

Refrigerated storage of pitombas subjected to different packaging

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Abstract

This study aimed to verify the effect of the association between refrigeration and packaging on the preservation of postharvest quality of pitombas during storage. The fruits were harvested, transported to the laboratory, where they were selected, washed with neutral detergent and drinking water, and left to dry. Subsequently, the fruits packed in polypropylene (PP), low-density polyethylene (LDPE), polyethylene terephthalate (PET), polyvinyl chloride (PVC) + expanded polystyrene (EPS), and no packaging (Control). After this process, they were stored at temperatures of 6, 8, 10, 12, and 14±1 °C at 75±5% relative humidity (RH). The fruits were evaluated during 12 days for postharvest preservation, firmness, soluble solids content, pH, hue angle and chroma of the peel, with three replications of 10 fruits each, using a completely randomized design in a 5 × 5 × 7 factorial scheme (5 temperatures × 5 packages × 7 days of analysis). The results were subjected to analysis of variance ($P \leq 0.05$) and, when significant, the means were compared using the Scott-Knott test and regression at a 5% significance level. The use of LDPE packaging associated with refrigeration at 6 °C can be used to store pitombas for 12 days, as these conditions preserved the evaluated parameters, guaranteeing fruit quality.

Keywords: *Talisia esculenta* Radlk., quality, passive modified atmosphere, films

Introduction

Brazil is one of the three largest fruit producers after China and India due to its territorial extension, geographical location, and favorable edaphoclimatic conditions (Moreira-Araújo et al., 2019).

The worldwide interest in Brazilian fruits has increased, stimulating research with native fruits from the Cerrado, which is the second-largest biome in South America, occupying around 22% of the national territory (Brasil, 2019).

Among the native fruits is the pitomba (*Talisia esculenta* Radlk.), which belongs to the Sapindaceae family and is grown in the North and Northeast regions. Its pulp is the only edible part and has a white-pink color and apricot-like texture (Guarim Neto et al., 2000) and can be used both for fresh and processed consumption, as it has high values of minerals, soluble solids, and vitamin C, besides excellent physical, chemical, and functional

characteristics, with high contents of proteins, phenolic compounds, carotenoids, and flavonoids (Queiroga et al., 2019; Fraga & Carvalho, 2020).

Thus, studies to extend its shelf life are important, as its commercialization is restrictive due to its high perishability to be sold fresh. Among the technologies used to increase fruit shelf life is the refrigeration, and its use can be associated or not with packaging.

Refrigeration acts to prolong the postharvest life of plants, inhibiting the development of rot and growth of microorganisms (Samira et al., 2011; Serpa et al., 2014). Changes in the main chemical and physical transformations of commercial interest for the fruit may occur depending on the storage temperature, especially regarding the contents of carbohydrates, organic acids, pigments, volatile compounds, texture (Pompeu et al., 2009; Vieites et al., 2011) and other quality attributes.

However, the use of refrigeration in isolation may

not be satisfactory to maintain the quality and prolong the shelf life of fruits, which is due to the ripening process, making it necessary to associate technologies (Silva et al., 2016).

Thus, the use of a passive modified atmosphere associated with refrigeration is necessary and beneficial, as the use of films limits gas exchange with the environment, decreasing deteriorating chemical and biochemical reactions and slowing or preventing the proliferation of microorganisms, prolonging their quality. This technique also provides other desirable effects, such as the maintenance of color, texture, flavor, and the nutritional value of the product by altering the composition of gases that surround the fruits (Arruda et al., 2011; Edusei & Ofosu-Anim, 2013; Oshiro et al., 2013).

In this context, this study aimed to verify the effect of the association between refrigeration and packaging on the preservation of postharvest quality of pitombas during storage.

Material and Methods

The fruits were extractively harvested from December 2017 to January 2018 at Fazenda Córrego da Mata, located in Montes Claros de Goiás, Goiás, Brazil, with geographical coordinates of 16°00'30" S and 51°23'24" W, an altitude of 424 meters, and 317 km from Anápolis, GO, Brazil. The fruits were at the physiological ripening stage, which corresponds to an epicarp color ranging from light to dark yellow (Guarim Neto et al., 2003).

After harvesting, the pitombas were placed in expanded polystyrene packaging and transported to the Laboratory of Drying and Storage of Plant Products at the State University of Goiás, campus of Anápolis, where they were selected manually and visually for the absence of defects, ripening stage, and injuries aiming at maximum lot uniformity.

Subsequently, the fruits were sanitized in a 2% sodium hypochlorite solution for 10 minutes, rinsed in distilled water, dried, and packed in the following packages under a passive modified atmosphere: polypropylene (PP), low-density polyethylene (LDPE), polyvinyl chloride (PVC) + expanded polystyrene (EPS), polyethylene terephthalate (PET), and no packaging (Control). The packages were stored in a biochemical oxygen demand (BOD) incubator at temperatures of 6, 8, 10, 12, and 14±1 °C and 75±5% relative humidity (RH).

The experimental design was completely randomized in a 5 × 5 × 7 factorial scheme (5 temperatures × 5 packages × 7 days of analysis), with three replications of 10 fruits each for a period of 12 days of storage. The

fruits were evaluated every two days for postharvest conservation, firmness, pH, soluble solids content, and hue angle.

Postharvest conservation was given by the number of days the fruits were preserved according to their commercial quality (sanity and color). For this, a subjective score scale was used, as follows: 9 (fresh fruits with no fungi, darkening, and free from deterioration), 7 (fresh fruits with a slight presence of fungi, darkening, and deterioration), 5 (a little aspect of freshness with moderate presence of fungi, darkening, and deterioration), 3 (no freshness with high presence of fungi, darkening, and deterioration), and 1 (dehydrated fruits totally covered with fungi, darkened, and deteriorated). Score 7 was the limit for commercial quality. Eleven untrained evaluators classified the fruits, as proposed by Souza et al. (2010), with adaptations.

Firmness was determined on the fruit peel using a Brookfield CT3 50K texture analyzer set for a speed of 6.9 mm s⁻¹, with a TA4/1000 cylindrical test probe (38.1 mm diameter and 20 mm high). The results were expressed in Newton (N), being defined the maximum force required to break the pitomba peel.

The pH was obtained using a Kasvi pH 0-14 K39-0014P portable pH meter, with an accuracy of ±0.06 and automatic temperature compensation (AOAC, 2012).

The soluble solids content was determined by refractometric reading using a Reichert Brix/RI-Chek portable digital refractometer, which measures from 0 to 62 °Brix, following the AOAC (2012) recommendation.

The hue angle of the fruit peel was obtained by reflectance, using a Konica Minolta CR-400 portable colorimeter, with CIELAB scale (L*, a*, and b*). The coordinate a* is related to the lightness from green (-a) to red (+a) and the coordinate b* is related to the lightness from blue (-b) to yellow (+b). Hue was calculated from the coordinates a* and b*.

The results were subjected to analysis of variance and, when significant, the means were compared using the Scott-Knott test and regression at a 5% significance level.

Results and Discussion

The visual fruit quality is an extremely important and determining factor in the choice of consumers and may be affected by the presence of defects and injuries, which would make them less attractive. Therefore, postharvest conservation was determined according to the visual quality and health aspect by evaluating the fruits within a scale ranging from 9 to 1, and the lower the score, the lower the postharvest fruit preservation, with 7

representing the cut-off point for commercial quality.

Pitombas stored at low temperatures maintained their quality unchanged for a longer period. The temperature of 6 °C provided the postharvest

conservation extension for up to 16 days (Figure 1), visually standing out the low-density polyethylene (LDPE) packaging, responsible for less darkening compared to other packages (Figure 2).

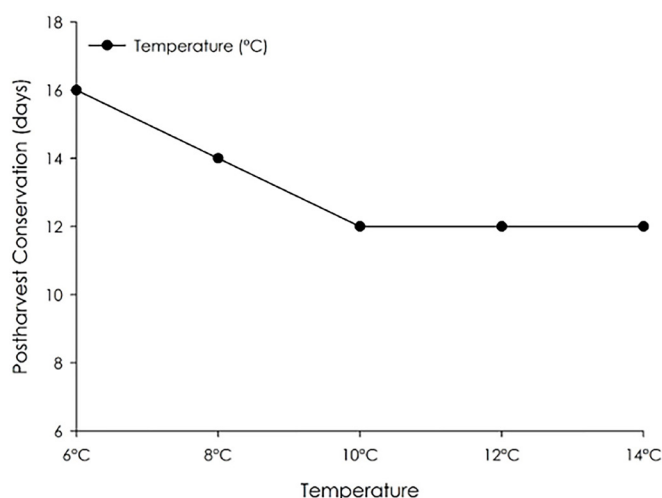


Figure 1. Postharvest conservation(days) of pitombas stored at 6, 8, 10, 12, and 14±1 °C and 75±5% RH for up to 16 days.

Vasconcelos et al. (2017) reported that low temperatures associated with LDPE packaging were responsible for maintaining the desirable postharvest characteristics, allowing the June plum fruit to preserve for up to 21 days its physical and visual quality, which was similar to that found in this study.

The results found for pitomba are also in agreement with Santos et al. (2011) and Kohatsu et al. (2011), who pointed out that the plastic packaging associated with refrigeration delayed fruit ripening, reducing respiration and transpiration, with satisfactory characteristics for better postharvest preservation.



Figure 2. Aspect of pitombas packed in polypropylene (PP), polyethylene terephthalate (PET), polyvinyl chloride (PVC) + expanded polystyrene (EPS), low-density polyethylene (LDPE), and no packaging (Control) at temperatures of 6 (16 days), 8 (15 days), 10 (13 days), 12 (13 days), and 14 °C (13 days).

Firmness is an important attribute that represents fruit quality and acceptance by the consumer (Onias et al., 2018), besides being associated with the maintenance of the postharvest shelf life. In this respect, the positive result regarding the increase in peel firmness is interesting for a wide variety of fruits, such as lychee, passion fruit, and banana (Freire et al., 2010; Martineli et al., 2010; Anjos et al., 2014), but not for pitomba because as the firmness increased, the peel became harder for being fibrous. Water loss in the fruits caused the peel to become harder, making it difficult to break to reach the pulp, which remained intact during storage.

According to the average firmness provided by the packages within the tested temperatures (Table 1), the evaluated packaging showed no significant difference from each other when stored at temperatures of 6, 8, and 10 °C. However, pitombas packed in PVC + EPS packaging and no packaging (control), stored at temperatures of 12 and 14 °C, showed the highest average firmness, differing statistically from the others.

It is possible that the non-solubilization of the pectins contained in the cell wall of the peel (Ishak et al., 2005; Trigo et al., 2012), as well as the low efficiency of the PVC packaging as a barrier to gases (O₂ and CO₂) (Rotili et al., 2013), may have favored an increase in firmness with the advance of fruit ripening.

The average temperatures inside each package showed a significant difference only for the control package, with the temperature of 14 °C being responsible for the highest average (145.51 N) (Table 1). This behavior, according to Souza et al. (2010), may be associated with the loss of moisture from fruits during storage, that is, the higher the loss of mass to the environment, the higher the fruit resistance.

Packaged fruits showed no significant difference from each other regarding firmness values up to the 10th day, and only the control differed statistically on the 12th day from the other packages, being responsible for the highest average of this parameter (156.15 N) (Table 1).

Table 1. Firmness (N) of pitombas packed in polypropylene (PP), low-density polyethylene (LDPE), polyethylene terephthalate (PET), polyvinyl chloride (PVC) + expanded polystyrene (EPS), and no packaging (Control) and stored at different temperatures (6, 8, 10, 12, and 14 °C) for 12 days.

Temperature	Packaging				
	PP	LDPE	PET	PVC+EPS	Control
6 °C	132.93 Aa	137.09 Aa	132.08 Aa	133.19 Aa	126.17 Ba
8 °C	125.82 Aa	127.70 Aa	135.21 Aa	130.18 Aa	117.60 Ba
10°C	119.51 Aa	122.81 Aa	135.40 Aa	125.21 Aa	126.16 Ba
12°C	120.41 Ab	125.57 Ab	122.06 Ab	137.09 Aa	136.66 Aa
14°C	128.40 Ab	124.08 Ab	129.03 Ab	142.26 Aa	145.51 Aa
Days					
0	99.67 Ca	99.67 Ba	99.67 Ba	99.67 Ca	99.67 Ca
2	123.18 Ba	128.71 Aa	123.02 Aa	127.96 Ba	126.14 Ba
4	133.38 Ba	131.01 Aa	138.34 Aa	137.03 Ba	124.17 Ba
6	146.43 Aa	140.91 Aa	141.94 Aa	150.25 Aa	128.61 Ba
8	124.64 Ba	139.74 Aa	135.99 Aa	154.59 Aa	141.56 Aa
10	130.36 Ba	128.26 Aa	146.35 Aa	135.37 Ba	136.64 Ba
12	120.22 Bb	123.86 Ab	130.82 Ab	130.21 Bb	156.15 Aa

Means followed by the same lowercase letter in the row (comparing the means of packages for each temperature and day of analysis) and uppercase letter in the column (comparing the means of temperatures and days of analysis for each package) do not differ significantly from each other ($p>0.05$) by the Scott-Knott test.

The averages of days of analysis within each package showed that the storage provided an increase in fruit firmness from the 2nd day for all tested packages. The 6th day presented the maximum peak of peel firmness for fruits in PP, with subsequent decrease until the end of storage, with the lowest average on the 12th day (120.22 N) (Table 1). This result, according to Oliveira et al. (2014), may be associated with CO₂ accumulation inside the package and fruit variability, i.e., different ripening stages, with oscillation during the evaluations, with no standardized behavior.

However, LDPE and PET packaging differed statistically only on the 1st day of evaluation (day 0), being

responsible for the smallest variation in firmness during the storage, mainly LDPE. Vasconcelos et al. (2017) verified a positive effect of LDPE packaging on the maintenance and potential of firmness in June plum during storage for up to 21 days, which was also verified in this work.

The soluble solids contents showed a significant influence ($p\leq 0.05$) by the F-test, only for the interactions temperature \times days (Figure 3) and packaging \times days (Table 2).

The soluble solids content increased during storage for all treatments up to the 8th day, especially for the temperature of 14 °C, which showed less variation during storage. However, the temperature of 6 °C

presented the highest increase in soluble solids up to the 8th day, with subsequent decrease until the end of storage, being responsible for the lowest value of this parameter, reaching 14.22 °Brix on the 12th day (Figure 3).

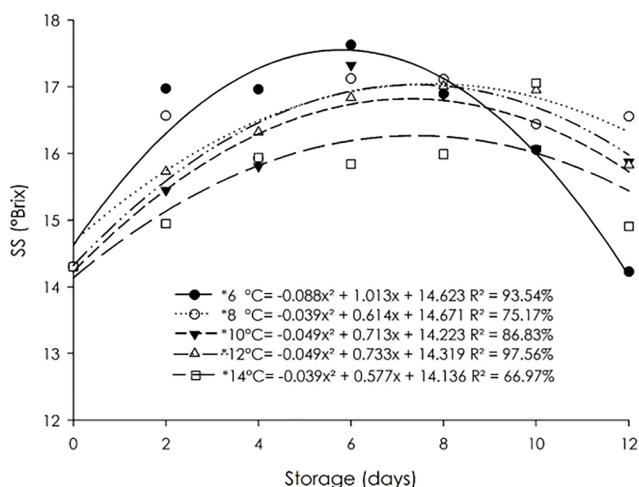


Figure 3. Soluble solids content (SS) of pitombas packed in packages and stored at different temperatures (6, 8, 10, 12, and 14 °C) for 12 days.

According to Nunes (2015), the decrease in soluble solids contents can be explained by the use of these compounds as a substrate in the respiration of fruits.

The LDPE packaging showed the lowest average at the end of storage, on the 12th day, with a value of 15.26 °Brix, with no significant difference between PVC + EPS and PET (Table 2). The results showed, in general, that fruits packed with plastic films presented higher maintenance of soluble solids than unpackaged fruits (control). This maintenance of soluble solids occurs because the packaging provides to fruits a reduction in their metabolic activity, delaying its ripening (Santos et al., 2011). Siqueira et al. (2017) stated that the decrease in the metabolic activity of packaged fruits is due to the atmospheric modification inside the packages, causing a decrease in the ripening rate.

Table 2. Soluble solids content (SS, °Brix) from pitombas packed in polypropylene (PP), low-density polyethylene (LDPE), polyethylene terephthalate (PET), polyvinyl chloride (PVC) + expanded polystyrene (EPS), and no packaging (Control) and stored at different temperatures (6, 8, 10, 12, and 14 °C) for 12 days.

Days	Packaging				
	PP	LDPE	PET	PVC+EPS	Control
0	14.30 Ca	14.30 Da	14.30 Ca	14.30 Da	14.30 Da
2	16.17 Ba	16.07 Ba	15.98 Ba	15.44 Ca	16.00 Ca
4	15.87 Bb	16.38 Ba	16.01 Bb	16.05 Bb	16.64 Ba
6	17.07 Aa	17.26 Aa	16.85 Aa	16.77 Aa	16.77 Ba
8	16.54 Ab	16.67 Ab	16.45 Ab	17.04 Aa	17.17 Aa
10	16.73 Ab	16.07 Bc	16.10 Bc	16.22 Bc	17.24 Aa
12	16.07 Ba	15.26 Cb	15.81 Bb	15.59 Cb	16.67 Ba

Means followed by the same lower case letter in the row and uppercase letter in the column do not differ significantly from each other (p>0.05) by the Scott-Knott test.

The pH values showed a relevant interaction only between the factors packaging x temperature (Table 3) and temperature x days (Figure 4). The average pH variation as a function of the factors packaging x temperature (Table 3) showed a significant difference between packages. In this case, the association between PP packaging and the temperature of 6 °C presented the lowest average (4.11), which may favor the inhibition and development of microorganisms responsible for food deterioration, causing an increase in the preservation period (Oliveira et al., 2010).

Table 3. pH of pitombas packed in polypropylene (PP), low-density polyethylene (LDPE), polyethylene terephthalate (PET), polyvinyl chloride (PVC) + expanded polystyrene (EPS), and no packaging (Control) and stored at different temperatures (6, 8, 10, 12, and 14 °C) for 12 days.

Temperature	Packaging				
	PP	LDPE	PET	PVC+EPS	Control
6 °C	4.11 Bb	4.19 Ba	4.20 Aa	4.16 Cb	4.13 Db
8 °C	4.17 Aa	4.19 Ba	4.19 Aa	4.15 Ca	4.21 Ca
10 °C	4.12 Bb	4.18 Ba	4.22 Aa	4.23 Ba	4.16 Db
12 °C	4.15 Bb	4.18 Bb	4.24 Aa	4.27 Ba	4.29 Ba
14 °C	4.21 Ac	4.25 Ac	4.25 Ac	4.33 Ab	4.48 Aa

Means followed by the same lowercase letter in the row and uppercase letter in the column do not differ significantly from each other (p>0.05) by the Scott-Knott test.

During storage, a decrease in pH was expected for all treatments, which would be associated with the accumulation of sugars (SS) and organic acids during fruit ripening (Nascimento Junior et al., 2008; Oshiro et al., 2013; Oliveira et al., 2014; Siqueira et al., 2017). However, this behavior was observed only for temperatures of 8 and 10 °C up to the 6th day, with a subsequent increase until the end of storage, being responsible for the lowest averages on the 12th day (4.36 and 4.35, respectively) (Figure 4).

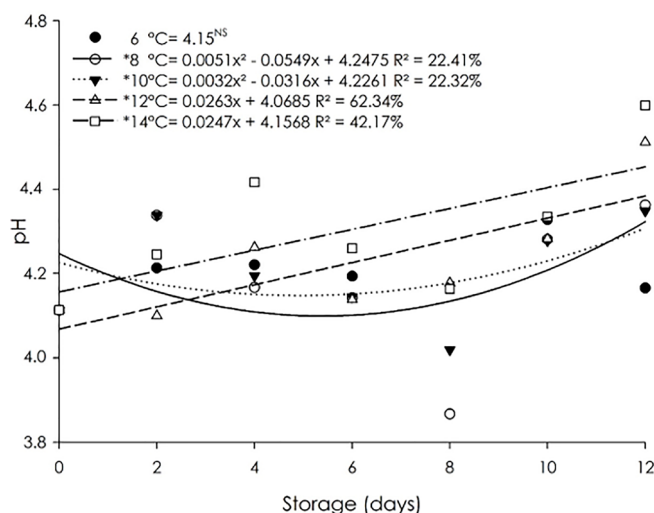


Figure 4. pH of pitombas packed in packages and stored at different temperatures (6, 8, 10, 12, and 14 °C) for 12 days.

On the other hand, temperatures of 12 and 14 °C showed a linear increase during storage from the beginning, standing out the temperature of 14 °C, with the highest average on the 12th day (4.60) (Figure 4), indicating a possible increase in the ripening rate and, consequently, accelerating fruit senescence. Bolzan (2013) also observed an increase in the pH as the storage temperature of physalis fruits increased, with the temperatures of 14 and 18 °C standing out with the highest averages.

The hue angle showed significance only in the interactions between packaging x temperature and packaging x storage time (Table 4). Fruit color can be interpreted from the data of °hue, which expresses the fruit color itself (Moreno et al., 2016), in which the 0° angle represents red, 90° yellow, 180° green, and 270° blue (Brackmann et al., 2011). In this context, pitomba fruits presented a color orange-yellow, ranging from 84.12 to 66.43°.

Table 4. Hue angle of pitombas packed in polypropylene (PP), low-density polyethylene (LDPE), polyethylene terephthalate (PET), polyvinyl chloride (PVC) + expanded polystyrene (EPS), and no packaging (Control) and stored at different temperatures (6, 8, 10, 12, and 14 °C) for 12 days.

Temperature	Packaging				
	PP	LDPE	PET	PVC+EPS	Control
6 °C	74.74 Aa	75.51 Aa	77.12 Aa	72.17 Ab	65.21 Bc
8 °C	75.34 Aa	76.47 Aa	78.34 Aa	72.20 Ab	66.17 Bc
10°C	75.20 Aa	77.04 Aa	76.48 Aa	73.55 Ab	68.08 Bc
12°C	73.86 Aa	75.67 Aa	75.44 Aa	74.61 Aa	71.85 Aa
14°C	73.48 Aa	75.17 Aa	75.05 Aa	74.82 Aa	74.24 Aa
Days					
0	84.12 Aa	84.12 Aa	84.12 Aa	84.12 Aa	84.12 Aa
2	74.36 Bb	77.63 Ba	76.56 Ba	77.07 Ba	72.72 Bb
4	74.16 Ba	77.29 Ba	77.11 Ba	74.10 Ba	66.57 Cb
6	74.22 Bb	79.62 Ba	76.45 Bb	75.06 Bb	68.14 Cc
8	73.10 Bb	74.68 Ca	77.62 Ba	70.77 Cb	65.28 Cc
10	71.19 Ca	69.67 Db	73.43 Ca	68.92 Cb	65.68 Cb
12	67.72 Ca	68.79 Da	70.09 Ca	64.25 Db	61.28 Db

Means followed by the same lowercase letter in the row (comparing the means of packages for each temperature and day of analysis) and uppercase letter in the column (comparing the means of temperatures and days of analysis for each package) do not differ significantly from each other ($p>0.05$) by the Scott-Knott test.

A significant difference was observed only for PVC + EPS packaging and NP (control) stored at temperatures of 6, 8, and 10 °C, responsible for the lowest averages of this parameter (Table 4). Overall, the °hue was maintained for fruits packaged in PP, LDPE, and PET packaging maintained at low temperatures (6, 8, and 10 °C). This result is in agreement with Moreno et al. (2016), who verified that low temperatures (4 °C) associated with plastic packaging provided °hue maintenance in 'Maciel' peaches.

Likewise, the average temperatures for each package in isolation showed that only the control (no packaging) had a significant difference, with the temperatures of 12 and 14 °C differing from the others and showing the highest averages of this treatment (Table 4).

In general, the hue angle decreased from the beginning to the 12th day for all treatments (Table 4), possibly due to the alteration and degradation of carotenoids (Vilas Boas et al., 2012), indicating a change in the yellow color of the pitomba peel to a yellow-orange hue. In this context, Infante et al. (2011) and Gonçalves et al. (2010) stated that usually, the °hue decreases with fruit ripening, which, according to Cao et al. (2016), is related to the ripening process, a behavior observed during

storage.

At the end of storage, PET was responsible for the least variation and, consequently, higher stability in color modification compared to the other packages, but significantly similar to PP, with an average ranging from 84.12° (1st day) to 70.09° (12th day).

Conclusions

The association of packaging with lower temperatures was efficient to prolong the shelf life of pitomba fruits. The use of LDPE packaging associated with refrigeration at 6 °C can be used to store pitombas for 12 days, as it preserved the evaluated parameters, guaranteeing fruit quality.

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References

Anjos, V.D.A., Valentini, S.R.T., Benato, E.A. 2014. Influência de tratamento térmico e sistemas de embalagens na qualidade de lichia 'Bengal'. *Revista Brasileira de Fruticultura* 36: 820-827.

- Arruda, M.C., Jacomino, A.P., Trevisan, M.J., Jeronimo, E.M., Moretti, C.L. 2011. Atmosfera modificada em laranja 'Pêra' minimamente processada. *Bragantia* 70: 664-671.
- AOAC. Association of Official Analytical Chemists. Official methods of analysis. 19.ed. Washington, 2012.
- Bolzan, R.P. 2013. *Conservação pós-colheita e caracterização de frutos de physalis (Physalis angulata L.) produzidos na região metropolitana de Curitiba-Paraná*. 102f. (PhD Thesis) - Federal University of Paraná, Curitiba, Brazil.
- Brackmann, A., Anese, R.O., Giehl, R.F.H., Weber, A., Eisermann, A.C., Sestari, I. 2011. Pré-resfriamento para conservação pós-colheita de melões Cantaloupe 'Hy Mark'. *Bragantia* 70: 672-676.
- BRASIL. Ministério do Meio Ambiente. O Bioma cerrado. 2019. <http://www.mma.gov.br/biomas/cerrado><Access on 26 nov. 2019>
- Cao, S., Song, C., Shao, J., Bian, K., Chen, W., Yang, Z. 2016. Exogenous Melatonin Treatment Increases Chilling Tolerance and Induces Defense Response in Harvested Peach Fruit during Cold Storage. *Journal of Agricultural and Food Chemistry* 64: 5215-5222.
- Edusei, V.O., Ofosu-Anim, J. 2013. Biochemical changes in green chilli pepper fruits during storage in polymeric films. *Journal of Research in Agriculture* 2: 187-192.
- Fraga, L.N., Carvalho, I.M.M. 2020. *Talisia esculenta* (A. ST.-HIL.) Radlk: physico-chemical characteristics, antioxidant activity and biological activity. *Research, Society and Development* 9: 1-19.
- Freire, J.L.O., Cavalcante, L.F., Rebequi, A.M., Dias, T.J., Nunes, J.C., Cavalcante, I.H.L. 2010. Atributos qualitativos do maracujá amarelo produzido com água salina, biofertilizante e cobertura morta no solo. *Revista Brasileira de Ciências Agrárias* 5: 102-110.
- Gonçalves, G.A.S., Vilas Boas, E.V.B., Resende, J.V., Machado, A.L.L., Vilas Boas, B.M. 2010. Qualidade do pequi submetido ao cozimento após congelamento por diferentes métodos e tempos de armazenamento. *Revista Ceres* 57: 581-588.
- Guarim Neto, G., Santana, S.R., Silva, J.V.B. 2000. Notas etnobotânicas de espécies de Sapindaceae Jussieu. *Acta Botânica Brasileira* 14: 327-334.
- Guarim Neto, G., Santana, S.R., Silva, J.V.B. 2003. Botanical repertorium of the pitombeira (*Talisia succulenta* (A. St.-Hil.) Radlk. – Sapindaceae. *Acta Amazonica* 33: 237-242.
- Infante, R., Contador, L., Rubio, P., Mesa, K., Meneses, C. 2011. Non-destructive monitoring of flesh softening in the black-skinned Japanese plums 'Angeleno' and 'Autumn beaut' on-tree and postharvest. *Postharvest Biology and Technology* 61: 35-40.
- Ishak, S.A., Ismail, N., Mohd Noor, M.A., Ahmad, H. 2005. Some physical and chemical properties of ambarella (*Spondias cytherea* Sonn.) at three different stages of maturity. *Journal of Food Composition and Analysis* 18: 819-827.
- Kohatsu, D.S., Zucareli, V., Brambila, W.P., Evangelista, R.M. 2011. Qualidade de frutos de cajá-manga armazenados sob diferentes temperaturas. *Revista Brasileira de Fruticultura* 33: 344-349.
- Martineli, M., Coneglian, R.C.C., Vasconcellos, M.A.S., Busquet, R.N., Silva, E., Vital, H.C. 2010. Qualidade de frutos de banana 'Prata' submetidos à radiação gama antes do processo de climatização. *Revista Trópica: Ciências Agrárias e Biológicas* 4: 44-51.
- Moreira-Araújo, R.S.R., Barros, N.V.A., Porto, R.G.C.L., Brandão, A.C.A.S., Lima, A., Fett, R. 2019. Bioactive compounds and antioxidant activity three fruit species from the Brazilian Cerrado. *Revista Brasileira de Fruticultura* 41: Epub.
- Moreno, M.B., Barreto, C.F., Silva, P.S., Malgarim, M.B., Fachinello, J.C. 2016. Qualidade de pêssegos 'Maciel' sob armazenamento refrigerado com a utilização de embalagens. *Revista Iberoamericana de Tecnología Postcosecha* 17: 58-64.
- Nascimento Junior, B.B., Ozorio, L.P., Rezende, C.M., Soares, A.G., Fonseca, M.J.O. 2008. Diferenças entre bananas de cultivares Prata e Nanicao ao longo do amadurecimento: características físico-químicas e compostos voláteis. *Revista Ciência e Tecnologia de Alimentos* 28: 649-658.
- Nunes, S.P. 2015. *Irradiação gama e UV-C na qualidade pós-colheita de mirtilo*. 94p. (M.Sc. Thesis) - Federal University of Lavras, Lavras, Brazil.
- Oliveira, J., Silva, I.G., Silva, P.P.M., Spoto, M.H.F. 2014. Atmosfera modificada e refrigeração para conservação pós-colheita de camu-camu. *Ciência Rural* 44: 1126-1133.
- Oliveira, M.E.B., Guerra, N.B., Maia, A.H.N., Alves, R.E., Matos, N.M.S., Sampaio, F.G.M., Lopes, M.M.T. 2010. Características Químicas e Físico-Químicas de pequi da Chapada do Araripe, Ceará. *Revista Brasileira de Fruticultura* 32: 114-125.
- Onias, E.A., Teodosio, A.E.M.M., Bomfim, M.P., Rochar, H.C., Lima, J.F., Medeiros, M.L.S. 2018. Revestimento biodegradável à base de *Spirulina platensis* na conservação pós-colheita de goiaba Paluma mantidas sob diferentes temperaturas de armazenamento. *Revista de Ciências Agrárias* 41: 849-86.
- Oshiro, A.M., Dresch, D.M., Scalón, S.P.Q. 2013. Atmosfera modificada e temperaturas de armazenamento na conservação pós-colheita de guavira (*Campomanesia adamantium* Camb.). *Bioscience Journal* 29: 421-1430.
- Pompeu, D.R., Barata, V.C.P., Rogez, H. 2009. Impacto da refrigeração sobre variáveis de qualidade dos frutos do açazeiro (*Euterpe oleracea*). *Alimentos e Nutrição* 20: 141-148.
- Queiroga, A.X.M., Costa, F.B., Santiago, M.M., Sousa, F.F., Santos, K.P., Silva, J.L., Medeiros, A.E.M., Sales, G.N.B., Bernardino Filho, R. 2019. Physical, chemical-physical characterization and determination of bioactives

compounds of the pitombeira fruits. *Journal of Agricultural Science* 11: 303-312.

Rotili, M.C.C., Vorpapel, J.A., Braga, G.C., Kuhn, O.J., Salibe, A.B. 2013. Atividade antioxidante, composição química e conservação do maracuja-amarelo embalado com filme de PVC. *Revista Brasileira de Fruticultura* 4: 942-952.

Santos, A.E.O., Assis, J.S., Batista, P.F., Santos, O.O. 2011. Utilização de atmosfera modificada na conservação pós-colheita de mangas 'Tommy Atkins'. *Revista Semiárido de Visu* 1: 10-17.

Samira, A., Woldetsadik, K., Workneh, T.S. 2011. Postharvest quality and shelf life of some hot pepper varieties. *Journal of Food Science and Technology* 50: 842-855.

Serpa, M.F.P., Castricini, A., Mitsobuzi, G.P., Martins, R.N., Batista, M.F., Almeida, T.H. 2014. Conservação de manga com uso de fécula de mandioca preparada com extrato de cravo e canela. *Revista Ceres* 61: 975-982.

Silva, G.M.C., Silva, M.P.S., Biazatti, M.A., Santos, P.C., Silva, N.M., Mizobutsi, G.P. 2016. Uso do 1-MCP e atmosfera modificada na pós-colheita de atemoia 'Gefner'. *Revista Brasileira de Ciências Agrárias* 11: 67-72.

Siqueira, C.L., Lopes, O.P., Batista, P.S.C., Rodrigues, M.L.M., Serpa, M.F.P., Mizobutsi, G.P., Mota, W.F. 2017. Atmosfera modificada e refrigeração na conservação pós colheita de bananas 'Tropical' e 'Thap Maeo'. *Nativa* 5: 157-162.

Souza, A.V., Vieites, R.L., Lima, G.P.P. 2010. Influência do tratamento térmico na qualidade de lichias refrigeradas. *Revista Iberoamericana Tecnología Postcosecha* 10: 110-119.

Trigo, J.M., Albertini, S., Spoto, M.H.F., Reyes, A.E.L., Sarriés, G.A. 2012. Effect of edible coatings on the preservation of fresh cut papayas. *Brazilian Journal of Food Technology* 15: 125-133.

Vasconcelos, L.H.C., Evangelista, Z.R., Campos, A.J., Teixeira, I.R. 2017. Diferentes embalagens na conservação pós-colheita de Cajá-Manga. *Revista Espacios* 38: 1-10.

Vieites, R.L., Daiuto, E.R., Moraes, M.R., Neves, L.C., Carvalho, L.R. 2011. Caracterização físico-química, bioquímica e funcional da jabuticaba armazenada sob diferentes temperaturas. *Revista Brasileira de Fruticultura* 33: 362-375.

Vilas Boas, B.M., Gonçalves, G.A.S., Alves, J.A., Valério, J.M., Alves, T.C., Rodrigues, L.J., Piccoli, R.H., Vilas Boas, E.V.B. 2012. Qualidade de pequis fatiados e inteiros submetidos ao congelamento. *Ciência Rural* 42: 904-910.

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