase letters in the column do not differ significantly at the 5% level in Tukey's test. Same capital letters, on the line, do not differ significantly at the 5% level in Tukey's test.

solids adequate to that required by the juice processing industry (14°Brix), where there is preference for fruits with higher soluble solids content (Raimundo et al., 2009). In the treatments at room temperature, the fruits kept unpacked and those packaged in 30µm HDPE presented the highest values of soluble solids, being above 14°Brix at seven days of storage. In the refrigerated condition the highest values were obtained in fruits coated with 12% carnauba wax.

Under ambient conditions, the untreated control presented the lowest Brix values after 14 days of storage, while the 10µm PVC treatment had similar results to the refrigerated condition (Table 1). This parameter varied between 14.93 and 12.97 °Brix at room temperature, and between 14.93 and 12.73 °Brix at 10 °C. Variations in soluble solids values probably occurred due to the use of the compounds in the respiratory process to maintain metabolism, and to considerable fresh weight loss, causing solid accumulation.

Fresh weight loss percentage was significantly lower in fruits kept under refrigeration, reaching a maximum of 16% at 14 days of storage in the untreated control (Table 2). The treatments with 10µm PVC and 30µm HDPE presented the lowest percentage of fresh weight loss in both storage conditions. However, the 30µm HDPE treatment was the most effective, presenting 1.72% and 0.49% weight loss, respectively, under ambient and refrigerated conditions.

Yellow passion fruit fruits were considered wilted if fresh weight loss reaches 8%, depreciating there appearance and commercial value (FAEP, 2015). In this work, the fruits kept in the 10µm PVC film and 30µm HDPE plastic packaging and stored under refrigeration were significantly below this limit during the 14 days of storage (Table 2). The 30µm HDPE treatment was also effective in keeping weight loss significantly lower than 8% under ambient conditions. The other treatments presented weight loss percentage below 8% only up to seven days of storage. For yellow passion fruit fruits, it is recommended that they be marketed immediately after harvest, as they present symptoms of senescence, such as wrinkling between three and seven days after their abscission (Venâncio et al., 2013). Thus, alternatives that delay the process of fresh fruit weight loss are fundamental to increase

Table 2. Evaluation of the fresh weight loss, texture and luminosity in BRS Pérola do Cerrado passion fruit during storage under two different environmental conditions

Treatments	Fresh weight loss (%)		
	Ambient storage		
	Storage time (days)		
	0	7	14
Without packaging	0.00aC	15.42aB	31.48aA
PVC 10µm	0.00aC	5.10bB	11.06bA
HDPE 30µm	0.00aB	0.77cAB	1.72cA
Carnauba wax 12%	0.00aC	15.29aB	31.92aA
	Refrigerated storage (10ºC)		
Without packaging	0.00aC	7.86aB	15.80aA
PVC 10µm	0.00aC	1.53bB	3.05A
HDPE 30µm	0.00aA	0.23bA	0.49dA
Carnauba wax 12%	0.00aC	7.30aB	14.09bA
	Texture (N)		
	Ambient storage		
	0	7	14
Without packaging	22.25aA	10.78cB	8.07aB
PVC 10µm	22.25aA	17.08bB	4.83aC
HDPE 30µm	22.25aA	21.27aA	6.30aB
Carnauba wax 12%	22.25aA	12.11cB	7.89aC
	Refrigerated storage (10ºC)		
Without packaging	22.25aA	14.04abB	7.83cC
PVC 10µm	22.25aA	17.53aB	12.72bC
HDPE 30µm	22.25aA	16.15abC	19.89aB
Carnauba wax 12%	22.25aA	13.87bB	15.77bB
	Luminosity		
	Ambient storage		
	0	7	14
Without packaging	54.55aA	52.37aA	51.83aA
PVC 10µm	54.55aA	54.65aA	56.99aA
HDPE 30µm	54.55aA	53.80aA	56.71aA
Carnauba wax 12%	54.55aA	53.47aA	54.31aA
	Refrigerated storage (10ºC)		
Without packaging	54.55aA	53.02aA	50.62aA
PVC 10µm	54.55aA	52.09aA	51.39aA
HDPE 30µm	54.55aA	52.38aA	52.88aA
Carnauba wax 12%	54.55aA	56.63aA	54.24aA

[1]Same lowercase letters in the column do not differ significantly at the 5% level in Tukey's test. Same capital letters, on the line, do not differ significantly at the 5% level in Tukey's test.

the post-harvest life of passion fruit (Campos et al., 2005). Fresh weight loss causes deterioration and loss of visual quality of fruits and vegetables, and can lead to dehydration, wilting, loss of firmness, reduced crispness, nutritional quality and early senescence, reducing the enzymatic and regulatory processes (Cia et al., 2010; Rotili et al., 2013).

Fruits stored in refrigerated conditions tend to have greater resistance to perforation. Fruit firmness is very important in the choice of a cultivar, both for *in natura* consumption and for industrialization, and is directly correlated to texture. During storage passion fruit fruits wilt, thus losing vigor, water and mass, becoming more fragile (Guimarães et al., 2016). Texture values fluctuated during the experiment, and at 14 days all treatments under room conditions presented low resistance to perforation (Table 2). The fruits stored at room temperature ranged between 4.83N and 22.25N. Under refrigerated conditions at 10°C, the variation was between 7.83N and 22.25N. The treatments with the highest texture values were those with fruits packed in 30µm HDPE, where they reached 21.27N after 7 days of storage in ambient conditions, and at 14 days of storage under refrigerated conditions with a texture value of 19.89N. The fruits in the untreated control were the least resistant to perforation in the refrigerated condition after 14 days of storage. In the present work, the considerable loss of fresh fruit mass in the majority of treatments certainly influenced BRS Pérola do Cerrado passion fruit texture.

Luminosity values varied between 50.62 and 56.99, thus representing an oscillation of up to 10% during the 14 days of storage (Table 2). Nevertheless, there were no significant differences among the treatments and between storage conditions. Rinaldi et al. (2017) also did not observe significant variations in luminosity values of BRS Pérola do Cerrado passion fruits submitted to different sanitizers and stored at different temperatures for 21 days.

In general, it was observed a change of coloration on the fruits of BRS Pérola do Cerrado during storage. The levels of browning are an important factor for fruit color, hence browning increase is inversely correlated to fruit acceptance by the final consumer (Table 3). Browning ranged from zero to 20.48, thus obtaining an average of 17.05 at ambient temperature conditions and 15.14 when stored in a refrigerated environment at 10°C. There were no significant differences among the treatments.

Chromaticity values fluctuated between 25.71 and 37.90 in ambient condition and between 33.39 and 40.05 in refrigerated condition throughout storage (Table 3). Variations were statistically significant only under ambient storage condition. The 30µm HDPE treatment provided the best chromaticity indices with lower oscillations (30.15 and 37.90) in fruit color under both storage conditions. Chromaticity expresses color intensity, that is, the color in terms of pigment saturation. In the present study, passion fruit fruits presented intermediate chromaticity values, making it impossible to access if they have neutral or vivid colors.

The hue angle values ranged from 82.05 to 91.20 over the entire storage period (Table 3). In general, fruits maintained at 10 ºC presented higher hue angle values during the 14 days of storage without significant variation, confirming that this condition is more adequate in maintaining stable fruit coloration. Under refrigerated condition the fruits remained with hue angle values around 90, which is near the color yellow.

The 10µm PVC and 30µm HDPE treatments significantly interfered with oxygen and carbon dioxide concentration inside the packages during storage of BRS Pérola do Cerrado fruits (Table 4). Oxygen varied significantly, between 1.83% and 21.00%, under refrigerated storage. In ambient condition, the fruits packed in 10µm PVC presented higher oxygen levels after 14 days of storage. The effect was similar under refrigerated condition, but at significantly higher levels, confirming that lower fruit respiration rates occur when they are kept under refrigeration. Fruits packed with 30µm HDPE had the lowest oxygen rates, ranging from 21.00% to 4.73% in ambient conditions and from 21.00% to 1.83% under refrigeration. Thus indicating, that this package may present typical conditions for fruit fermentation.

CO_2 levels increased significantly during storage, reaching a maximum value of 9.0% after seven days in the 10µm PVC treatment under ambient condition (Table 4). In refrigeration the same treatment reached 5.97% of CO_2 as its highest value, also, after seven days of storage. In the 30µm HDPE treatment the

Table 3. Evaluation of the fruit browning, chromaticity and hue angle in BRS Pérola do Cerrado passion fruit under two different storage conditions

Treatments	Browning		
	Ambient storage		
	Storage time (days)		
	0	7	14
Without packaging	0.00aC	16.73aB	19.49aA
PVC 10µm	0.00aC	14.71aB	18.51aA
HDPE 30µm	0.00aC	12.81aB	20.48aA
Carnauba wax 12%	0.00aC	15.01aB	18.69aA
	Refrigerated storage (10ºC)		
Without packaging	0.00aB	13.61aA	14.18aA
PVC 10µm	0.00aC	12.36aB	16.39aA
HDPE 30µm	0.00aB	15.66aA	14.88aA
Carnauba wax 12%	0.00aC	18.98aA	15.05aB
	Chromaticity		
	Ambient storage		
	0	7	14
Without packaging	35.14aA	35.08aA	29.51bB
PVC 10µm	35.14aA	27.49bB	25.71bB
HDPE 30µm	35.14aA	30.15abB	37.90aA
Carnauba wax 12%	35.14aA	34.24aA	36.85aA
	Refrigerated storage (10 ºC)		
Without packaging	35.14aA	35.30aA	33.39aA
PVC 10µm	35.14aA	34.08aA	33.70aA
HDPE 30µm	35.14aA	34.10aA	34.88aA
Carnauba wax 12%	35.14aA	40.05aA	37.77aA
	Hue angle (°h)		
	Ambient storage		
	0	7	14
Without packaging	91.20aA	90.61aA	85.36aB
PVC 10µm	91.20aA	89.76aA	84.14aB
HDPE 30µm	91.20aA	89.03aA	82.05aB
Carnauba wax 12%	91.20aA	89.95aA	82.24aB
	Refrigerated storage (10ºC)		
Without packaging	91.20aA	91.02aA	89.96aA
PVC 10µm	91.20aA	91.07aA	90.87aA
HDPE 30µm	91.20aA	90.78aA	90.42aA
Carnauba wax 12%	91.20aA	90.93aA	90.41aA

[1]Same lowercase letters in the column do not differ significantly at the 5% level in Tukey's test. Same capital letters, on the line, do not differ significantly at the 5% level in Tukey's test.

Table 4. Evaluation of the oxygen and carbon dioxide percentage inside packaged treatments on BRS Pérola do Cerrado passion fruit during storage under two different environmental conditions

Treatments	Oxigen (O_2%)		
	Ambient storage		
	Storage time (days)		
	0	7	14
PVC 10µm	21.00aA	3.07aC	6.83aB
HDPE 30µm	21.00aA	4.93aA	4.73aA
	Refrigerated storage (10ºC)		
PVC 10µm	21.00aA	5.30aC	7.03aB
HDPE 30µm	21.00aA	2.80bB	1.83bB
	Carbon dioxide (CO_2%)		
	Ambient storage		
	0	7	14
PVC 10µm	0.03aB	9.00bA	8.57bA
HDPE 30µm	0.03aB	15.20aA	14.83aA
	Refrigerated storage (10ºC)		
PVC 10µm	0.03aB	5.97bA	5.27bA
HDPE 30µm	0.03aB	8.93aA	8.77aA

[1]Same lowercase letters in the column do not differ significantly at the 5% level in Tukey's test. Same capital letters, on the line, do not differ significantly at the 5% level in Tukey's test.

values were significantly higher reaching 15.20% under ambient condition and 8.93% under refrigeration after seven days of storage. In this experiment the CO_2 levels ranged from 0.03% to 15.20% in ambient temperature conditions and from 0.03% to 8.93% under refrigerated conditions at 10°C. The 10µm PVC packaging presented greater stability regarding oxygen and carbon dioxide concentration.

Total mesophyll aerobes count at the beginning of storage was of 7.1 x 10^2 CFU/g, which was consider low for a product that was not submitted to any pre-storage heat treatment (Table 5). The lowest count (5.3 x 10^2 CFU/g) during the 14-day storage period occurred on fruits coated with carnauba wax at 14 days of storage. The highest counts (10^5 CFU/g) were obtained from fruits packed in the 30 µm HDPE packaging stored under ambient conditions.

The psychotropic organism's count was initially 1.4 x 10^2 CFU/g, reaching a maximum value of 2.9 x 10^5 CFU/g on the untreated fruits kept under refrigeration after 14 days of storage (Table 5). The fruits coated

Table 5. Mean values of microbiological analysis on BRS Pérola do Cerrado fruits under two different storage conditions

Treatments	Total mesophyll aerobes count (CFU/g)	Total psychrotrophs count (CFU/g)	Total mold and yeast count (CFU/g)	Total coliforms (MPN/g)	Thermotolerant coliforms (MPN/g)
			Day zero		
	7.1 x 10^2	1.4 x 10^2	1.0 x 10^2	2.3 x 10^1	<3.0
			7^{th} day		
Control A	1.4 x 10^3	4.0 x 10^3	5.0 x 10^3	>1.1 x 10^3	<3.0
PVC 10µm A	1.1 x 10^4	8.3 x 10^3	5.9 x 10^3	>1.1 x 10^3	<3.0
HDPE 30µm A	2.4 x 10^5	1.2 x 10^4	4.6 x 10^3	>1.1 x 10^3	<3.0
Wax 12% A	8.7 x 10^3	5.2 x 10^2	2,3 x 10^3	>1.1 x 10^3	<3.0
Control R	8.9 x 10^2	1.5 x 10^4	6.4 x 10^2	7.2 x 10	<3.0
PVC 10µm R	2.1 x 10^3	2.9 x 10^3	1.4 x 10^3	4.3 x 10^1	<3.0
HDPE 30µm R	1.2 x 10^3	6.3 x 10^3	2.2 x 10^3	2.4 x 10^2	<3.0
Wax 12% R	3.3 x 10^3	3.6 x 10^3	9.0 x 10^1 est.	<3.0	<3.0
			14^{th} day		
Control A	4.7 x 10^3	1.4 x 10^4	2.1 x 10^4	2.1 x 10^1	<3.0
PVC 10µm A	8.2 x 10^2	7.4 x 10^3	1.0 x 10^3	>1.1 x 10^3	<3.0
HDPE 30µm A	2.1 x 10^5	1.8 x 10^4	2.9 x 10^5 est	>1.1 x 10^3	<3.0
Wax 12% A	1.3 x 10^4	4.8 x 10^3	1.2 x 10^4	>1.1 x 10^3	<3.0
Control R	8.9 x 10^4	2.9 x 10^5	8.8 x 10^3	>1.1 x 10^3	<3.0
PVC 10µm R	3.3 x 10^3	1.8 x 10^3	1.0 x 10^3	2.3 x 10^1	<3.0
HDPE 30µm R	6.0 x 10^4	1.2 x 10^4	1.2 x 10^5	>1.1 x 10^3	<3.0
Wax 12% R	5.3 x 10^2	7.4 x 10^2	5.8 x 10^2	3.6 x 10	<3.0

[1]CFU = Colony forming unit. MPN = Most probable number. est.: estimated count. A = Ambient. R = Refrigerated.

with carnauba wax also had the lowest counts for these microorganisms. Although there is no standard concentration under brazilian legislation, high colony counts (> 10^5 CFU/g) mean that the fruits are inadequate for consumption, due to the loss of sensorial qualities, and presence of pathogenic/rotting microorganisms (Bruno et al., 2005).

For molds and yeasts the initial count was 1.0 x 10^2 CFU/g. There highest concentrations where at seven and 14 days of storage, especially on fruits stored under ambient conditions (Table 5). According to Resolution RDC Nº. 12, of January 2, 2001 (Brazil, 2001), the concentration limit is of 10^3 CFU/g for food safety. In the present work, at seven days of storage, all treatments corresponded to the requirements of the legislation. At 14 days, the fruits in the 10µm PVC treatment, in both storage conditions, the untreated refrigerated control and the refrigerated 12% carnauba wax treatment also showed mold and yeast counts acceptable by the current legislation.

The presence of total coliforms was between <3 and > 1.1 x 10^3 MPN/g, also with lower values in fruits coated with carnauba wax (Table 5). In the brazilian food legislation there is also no standard for total coliforms, but low counts for these microorganisms are important (Brazil, 2001). Concentrations around 10^3 NMP/g are considered acceptable for fresh fruits during post-harvest storage. The count of thermotolerant coliforms was low (<3.0), according to the requirements of the legislation that allows a maximum of 5 x 10^2 MPN/g for coliforms at 45ºC, on fresh fruits, processed (peeled or selected or fractioned) sanitized, chilled or frozen, for direct consumption. The results obtained in the present work showed that *P. setacea* (BRS Pérola do Cerrado) fruits were stored according to legislation requirements for this type of microorganism. According to Bonnas et al. (2003), the presence/absence of coliforms can also function as a parameter of hygienic-sanitary conditions during food processing. Thus, from the results obtained, the hygienic-sanitary conditions were satisfactory during the experiment.

Conclusion

BRS Pérola do Cerrado fruits stored under refrigerated conditions, and using 10µm PVC packaging material presented low fresh weight loss and the highest oxygen concentration (no fermentation) during the 14-day experiment, thus being considered the best treatment evaluated in this trial.

Acknowledgments

The authors thank the National Council for Scientific and Technological Development (CNPq) Project No. 404847/2012-09 for financial support, and the Brazilian Agricultural Research Corporation (Embrapa) for their support in the development of this research project.

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