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Shelf life and quality of minimally processed pumpkins

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Abstract

Pumpkins are generally large vegetables, and therefore have difficulties in marketing, storage and handling, which ends up causing many losses. In this sense, minimal processing is the most viable alternative to enhance commercialization and, therefore, the study of cultivars is essential to understand the physiological responses and select materials most suitable for this technique. Thus, this work aimed to evaluate the quality and useful life of pumpkins cv. Regional and Cabotiá minimally processed and stored at 10 ºC for 12 days. Physical-chemical quality (mass loss, firmness and color index, soluble solids, titratable acidity, pH, SS/TA ratio) and sensory quality (aroma, whiteness incidence and overall quality) were investigated. During storage there was a significant increase ($p<0.05$) in weight loss and reduction in firmness index, color, soluble solids, titratable acidity and ratio (SS/TA), so that 'Regional' pumpkins were more resistant to the preservation of these characteristics over 12 days compared to Cabotiá. Regarding the sensory aspect both cultivars presented low whitish indexes, however, the characteristic aroma of fresh fruit as well as the overall quality measured as shelf life was significantly better ($p<0.05$) in the 'Regional' pumpkins. With these results cv. Regional is more likely to be used in minimal processing by preserving quality attributes during the storage period.

Key-words: *Curcubita moshata* Duch., *Curcubita maximum* X *Cucurbita Moschata* Duch., Cultivars, Postaharvest Conservation

Introduction

The genus Cucurbita gathers species of pumpkins with economic and food importance in Brazil, especially pumpkins (*Cucurbita moschata* and *Cucurbita pepo*), moranga (*Cucurbita maxima*) and the interspecific hybrid known as 'Tetsukabuto' or 'Cabotiá' as a result of the crossbreeding between selected strains of pumpkin (*Cucurbita maximum* Duch.) and squash (*Cucurbita moschata* Duch.) (Ferreira et al., 2006; Amaro et al., 2014).

In general, these vegetables have high food value, that is, rich in sources of vitamins A and B, minerals such as calcium, iron, phosphorus and zinc, as well as antioxidant compounds such as α-carotene, β-carotene, lycopene. and carotenoids (Taco, 2011; Daiuto et al., 2012; Ribeiro et al., 2013) besides the socioeconomic role that it plays for populations of the North, Northeast and Center South regions of Brazil (Resende et al., 2013).

However, one of the biggest trade barriers is due to the size of these fruits, which makes transport, handling and storage difficult (Sasaki et al., 2006; Costa et al., 2011), thus, minimal processing (MP) emerges as an alternative to reduce these problems and add value to the product. According to the *International Fresh-Cut Producers Association* (2016), minimally processed products are defined as any fruit or vegetable in which its physical form has been altered from the original (*in natura*) while maintaining its fresh state. Regardless of the type, the food is selected, washed, peeled and cut, and then packed or prepacked. In other words MP is a booming

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market trend and products subjected to this technique become convenient by reducing preparation time, better standardization and reducing post harvest losses (Russo et al., 2012).

Considering that the quality of minimally processed foods is associated with the maintenance of their sensory characteristics (taste, aroma, flavor) as well as their physicochemical characteristics, this work aimed to evaluate the physicochemical and sensory quality associated with conservation and shelf life of freshly processed pumpkins stored under refrigeration (10 °C).

Material and methods

Plant material

Pumpkins Regional cultivar (*Cucurbita Moschata* Duch.) and Cabotiá hybrid (*Cucurbita maximum* X *Cucurbita Moschata* Duch.) were acquired physiologically mature in the local Altamira - PA trade, selected for shell size, shape and color and transported to Product Technology of the Federal University of Pará, Campus Altamira - PA, where they were washed in running water followed by sanitization in chlorinated water (5 $mg.L^{-1}$) for one minute and then subjected to minimum processing steps.

Minimal processing

Initially, the fruits ('Regional' and 'Cabotiá') were cut into 3.0 cm thick slices and peeled with the aid of a previously sterilized stainless steel knife and the seeds removed with a spoon. The slices were cut into 3.0 X 3.0 X 3.0 cm cubes and immersed in distilled water to remove excess cell juice, afterwards the cubes were sanitized in chlorinated solution (5 $mg.L^{-1}$) by one minute followed by rinsing in distilled water and left over sieve to drain excess water before being weighed and packaged.

Packaging and storage

After drying the cubes were weighed (~ 200 g) and placed in expanded polystyrene trays covered with 14 micron PVC plastic film followed by storage in a refrigerator (10 ± 2 °C) and 85% RH for a period of 12 days evaluation of physicochemical and sensory characteristics every three days.

Physicochemical and sensory analysis

The determinations were made as:

Fresh mass loss (PMF): determined by weighing the packages on a 0.01g precision scale, and the results expressed as a percentage (%), estimated from the experimental unit mass differences between the zero day of storage. fruits and the evaluation day.

Total soluble solids (TSS): Cell-determined was extracted from about 200 g of the sample after processing in a domestic centrifuge. TSS levels were obtained with the aid of a digital temperature-compensated refractometer and results expressed in ºBrix (AOAC, 2012).

Total titratable acidity (TTA): Determined by titration using 5 ml of the juice extracted for SST and homogenized in 45mL of distilled water, plus 3 drops of 1% alcohol phenolphthalein as indicator using sodium hydroxide solution (0.1N NaOH) until reaching the turning point for the pink color. Results were expressed as a percentage of citric acid equivalent to the amount of NaOH spent on titration (AOAC, 2012).

Hydrogenionic potential (pH): Determined with the aid of a digital bench calibrator properly calibrated in 4.0 and 7.0 buffer solution by direct immersion of the electrode in the juice extracted for SST (AOAC, 2012).

Ratio Total soluble solids and total titratable acidity (SST/ATT): Obtained by the ratio between the content of SST and ATT and the results expressed by the absolute value found.

Sensory quality was determined by the descriptive method by assigning grades based on a five-point hedonic scale on the following variables: firmness (5 = firm; 4 = moderately firm; 3 = slightly firm; 2 = mildly firm 1 = soft) (Menezes et al., 2017). For the aroma, coloration and whitening incidence and overall quality (shelf life) was followed the methodology described by Dutcosky (2011) with modifications (9 = very liked; 7 = moderately liked; 5 = neither liked / disliked; 3 = disliked moderately; 1 - disliked a lot). Note 5 was considered the limit for marketing.

Experimental Design and Statistical Analysis

It was adopted a completely randomized experimental design (DIC) and a 2x5 factorial arrangement that corresponds to two genetic materials (cv. Regional and the Cabotiá hybrid) and five evaluation days (0, 3, 6, 9 and 12 days), with

three replications. and the experimental plot composed of 200 g samples.

Data were submitted to analysis of variance (ANAVA) followed by Tukey test for multiple comparison between means at 0.05% significance level with the aid of Sisvar 5.6 statistical software (Ferreira, 2011).

Results and discussion

Pumpkins fresh mass loss increased with storage time, however 'Regional' samples showed significantly lower percentage ($p<0.05$) (13.3%) compared to 'Cabotiá' (17.6%). (Figure 1A) on the 12 day assessment. This higher mass loss (water) in 'Cabotiá' samples was reflected in the lowest significantly affected firmness index ($p<0.05$) after the sixth day of storage when the mean value was 4.25 (moderately firm) and at 12 days 3.75 (slightly firm) compared to 4.75 and 4.25, respectively presented by cv. Regional (Figure 1B).

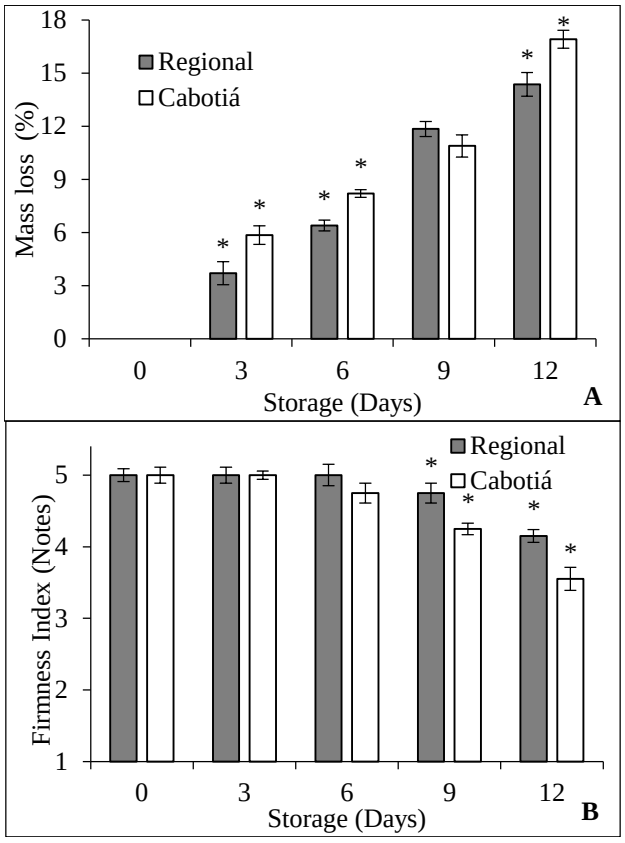

Fig. 1: Mass loss (A) and firmness index (B) in freshly processed pumpkins stored at 10 ºC for 12 days. * Represents a significant difference between treatments within each storage time, $p<0.05$.

After harvesting plant products lose the water supply provided by the plant and respiratory metabolism coupled with perspiration leads to a water deficit that favors quantitative and qualitative losses (Finger and França, 2011) and minimal processing due to the mechanical stress generated as well as accelerating the rate of perspiration (water loss) is also a determining factor in the weight loss (fresh mass) of vegetables as a whole. In this study, the mass loss observed in squashes exceeded 10% over 12 days of storage at 10 °C (Figure 1A) and mass loss of 5 and 10% in vegetables significantly compromises the visual quality of the product (Lana and Vieira, 2000).

The main consequence of water (mass) loss is wilting and/or wrinkling due to loss of cell wall integrity, especially in products subjected to minimal processing. This fact justifies, for example, the reduction in the firmness index of the samples (Figure 1B) with the storage time.

Regarding the color index (Figure 2), the best preservation of the natural color of the fruits in the samples of cv. Regional in relation to 'Cabotiá' ($p<0.05$) whose averages corresponded to 7.0 (moderately liked) and 5.15 (neither liked/disliked), respectively after 12 days of storage.

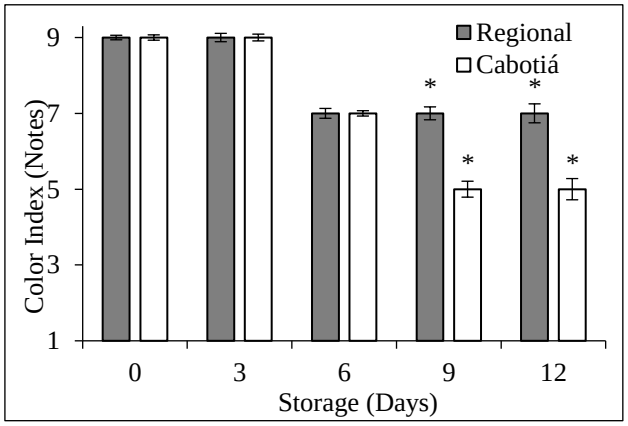

Fig. 2: Color index in freshly processed pumpkins stored at 10 ° C for 12 days. * Represents a significant difference between treatments within each storage time, $p<0.05$.

According to Alves et al. (2010) the reduction in yellow color in minimally processed products such as squash is due to the cuts suffered through enzymatic oxidation, and also by loss of vitamins, especially carotenoids that give the orange-yellow color. Soares et al. (2018) also observed color reduction in pumpkins samples processed and packed in vacuum packages during 16 days of storage at 5 ºC.

Soluble solids (SS) content decreased with storage time from 3.69 ºBrix to 2.53 ºBrix after 12 days in both cultivars. However, SS preservation was higher in 'Regional' samples compared to 'Cabotiá

samples, especially on the ninth and 12th assessment days (Figure 3).

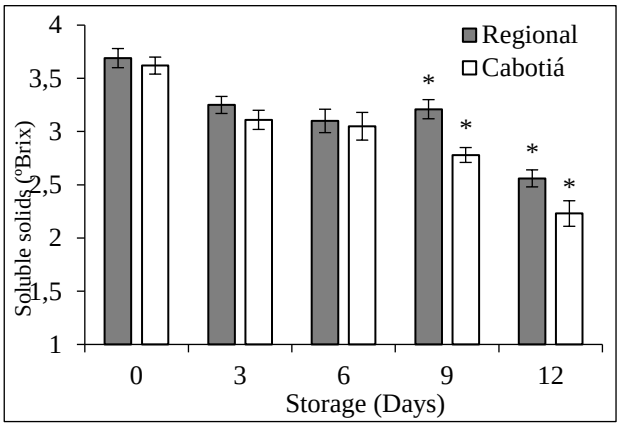

Fig. 3: Content of soluble solids (ºBrix) in freshly processed pumpkins stored at 10 ºC for 12 days. * Represents a significant difference between treatments within each storage time, p<0.05.

Generally, SS tend to increase during fruit storage / ripening, either by sugar synthesis, starch degradation and water loss that concentrates these compounds. (Chitarra and Chitarra, 2005). In this case, the probable reduction observed is due to the minimal processing (cutting) that when injuring the fruit promoted greater sugar degradation, that is, being used, for example as a substrate in the respiratory metabolism since the transpiration rate is higher. It is still associated with the ethylene synthesis itself that accelerates maturation in injured tissues. Silva et al. (2009) also reported reduced SS content in freshly processed vacuum packed pumpkins over 12 days of storage at 10 °C. On the other hand, Costa et al. (2011) observed that Cabotiá pumpkins stored at 4 ºC for eight days showed an increase in SS content (7.5 to 8.2 ºBrix). This difference in relation to that obtained in this study can be explained by the storage temperature itself, which besides reducing the perspiration rate, the respiratory activity preserves the SS content against degradation.

Despite the reduction in titratable acidity (AT) with storage time, 'Regional' samples (0.13% citric acid.100 g pulp) maintained significantly higher organic acid content (p<0.05) when compared to 'Cabotiá' (0.09% citric acid.100g pulp) after 12 days of evaluation (Figure 4).

Despite the reduction, a significantly higher titratable acidity content is noted in the early days in 'Cabotiá' samples (0.24% citric acid. 100g pulp) compared to 'Regional' (0.17% citric acid.100g pulp), this fact is related to the genetic characteristic of this hybrid, that is, capable of concentrating a larger amount of compounds, such as the organic acids in the pulp. Andón-Sánchez et al. (2016) also found significant variations in the titratable acidity present in pumpkins 'Taína Dorada' e 'Isabela'. The decrease as a whole is due to the use of organic acids as an energy currency for the maintenance of respiratory metabolism. Reductions in titratable acid content have also been reported in processed pumpkins (Santos et al., 2016; Muzzaffar et al., 2016).

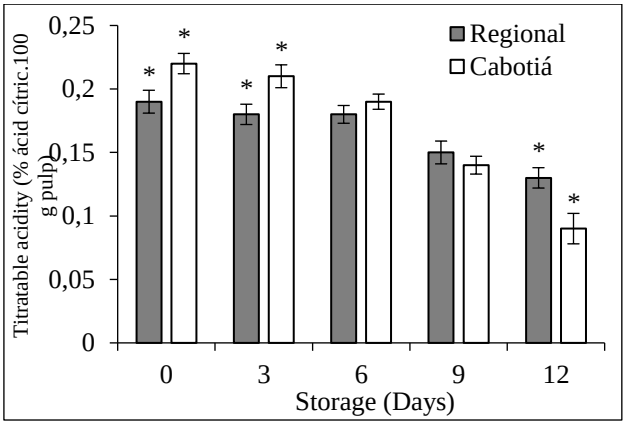

Fig. 4: Titratable acidity (% citric acid) in freshly processed pumpkins stored at 10 ° C for 12 days. * Represents a significant difference between treatments within each storage time, p<0.05.

The pH was not changed throughout the storage period and between cultivars (p>0.05) with averages ranging from 5.64 on day zero and 5.71 at 12 days of evaluation (Figure 5).

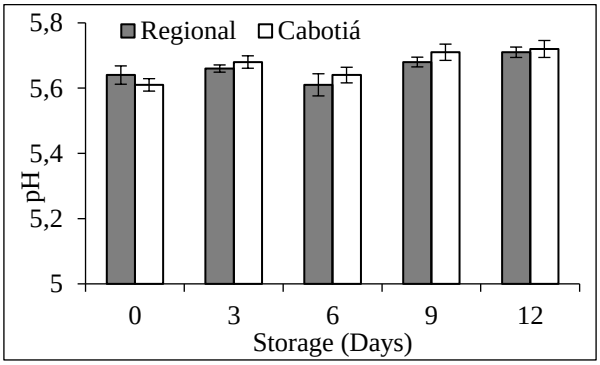

Fig. 5: pH in freshly processed pumpkins stored at 10 ºC for 12 days.

There is a reduction in the estimated flavor ratio by the ratio between SS and TA with the storage time and in the evaluated cultivars, even so, samples of cv. Regional showed a significantly higher relationship (p<0.05) (10.81) at the end of 12 days when compared to 'Cabotiá' samples with a mean of 8.21 (Figure 6).

This best SS/AT flavor ratio expressed by cv. Regional, both the preservation of soluble solids

(sugars) content (Figure 3) and the maintenance of organic acids (Figure 4) are components of titratable acidity. In other words, the high ratio (SS/TA) is revealed as an indicator of sensory quality (taste) but also of senescence when low at the end of storage.

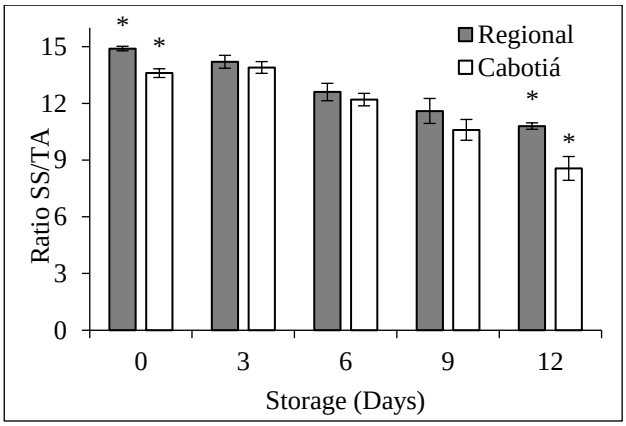

Fig. 6: SS/TA ratio in freshly processed pumpkins stored at 10 °C for 12 days. * Represents a significant difference between treatments within each storage time, p <0.05.

The analysis of the sensory profile (aroma, whiteness and general quality) of the 'Regional' pumpkin and the 'Cabotiá' hybrid is presented in Table 1.

For the aroma characterized by the characteristic odor of fresh fruit the samples of cv. Regional received the highest grades during the storage period compared to 'Cabotiá' ($p<0.05$), especially on the 12th day of evaluation when the average was 7.0 (liked moderately) and 5.0 (neither liked/nor did I dislike) for 'Regional' and 'Cabotiá', respectively (Table 1).

In general, there was no significant effect ($p>0.05$) of the whitening incidence on the cultivars ('Regional' and 'Cabotiá') during the storage period since at 12 days both were characterized with grade 7.0 (liked moderately) (Table 1).

Surface whitening in minimally processed products, such as squash, is due to the absence of the protective epidermis and damage to the cells, making them more vulnerable to discoloration from deep orange to pale Orange (Carrasco e Cisneros-Zevallos, 2002; Pereira et al., 2008). In pumpkins (Sasaki et al., 2006; Russo et al., 2012) and carrots (Silva et al., 2009; Cavalcante Fai et al., 2015; Guimarães et al., 2016) whitening was also observed, mainly associated with loss of mass and color, similar to that reported in this study.

The overall quality characterized by the useful life remained significantly better ($p <0.05$) in the samples of cv. Regional in relation to Cabotiá (Table 1). In the 'Regional' samples the quality was characterized with a grade pf 9.0 (I liked it a lot) until the sixth day of storage whereas in the 'Cabotiá' samples the average grade was 7.0 (I liked it moderately). On the 12th day the samples were characterized with grades 5.0 (neither liked/disliked) and 3.0 (moderately disliked) for 'Regional' and 'Cabotiá', respectively ($p<0.05$) corroborating the best preservation of quality (shelf life).

Table 1. Sensory analysis on the variables: aroma, whiteness, general quality in freshly processed pumpkins stored at 10 ºC for 12 days.

Storage (Days)	Variables/Cultivars					
	Aroma		Whiteness		General quality	
	Regional	Cabotiá	Regional	Cabotiá	Regional	Cabotiá
0	9,0 ± 0,09	9,0 ± 0,09	9,0 ± 0,08	9,0 ± 0,08	9,0 ± 0,06	9,0 ± 0,06
3	9,0 ± 0,16	9,0 ± 0,11	9,0 ± 0,09	9,0 ± 0,08	9,0 ± 0,11	9,0 ± 0,09
6	9,0 ± 0,19*	7,0 ± 0,16*	9,0 ± 0,06	9,0 ± 0,07	9,0 ± 0,11*	7,0 + 0,13*
9	7,0 ± 0,13	7,0 ± 0,11	9,0 ± 0,09*	7,0 ± 0,51*	7,0 ± 0,16	7,0 ± 0,15
12	7,0 ± 0,11*	5,0 ± 0,12*	7,0 ± 0,22	7,0 ± 0,18	5,0 ± 0,17*	3,0 ± 0,33*

* Represents a significant difference between treatments within each storage time, p <0.05.

According to Sediyama et al. (2009) Cabotiá hybrid pumpkins have prolonged postharvest conservation when compared to open-pollinated local cultivars, such as cv. Regional. However, the results of this study show contrary results, possibly this statement considers the whole fruit and postharvest response of plant products in their fresh form during storage is completely different when subjected to minimal processing.

Conclusion

Minimally processed 'Regional' and 'Cabotiá' pumpkins have different quality and shelf life responses. The cv. Regional presented over 12 days of storage (10 ºC) better preservation of physicochemical and sensory quality and can be further explored commercially in its processed form.

Conflict of interest: All authors declare no conflict of interest.

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