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Influence of different edible coatings in minimally processed pumpkin (*Cucurbita moschata* Duch)

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Abstract

Edible coatings may be used to advantage on processed vegetables for improving the structural integrity. The objective of this study was to evaluate the preservation of pumpkins processed by the use of edible coatings based on xanthan gum, stored for 12 days at 4°C. The treatments were used: (A) control, (B) 1% glycerol and 0,5% xanthan gum, (C) 1% glycerol, 0.5% xanthan gum and 1% chitosan; (D) 1% glycerol, 0.5% xanthan gum and 0.25% guar (E) 1% glycerol, 0.5% xanthan gum, 0.25% guar and 1% chitosan. It was carried out physicochemical analysis of weight loss, firmness, pH, acidity, color, and microbiological characteristics of psychrophilic *Salmonella* ssp., total and thermotolerant coliform. The different coatings based on xanthan gum were effective in reducing weight loss, maintaining firmness, color and control of psychrophilic microorganisms. Thus, the use of xanthan gum, a thickening agent, is a viable alternative to coat pumpkin minimally processed.

Introduction

Pumpkin (*Cucurbita moschata* Duch) is a seasonal crop that has traditionally been used both as food for humans and animals. It is grown in all tropical and subtropical countries. It covers a large number of species of the family *Cucurbitaceae*, mostly with real or potential economic value (Mayor *et al*., 2006; Dutta *et al*., 2006; Incedayi *et al*., 2009). It is a source of nutrients such as carotenoids, K^+, vitamins B_2, C and E, with low energy content and a lot of fiber (De Escalada Pla *et al*., 2007). This vegetable has shown great potential to expand the market of minimally processed vegetables, and fruits as they are large and have considerable difficulties in the marketing, storage and handling, causing many damages (Sasaki *et al*., 2006). According to this author processing pumpkin minimally could increase sales and add value to the product.

However, the minimum processing pumpkin causes an impairment of the visual aspect of greenery. Changes such as weight loss and cold injury are likely to occur during storage (Silva *et al.*, 2009). Minimally processed vegetables deteriorate rapidly in quality and have a short storage life. The high moisture content and numerous cut surfaces of minimally processed vegetables provide optimal conditions for the growth of microorganisms (Vescovo *et al*., 1995). One way of rectifying the problems related to minimal processing is the use of edible coatings, defined as a thin layer of edible material and formed directly on the product surface (Kester and Fennema, 1986; Soares and Geraldine, 2007). The following are commonly used as gelling agents: alginates, gellan, starch, among others. The combinations of xanthan gum and guar gum are classified as thickening agents and chitosan is still classified as an agent which may represent antimicrobial alternatives as edible coatings on the preservation of minimally processed pumpkin.

Recently, there has been an increasing market demand for minimally processed fruits and vegetables due to their fresh-like character, convenience, and human health benefits. Chitosan has been reported to maintain the quality apple slices (Qi *et al*., 2011) and fresh-cut pear (Xu *et al.*, 2013). Xanthan gum has been effective in the preservation of minimally processed peaches (Pizato *et al.*, 2013).

Edible coatings can be formulated with polysaccharides, such as starch and alginate. Cassava starch coatings reduced weight loss and maintained the mechanical properties and color parameters, while fresh-cut mangoes coated with sodium alginate coatings presented lower stress at failure and browning along the storage time (Chiumarelli *et al*.,

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2011). The objective of this study was to evaluate the preservation of minimally processed pumpkin by the use of edible coatings.

Material and Methods

Material

Pumpkin (*Curcurbita moschata* Duch) were bought at the local supermarket in the Rio Grande city, Rio Grande do Sul (Brazil). The fruits were selected by size (about 3 kg), color and rounded shape. The vegetables were free of infections and physiological defects caused by microorganisms visually detectable. The samples were transported in Styrofoam boxes to the Laboratory of Food Technology at the School of Food and Chemistry, Federal University of Rio Grande, where the processing was carried out.

Preparation of samples

Processing was performed at a temperature of about 10°C with the previously sanitized utensils with a solution of organic chlorine (dichloro cyanurate) at a concentration of 2 $g.L^{-1}$. Pumpkins were also cleaned with a solution of organic chlorine in the concentration of 2 $g.L^{-1}$ for 10 minutes. The operators were adequately protected with gloves, aprons, hats and masks, in order to protect the product as much as possible from contamination. The raw material was subjected to manual removal of the peel and seeds and afterwards it was cut by hand, into cubes of approximately 2.5 x 2.5 cm. Then the pieces were rinsed with chlorinated water (0.2 $g.L^{-1}$) to eliminate cellular spilled juice. Water was drained using sieves for a period of 2-3 minutes. The coating was used xanthan gum (Shandong Fufeng), guar gum (Sarda), chitosan (deacetylation degree of about 89% and molecular weight between 150 and 170 kDa, FURG) and glycerol (Quimex P.A.). The treatments used in pumpkin cubes were: (A) control (cut pumpkin); (B) 1% glycerol and 0.5% xanthan gum; (C) 1% glycerol, 0.5% xanthan gum and 1% chitosan; (D) 1% glycerol, 0.5% xanthan gum and 0.25% guar; (E) 1% glycerol, 0.5% xanthan gum, 0.25% guar and 1% chitosan.

The solutions were prepared by slow dissolution of the gum in deionized water under stirring until completely dissolved, then the plasticizer glycerol was added followed by heating to 60 °C and cooling to room temperature. Cubes of pumpkin were totally submerged in the solutions for 1 minute, and then drained using sieves, for 2-3 minutes. Finally, the samples were packaged in PET, standardizing the number of pieces per package and stored in refrigerated conditions at 4ºC for 12 days. The physical, physicochemical (AOAC, 1995) and microbiological tests (APHA 2001) were performed in triplicate on the day of processing the samples (day 0) and after 1, 3, 5, 7, 9 and 12 days of storage.

Weight loss

The weight loss was obtained by taking the difference between the initial weight of the pumpkin minimally processed and that obtained at the end of each storage time.

Total soluble solids

The content of total soluble solids was determined in a bench-type refractometer Abbé, with temperature correction to 20°C. The results were expressed in °Brix (AOAC, 1995).

Texture analysis

The measures of firmness of the cubes of pumpkin were determined using a texture analyzer Model TA-XT2 plus (Stable Micro Systems, Surrey, England). We used a cylindrical probe in the pre-test speed of 4 $mm.s^{-1}$, post-test 8 $mm.s^{-1}$, and test 2 $mm.s^{-1}$, and penetration depth of 5 mm. The results were expressed in Newton (N).

Color

The color analysis was evaluated using a Minolta colorimeter, model Chroma Meter CR400. We checked the parameters of luminosity L^* [0 (black) to 100 (white)], Chroma a^* [green chromaticity (-60) to red (+60)] and Chroma b^* [blue chromaticity (-60) to yellow (+60)].

pH

The pH was determined using the method described by AOAC (1995). The pH was measured using a digital pH meter (Model PA 200, Marconi Instruments, Inc., Piracicaba, Brasil 2001). It was prepared a suspension of 20 g of sample in 100 mL of distilled water, thus measuring the pH with the aid of a pH meter.

Analysis of acidity

The total titratable acidity was determined and calculated as the volume in mL of NaOH 0.1 $mol.L^{-1}$, required to titrate 10 mL of the diluted sample and homogenized in 100 mL of water. The results were expressed as percentage of citric acid (AOAC, 1995).

Microbiological analysis

Microbiological tests performed were psychrotrophic, total and thermotolerant coliforms and *Salmonella* ssp. following the methods described in APHA (2001).

Statistical analysis

The physical and physicochemical evaluations were submitted to variance analysis and comparison of the mean was done by Tukey test with a significance level of 5%, using Statistica 7.0 software.

Results and Discussion

Weight loss

Table 1 presents the average results of mass loss of samples pumpkin coated with different coatings during 12 days of storage at 4°C. The average levels of weight loss ranged from 0.13 to 3.93%. Edible coatings have the ability to control the moisture loss, and providing other functions (Thompson, 2003), and consequently the weight loss. It was observed an increase in mass loss during storage; the samples which were coated had losses significantly lower than in the control sample. The samples submitted to treatment B and C had the lowest weight loss over 12 days of storage when compared with those under treatments D and E. This behavior seems related to the presence of guar gum, while in the control sample a significantly higher loss came to 3.93% and the weight loss was prevented by the presence of the coating used. Aleryani-Raqeeb *et al.* (2008) worked with chitosan coating on papaya, and observed that it prevented weight loss.

Sasaki *et al.* (2006) evaluated the mass loss of samples of minimally processed pumpkin under different types of cuts. According to result, the values obtained were 0.87% for the slice cut in half, 1.58% for the cubes and 2.66% for the flap cuts. The value found by the author when cut into cubes was lower than that obtained in this study, however the packaging may have influenced these results, since it was used polystyrene trays covered with PVC.

Total soluble solids

Table 2 presents the average results of total soluble solids of samples of pumpkin coated with different coatings during 12 days of storage at 4°C. The average levels of total soluble solids ranged from 6.90 to 5.20 °Brix, checking lower concentrations in the control sample (A). Contrary to occurring with most minimally processed products, the pumpkin did not show a linear increase in soluble solids. According Silva *et al.* (2009), the common fact is due to loss of water from the product, which may occur immediately after the processing. Shellie and Saltveit (1993) disagree with this progressive behavior and found a constant behavior of the soluble solids content of melon tracery throughout the storage period.

In this study with edible coating in pumpkin it was observe the reduction in soluble solids for all samples during the course of storage. The control treatment and treatment E showed the greatest reduction in soluble solids, reaching values of 5.50 and 5.53 °Brix, respectively on the 12 days of storage at 4°C. Treatments B and C showed less decline reaching 5.92 and 5.80°Brix, respectively. However, there was a clear relationship between the soluble solids in the presence of different coatings.

Sasaki *et al*. (2006) also observed reduction in soluble solids of pumpkins minimally processed subjected to storage at different temperatures, for twelve days. Initially the value found was 5.48 °Brix, reaching values of 5.00, 4.93 and 4.65 °Brix, at temperatures of 1ºC, 5ºC and 10°C, respectively. This author believes that the reduction in soluble solids is a result of breathing which is the oxidative decomposition of complex substances (polysaccharides, simple sugars, organic acids, proteins and lipids) into simple molecules (CO_2 and H_2O) and energy (Kluge *et al.*, 2002).

The reduction of soluble solids of pumpkin minimally processed stored for twelve days at different

Table 1. Values of mass loss (%) of samples of minimally processed pumpkin, using different coatings stored at 4°C for 12 days.

	Days						
Samples	0	1	3	5	7	9	12
A	0^{a,G}	0.72^{a,F}	1.03^{a,E}	1.52^{a,D}	2.29^{a,C}	3.10^{a,B}	3.93^{a,A}
B	0^{a,G}	0.13^{e,F}	0.28^{c,E}	0.60^{d,D}	1.12^{d,C}	1.29^{d,B}	1.95^{c,A}
C	0^{a,G}	0.14^{d,F}	0.29^{c,E}	0.71^{c,D}	1.20^{c,C}	1.54^{c,B}	1.98^{c,A}
D	0^{a,G}	0.38^{b,F}	0.78^{b,E}	1.20^{b,D}	1.55^{b,C}	2.08^{b,B}	2.44^{b,A}
E	0^{a,G}	0.34^{c,F}	0.78^{b,E}	1.18^{b,D}	1.58^{b,C}	2.12^{b,B}	2.47^{b,A}

Means followed by same letter in the column and capital on the line do not differ by Tukey test at 5% probability. (A) control; (B) glycerol 1% and xanthan gum 0.5% ; (C) glycerol 1%, xanthan gum 0.5% and chitosan 1%; (D) glycerol 1%, gum guar 0.5% and xanthan 0.25%; (E) glycerol 1%, xanthan gum 0.5%, gum guar 0.25% and chitosan 1%.

Table 2. Values of total soluble solids (ºBrix) samples of minimally processed pumpkin, using different coatings stored at 4°C for 12 days.

	Days						
Samples	0	1	3	5	7	9	12
A	6.80^{a,A}	6.80^{a,A}	5.80^{c,B}	5.30^{d,DC}	5.20^{d,ED}	5.30^{d,DC}	5.50^{bcd,C}
B	6.70^{a,A}	6.71^{a,A}	6.70^{a,A}	6.57^{a,AB}	6.34^{a,BC}	6.21^{a,CD}	5.92^{a,D}
C	6.70^{a,A}	6.71^{a,A}	6.60^{a,A,B}	6.46^{a,AB}	6.33^{a,BC}	6.07^{a,CD}	5.80^{ab,D}
D	6.90^{a,A}	6.90^{a,A}	6.20^{b,BC}	5.90^{cb,CDEF}	5.82^{bc,DEF}	5.73^{bc,EF}	5.62^{bc,F}
E	6.90^{a,A}	6.90^{a,A}	6.22^{b,BC}	6.02^{b,CD}	5.80^{c,DEF}	5.67^{c,EF}	5.53^{c,F}

Means followed by same letter in the column and capital on the line do not differ by Tukey test at 5% probability. (A) control; (B) glycerol 1% and xanthan gum 0.5% ; (C) glycerol 1%, xanthan gum 0.5% and chitosan 1%; (D) glycerol 1%, gum guar 0.5% and xanthan 0.25%; (E) glycerol 1%, xanthan gum 0.5%, gum guar 0.25% and chitosan 1%.

Table 3. Values of firmness (n) samples of minimally processed pumpkin, using different coatings stored at 4°C for 12 days.

	Days						
Samples	0	1	3	5	7	9	12
A	83.51^{a,F}	87.69^{a,E}	87.69^{a,E}	94.22^{a,C}	93.61^{a,D}	99.52^{a,B}	100.09^{a,A}
B	83.51^{a,A}	83.56^{b,A}	83.05^{c,B}	82.16^{b,C}	82.22^{b,C}	80.84^{b,D}	80.13^{b,E}
C	83.51^{a,A}	83.52^{b,A}	83.15^{b,B}	81.95^{c,C}	80.94^{c,D}	80.43^{c,E}	79.77^{c,F}
D	83.51^{a,A}	83.58^{b,A}	82.34^{d,B}	81.66^{d,C}	79.53^{d,D}	77.68^{d,E}	76.19^{d,F}
E	83.51^{a,A}	83.58^{b,A}	82.06^{e,B}	81.40^{e,C}	79.25^{e,D}	77.64^{d,E}	75.65^{e,F}

Means followed by same letter in the column and capital on the line do not differ by Tukey test at 5% probability. (A) control; (B) glycerol 1% and xanthan gum 0.5%; (C) glycerol 1%, xanthan gum 0.5% and chitosan 1%; (D) glycerol 1%, gum guar 0.5% and xanthan 0.25%; (E) glycerol 1%, xanthan gum 0.5%, gum guar 0.25% and chitosan 1%.

temperatures and packaging, was also reported by Silva *et al.* (2009). The average levels of total soluble solids ranged from 9.83 to 10.38 °Brix, however the initial value was 12.25 °Brix. The highest values were found when samples were packed with plastic and kept at 10°C. With higher temperature and respiration rate, there are more substrates consumed. Moreover, low temperatures during storage slows down the metabolism of the plant by reducing their respiration rate (Chitarra and Chitarra, 1990) and thus avoiding drastic reductions in the levels of soluble solids.

Texture analysis

Table 3 presents the average results of firmness of the pumpkin samples coated with different coatings during 12 days of storage at 4°C. The pumpkins coated texture ranged from 75.65 to 100.09 N. There was an increase in the firmness of the control sample (A) at the end of twelve days of storage. Sarzi (2002) assessed the papaya texture verifying a significant increase in firmness, associated with the moisture loss with the formation of surface layer firmer. Sasaki *et al.* (2006) observed no loss of firmness pumpkins minimally processed stored at temperatures of 1°C and 5°C, however when the samples were stored at 10 °C, an increase of this parameter was observed, reaching values of 83.3 N.

For the treatments with edible coating it was observed a decrease in firmness. The largest reduction in the values of firmness was observed using treatment D (76.19 N) and E (75.65 N). As for the results of mass loss, the presence of guar gum seems to decrease the quality of the product.

Color

Table 4 present values of luminosity (L^*) the samples of pumpkin subjected to different covering, storage temperature of 4°C for 12 days. The luminosity obtained ranged from 56.29 to 77.99 in the samples coated pumpkin. Through the results we can observe that the values of brightness, in control samples of pumpkin (A) and with different coatings on the 12th day of storage increased relatively to time zero. In samples treated control was observed a higher whiteness of pumpkins, which can be verified by the increase in the values of brightness over the period of storage, starting value of 56.29 (at time 0), reaching 73.99 in last day of storage.

The whiteness is the result of dehydration of superficial cells, due to damage caused by processing (Tatsumi *et al.*, 1993; Avena-Bustillos *et al.*, 1994). Thus, the major results obtained in the mass loss of control treatment help to understand the results of the luminosity (Table 1). The uses of different coatings reduced the impairment of the visual aspect of the different samples. The results show that samples B and C showed a smaller increase of brightness 67.05 and 66.79, respectively, when comparing the results at time 0 and on day 12.

Table 4. Values of L^* of samples of minimally processed pumpkin, using different coatings stored at 4°C for 12 days.

	Days						
Samples	0	1	3	5	7	9	12
A	56.29^{e,F}	56.29^{e,F}	77.99^{a,A}	75.47^{a,B}	66.81^{b,E}	72.55^{a,D}	73.99^{a,C}
B	57.62^{b,F}	57.62^{b,F}	77.35^{b,A}	67.68^{c,C}	66.24^{c,E}	70.65^{b,B}	67.05^{d,D}
C	57.72^{a,F}	57.72^{a,F}	63.02^{d,E}	69.75^{b,A}	68.18^{a,C}	68.42^{c,B}	66.79^{e,D}
D	57.42^{c,E}	57.42^{c,E}	63.30^{e,D}	67.18^{d,B}	63.94^{e,C}	67.55^{d,A}	67.19^{c,B}
E	57.30^{d,F}	57.30^{d,F}	68.00^{c,A}	66.79^{e,D}	65.58^{d,E}	67.45^{e,B}	67.35^{b,C}

Means followed by same letter in the column and capital on the line do not differ by Tukey test at 5% probability. (A) control; (B) glycerol 1% and xanthan gum 0.5% ; (C) glycerol 1%, xanthan gum 0.5% and chitosan 1%; (D) glycerol 1%, gum guar 0.5% and xanthan 0.25%; (E) glycerol 1%, xanthan gum 0.5%, gum guar 0.25% and chitosan 1%.

Table 5. Chroma a^* values of samples of minimally processed pumpkin, using different coatings stored at 4°C for 12 days.

	Days						
Samples	0	1	3	5	7	9	12
A	11.28^{a,B}	11.28^{a,B}	6.56^{d,F}	9.48^{d,E}	16.33^{a,A}	10.70^{e,D}	10.80^{e,C}
B	8.57^{c,E}	8.57^{c,E}	2.92^{e,F}	14.53^{b,C}	15.49^{c,B}	14.25^{d,D}	17.91^{a,A}
C	11.09^{b,F}	11.09^{b,F}	15.99^{a,B}	14.08^{c,E}	14.84^{e,C}	14.57^{c,D}	16.18^{d,A}
D	8.26^{d,E}	8.26^{d,E}	15.18^{b,C}	14.54^{b,D}	15.16^{d,C}	15.67^{a,B}	16.28^{c,A}
E	8.64^{c,F}	8.64^{c,F}	14.60^{c,E}	15.06^{a,C}	15.64^{b,B}	14.75^{b,D}	17.44^{b,A}

Means followed by same letter in the column and capital on the line do not differ by Tukey test at 5% probability. (A) glycerol 1% (control); (B) glycerol 1% and xanthan gum 0.5% ; (C) glycerol 1%, xanthan gum 0.5% and chitosan 1%; (D) glycerol 1%, gum guar 0.5% and xanthan 0.25%; (E) glycerol 1%, xanthan gum 0.5%, gum guar 0.25% and chitosan 1%.

Table 6. Chroma b^* values of samples of minimally processed pumpkin using different coatings stored at 4°C for 12 days.

	Days						
Samples	0	1	3	5	7	9	12
A	34.40^{b,F}	34.40^{b,F}	59.31^{e,E}	65.76^{e,C}	72.32^{d,A}	69.02^{e,B}	62.26^{e,D}
B	33.27^{c,F}	33.27^{c,F}	68.31^{c,E}	77.35^{a,B}	74.90^{b,D}	78.01^{a,A}	75.10^{a,C}
C	35.58^{a,F}	35.58^{a,F}	67.94^{d,E}	72.33^{d,D}	75.72^{a,A}	73.95^{c,B}	73.18^{d,C}
D	30.86^{e,F}	30.86^{e,F}	70.31^{b,E}	76.18^{c,A}	70.54^{e,D}	73.51^{d,C}	74.77^{b,B}
E	33.05^{d,F}	33.05^{d,F}	76.78^{a,A}	76.46^{b,B}	73.41^{c,E}	75.02^{b,C}	74.1^{c,D}

Means followed by same letter in the column and capital on the line do not differ by Tukey test at 5% probability. (A) glycerol 1% (control); (B) glycerol 1% and xanthan gum 0.5% ; (C) glycerol 1%, xanthan gum 0.5% and chitosan 1%; (D) glycerol 1%, gum guar 0.5% and xanthan 0.25%; (E) glycerol 1%, xanthan gum 0.5%, gum guar 0.25% and chitosan 1%.

Table 5 present values of Chroma a^* the samples of pumpkin subjected to different covering, storage temperature of 4°C over 12 days. It was found to range from 6.56 (sample A in 3rd day) to 17.91 (sample B in 12th day). The Chroma a^* values increased for pumpkin samples with different coatings. However, this increase was not observed in the control sample, which followed the decrease in the values of Chroma a^* during storage.

It was observed that for the control sample there was a decrease in red intensity until the 12th day of storage. For the treatments with edible coating it was noted an increase in red intensity until the last day of storage. The fall in values of Chroma a^* in the control sample may indicate oxidative browning. The orange color of pumpkin pulp is due to the presence of compounds called carotenoids. The main carotenoids found in the pumpkins are the α-carotene and β-carotene. Oxidation is the main cause of degradation of carotenoids in foods, promoting the discoloration of the pigment. Carotenoids are easily

Table 7. Values of pH of samples of minimally processed pumpkin, using different coatings stored at 4°C for 12 days.

	Days						
Samples	0	1	3	5	7	9	12
A	$7.15^{a,AB}$	$7.15^{a,AB}$	$7.00^{b,CD}$	$6.88^{b,E}$	$6.94^{ab,DE}$	$7.02^{a,CD}$	$7.07^{b,BC}$
B	$7.20^{a,A}$	$7.20^{a,A}$	$7.11^{a,B}$	$7.00^{a,C}$	$7.00^{a,C}$	$7.10^{b,B}$	$7.10^{b,B}$
C	$6.92^{b,B}$	$6.92^{b,B}$	$6.86^{c,B}$	$6.89^{b,B}$	$6.89^{b,B}$	$6.93^{a,B}$	$7.21^{a,A}$
D	$6.60^{c,C}$	$6.60^{c,C}$	$7.00^{b,A}$	$7.08^{a,A}$	$6.80^{c,A}$	$7.08^{a,B}$	$7.02^{b,A}$
E	$6.89^{b,B}$	$6.89^{b,B}$	$6.86^{c,BC}$	$7.02^{a,A}$	$6.80^{c,C}$	$7.07^{a,A}$	$7.07^{b,A}$

Means followed by same letter in the column and capital on the line do not differ by Tukey test at 5% probability. (A) control; (B) glycerol 1% and xanthan gum 0.5% ; (C) glycerol 1%, xanthan gum 0.5% and chitosan 1%; (D) glycerol 1%, gum guar 0.5% and xanthan 0.25%; (E) glycerol 1%, xanthan gum 0.5%, gum guar 0.25% and chitosan 1%.

Table 8. Values of acidity (g citric acid/100 g) samples of minimally processed pumpkin, using different coatings stored at 4°C for 12 days.

	Days						
Samples	0	1	3	5	7	9	12
A	$0.086^{a,D}$	$0.089^{a,CD}$	$0.096^{a,BC}$	$0.098^{a,B}$	$0.101^{a,B}$	$0.110^{a,A}$	$0.118^{a,A}$
B	$0.086^{a,D}$	$0.087^{a,D}$	$0.094^{a,CD}$	$0.099^{a,BC}$	$0.099^{a,BC}$	$0.105^{a,AB}$	$0.109^{b,A}$
C	$0.086^{a,A}$	$0.086^{a,A}$	$0.083^{b,AB}$	$0.077^{b,BC}$	$0.072^{b,CD}$	$0.069^{bC,D}$	$0.065^{c,D}$
D	$0.086^{a,A}$	$0.086^{a,A}$	$0.080^{b,AB}$	$0.080^{b,AB}$	$0.072^{b,B}$	$0.061^{bc,C}$	$0.056^{d,C}$
E	$0.086^{a,A}$	$0.086^{a,A}$	$0.080^{b,A}$	$0.078^{b,AB}$	$0.070^{b,B}$	$0.060^{c,C}$	$0.054^{d,C}$

Means followed by same letter in the column and capital on the line do not differ by Tukey test at 5% probability. (A) control; (B) glycerol 1% and xanthan gum 0.5% ; (C) glycerol 1%, xanthan gum 0.5% and chitosan 1%; (D) glycerol 1%, gum guar 0.5% and xanthan 0.25%; (E) glycerol 1%, xanthan gum 0.5%, gum guar 0.25% and chitosan 1%.

oxidized due to the large number of conjugated double bonds. In intact tissue, the pigments are protected from oxidation; however, physical damage to the tissue increases its susceptibility to oxidation. It can be oxidized in the presence of heat, light and pro-oxidants (Ribeiro and Seravalli, 2004).

Table 6 present values of Chroma b* the samples of pumpkin subjected to different covering, storage temperature of 4°C for 12 days. The average levels of Chroma b* ranged from 30.86 (sample D) to 77.35 (sample B). As for the values of brightness and Chroma a*, values of Chroma b* increased until the 12th day of storage. The results show that there was an increase in the intensity of the yellow. Treatment B showed the greatest increase in Chroma b* (75.10) until the 12th day of storage.

Incedayi *et al.* (2009) evaluated the color of samples of minimally processed pumpkin packed in modified atmosphere. According to their results, the color values of the samples were very close to each other. The samples treated with citric acid and packed under a nitrogen atmosphere showed a higher value in the intensity of red (Chroma a* 28.7), however, no significant difference between Chroma b* showing an average value of 33.55, as well as the luminosity (L*), getting on average to 53.3 during the storage period.

pH analysis

In Table 7 there are the present average values of pH of samples of minimally processed pumpkin, stored at 4°C for 12 days. According to the results, it can be observed that the average levels of pH ranged from 6.60 to 7.20. There was a decrease in pH to the third and fifth day of storage, with a subsequent rise. The control samples and samples submitted to treatment B showed a reduction in pH at day 12th of storage when compared with the initial value. However, for treatments C, D and E there was an increase in pH values when compared these two storage times. It was not possible to establish a relationship with different coatings.

Silva *et al.* (2009) measured the pH of samples of minimally processed pumpkin stored in different packaging materials (PVC and vacuum) at temperatures of 5 and 10°C. The authors also found a decrease in pH until the 3rd day of storage and packaging for different temperatures, with subsequent increase until the 12th day of storage. At the end of storage the values were similar to those found in this study: 7.01 (packing PVC), 7.38 (vacuum packaging), 7.02 (5°C) and 7.37 (10°C). Alves *et al.* (2010) found values ranged from 6.11 to 6.59 with minimally processed pumpkin. After 8 days of storage was observed an increase in pH of minimally processed pumpkins, being related to the consumption of organic acids by the respiratory process being these values below those found in this study.

Analysis of acidity

Table 8 contains average values of acidity of the samples of minimally processed pumpkin stored at 4°C for 12 days. Clearly, the values of acidity of the samples of minimally processed pumpkin showed inverse behavior to that of pH. As for the pH values, no relation to the coatings used were found. It was found range 0.054 to 0.118 in minimally processed pumpkin. The acidity in vegetables is mainly attributed to organic acids which are dissolved in the vacuoles of the cell, either in free form, as combined with salts, esters, glycosides (Chitarra and Chitarra, 2005).

Sasaki *et al*. (2006) evaluated the acidity of samples of minimally processed pumpkin, stored at different temperatures, for twelve days. According to these results, levels of acidity remained stable throughout the storage period, regardless of temperature. The initial values were 0.078% (day 0) and remained at values of 0.083%, 0.104% and 0.093% for temperatures of 1°C, 5°C and 10°C, respectively. Silva *et al.* (2009) studied types of packaging and storage temperatures on minimally processed pumpkins, and acidity values ranging from 0.110 to 0.158, higher than obtained in this work with edible coatings.

Microbiological analysis

In Figure 1 there are the present growths of

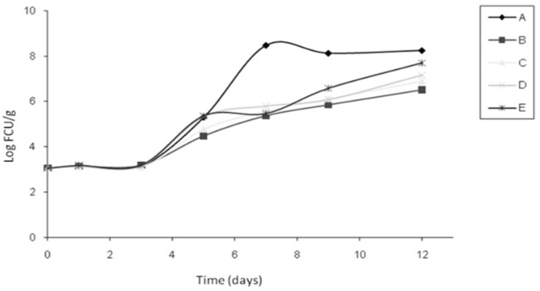

Figure 1. Growth of Psychrotrophic in samples of minimally processed pumpkin using different coatings.
(A) control, (B) glycerol 1% and xanthan gum 0.5% (C) glycerol 1%, xanthan gum 0.5% and chitosan 1% (D) glycerol 1%, gum guar 0.5% and xanthan 0.25% (E) glycerol 1%, xanthan gum 0.5%, gum guar 0.25% and chitosan 1%.

Psychrotrophics in samples of minimally processed pumpkin, stored at 4°C over 12 days. Through the results, one can observe that the samples coated with different polysaccharides showed similar behavior to the growth of psychrotrophic microorganisms. However, the development of microorganisms in the control sample was higher than the coated. The same comportment in minimally processed papaya with the same treatments was observed (Cortez-Vega *et al.*, 2013). Treatments B and C until the 12th day of storage showed lower development of psychrotrophics. However, it was verified the antimicrobial effect of the polysaccharide chitosan, since there was a sharp development of psychrotrophic microorganisms in samples coated with treatment E.

It was not detected the presence of total and thermotolerant coliforms ($<10^2$ CFU.g^{-1}) and *Salmonella* ssp. (absence in 25 g) in samples of minimally processed pumpkin, confirming the effectiveness of hygiene and the action of chlorine on organic disinfection of the samples. Sasaki *et al.* (2006) found similar values Psychrotrophic microorganisms in minimally processed pumpkin stored for 12 days, it has been 5.0×10^8, 7.5×10^8, 2.2×10^7, respectively to cut half-slice, cube and flaps. Under the National Agency of Sanitary Surveillance (ANVISA) legislation it is allowed in vegetables prepared fresh (peeled or selected or fractionated) sanitized and refrigerated, the presence of thermotolerant coliforms up to 10^2 CFU.g^{-1} and absence of *Salmonella* ssp. in 25 g of sample (Brasil, 2001). However, there is no indication about the allowed limit of psychrophilic or psychrotrophic microorganisms.

Conclusion

The different coatings were effective in reducing weight loss, color and control of psychrotrophic microorganisms. The presence of guar gum produced greater weight loss and better firmness to samples of minimally processed pumpkin. Antimicrobial effect was not observed in samples coated with chitosan. Thus, the coatings consist of only xanthan gum, a thickening agent, which presented the best results in the coating of minimally processed pumpkin.

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