

Full Length Research Paper

## Postharvest conservation of cherry tomato with edible coating

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This study aimed at evaluating quality maintenance in cherry tomatoes covered with edible films of yam starch and glycerol. Cherry tomatoes were acquired in the region of Viçosa (State of Minas Gerais, Brazil) and carried to UFV's Centreinar Laboratory. The tomatoes were washed and sanitized, then immersed in three suspensions of yam starch and glycerol: I - 7.5% starch and 30% glycerol, II - 7.5% starch and 40% glycerol and III - 7.5% starch and 50% glycerol, beyond tomatoes that were not immersed, at an average temperature of 25°C. Later, the solution was dried at a temperature approaching environment temperature (25 ± 3°C). The tomatoes coated with film were kept in a controlled environment of 25°C and 70% relative humidity, for 18 days. We performed analyses of loss in mass, total soluble solids, total titratable acidity and firmness every other day, beyond initial and final quantification of phenolic compounds, antioxidant activity and lycopene content in the coated and uncoated tomatoes. Coating with 7.5% yam starch and 30% glycerol promoted higher stability for the loss in mass, soluble solids/total titratable acidity ratio, phenolic compounds, antioxidant activity and lycopene content in relation to the freshly harvested fruit, since it got 46 and 18% less of loss in mass and soluble solid/total titratable acidity ratio, respectively, indicating the slower maturation of the fruit. Therefore, it was efficient for preserving the shelf life and quality of the cherry tomato.

**Key words:** Nutritional quality, antioxidants, perishable, shelf-life, postharvest, *Lycopersicum esculentum*.

### INTRODUCTION

Brazilian tomato (*Lycopersicum esculentum*) cultivars can be divided in five groups: Santa Cruz, Salad or Kaki, Saladinha, Saladete or Italian, and Cherry. Cherry tomato, known by the Brazilian consumer market since

the 1990s, is mainly characterized by its sensory properties, like excellent taste and attractive, uniform red coloration. Recently, there has been an increasing demand for this fruits, which is used in the decoration of

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dishes, as well as in restaurants (Alvarenga, 2004; Rocha et al., 2009).

Tomato has the status of functional food as it contains antioxidant substances like vitamin C, lycopene (Lyc) and phenolic compounds, which have a preventive role, especially against certain types of cancer and chronic non-communicable diseases (George et al., 2004). The fruit of the tomato plant has a high water content and is subject to variations of temperature and relative humidity of its environment, being thus a highly perishable fruit. Loss in water causes loss in mass and appearance of the fruit (Chiumarelli and Ferreira, 2006). Low relative air humidity results in higher weight loss, withering and nutritional losses (Kader, 1986). Therefore, biodegradable packaging can be used to slow down abovementioned alterations and, consequently, to increase the fruit's shelf life. The quality of coated tomatoes has been evaluated according to some parameters: acidity, soluble solid content, sugar content, Lyc content, appearance, texture, taste, size and succulence (Monteiro et al., 2008).

Application of edible coatings to fruits promotes the formation of a cover with partial filling of the stomata and lenticels, thus reducing moisture transfer (transpiration) and gas exchanges (respiration), which allows, in principle, to extend the fruit's life (Assis et al., 2009). Biodegradability is also a big advantage of edible coatings which needs to be highlighted (Luvielmo and Lamas, 2012). Among the compounds most used to make edible coatings are the polysaccharides (starch and its derivatives, pectin, cellulose and its derivatives, alginate and carrageenan), which, alone or in combination with other compounds (proteins, lipids), are used profitably to put in practice the specific characteristics of each compound class (Luvielmo and Lamas, 2012). Yam has 84.94% starch (Daiuto and Cereda, 2006), which favors the use of this tuberous root for extraction of starch and, consequently, exploitation of this compound in the making of edible films.

Glycerol is a hydrophilic plasticizer widely used in the preparation of biodegradable films, since it interacts with the starch chains, increasing molecular mobility and, consequently, hydrophilicity and flexibility of the plastic films (Mali et al., 2004). Edible packaging films must provide good food protection without losing quality through handling, and must also be flexible enough to adapt to possible food deformations, without mechanical damages (Alves, 2005).

Edible films were made with 4% yam starch and 1.3 and 2.0% glycerol to extend the shelf life of strawberries stored at 4°C and 85% relative humidity. Packaging significantly reduced fruit deterioration by comparison with the treatment without coating (Mali and Grossmann, 2003).

Experiments with starch as the main component in the making of edible films have found positive effects. Castrini et al. (2010) evaluated the influence of cassava starch coating at 1, 3 and 5%, in the maturation of entire papayas,

during 14 days of storage. This research used cassava starch formulations, and the 3 and 5% coatings reduced the loss in mass, keeping the green coloration during storage.

Trigo et al. (2012) applied edible coating made with 3% rice starch, 0.5% sodium alginate and 0.25% carboxymethyl cellulose to minimally processed papayas stored at 5°C and 90% relative humidity, and observed positive effects of the coatings by the 12th and 15th day for the preservation of the useful life of this fruit.

In this study, we expected the interaction between starch and glycerol to form solutions capable of maintaining the quality of the cherry tomato for longer, preserving traits like reduced mass loss, reduced fruit maturation and better preservation of the functional characteristics, like Lyc content, antioxidant and polyphenol. The objective of this study was to evaluate the postharvest quality of the cherry tomato coated with different edible films made of yam starch and glycerol, stored at 25°C and 80% relative humidity for 18 days.

## MATERIALS AND METHODS

About three hundred cherry-type tomatoes, *L. esculentum*, in maturation stage with more than 90% red content, visually quantified, just harvested, acquired directly from a producer of the region of Viçosa (State of Minas Gerais) were carried in plastic trays to the Centreinar laboratory of the Federal University of Viçosa. The fruits were selected in function of size, color and lack of damage, washed in running water and sanitized with a cooled 200 mg L<sup>-1</sup> sodium hypochlorite solution for 15 min under room conditions (Prates and Ascheri, 2011).

Starch extraction, elaboration of the filmogenic solution and selection of the treatments used in the present study were made in accordance with Reis et al. (2013). The following three treatments were used: T1 (7.5% yam starch + 30% glycerol), T2 (7.5% yam starch + 40% glycerol), and T3 (7.5% yam starch + 50% glycerol). The control treatment (T0) was realized without immersion of the fruits in the filmogenic solution. After the mixing of starch, glycerol and distilled water, the solutions were warmed up on a hotplate, for 4.5 min at 90°C and were left to settle until reaching a temperature close to room temperature (25 ± 3°C), being monitored by means of a digital skewer thermometer. Each tomato was immersed in the filmogenic solution for 5 min, suspended by tweezers, then disposed on expanded polystyrene trays and kept under conditions close to room conditions, at 25°C and 70% relative humidity, until drying of the coating, for about 30 min (Prates and Ascheri, 2011).

The experimental unit, represented by the tray, consisted of ten fruits. The twenty trays, 3 treatments + control (5 replications each) containing the fruits with fixed and dried coverings were stored for 18 days in a B.O.D. incubation chamber (Marconi, MA415, Brazil), at a temperature of 25 ± 1.0°C and 80 ± 5% relative humidity.

The firmness of the fruits was evaluated by means of compression assays, carried through with a Universal Testing Machine, TA.HD Texture Analyser, (Stable Micro Systems, United Kingdom), also known as texturometer, equipped with the software Texture Expert for Windows® with a load cell of 500 N. For the test, we used a circular flat plate probe with 100 mm in diameter and at a test speed of 0.02 m min<sup>-1</sup> (Van Dijk et al., 2006; Batu, 2004). Obtaining the compression curves of the product (force in function of the deformation), the values of the maximum force sustained by the fruit were determined, measured in newton (N).

The chemical analyses was based on the methodologies

recommended by the Adolf Lutz Institute (Brasil, 2005). Before each chemical analysis, the fruits were washed with distilled water, then dried at room temperature to remove the coatings. The fruits were manually kneaded and filtered. The total soluble solid content was determined by means of a digital refractometer (Ceti, Belgium), with 0.1 precision and direct reading, using one or two pulp drops. The total titratable acidity was obtained by titration with a 0.1 mol L<sup>-1</sup> sodium hydroxide solution. The loss in mass was evaluated in all storage periods using a digital scale (Scientech, AS-210, United States), with 10<sup>-6</sup> kg precision, and the results being expressed in percentage.

The analyses of phenolic compounds and antioxidant activity used a crude extract from the samples submitted to extraction with methanol 50% (v/v), followed by extraction with acetone 70% (v/v), according to the methodology described by Rufino et al. (2007). The determination of the phenolic compound content was based on the Folin-Denis colorimetric method. The total phenolic values were expressed as equivalents of Gallic acid (mg Gallic acid equivalent (GAE) for 100 g sample, in wet base) (AOAC, 2000).

The evaluation of the antioxidant activity was made by the DPPH method (2,2-diphenyl-1-picrylhydrazyl), according to the methodology described by Duarte-Almeida et al. (2006) and Andrade et al. (2007), with a reaction time of 0.5 h, absorbance being measured at 517 nm with a spectrophotometer UV-VIS (E225 D, single-beam, United States). DPPH ethanol solution (1 M) was used as control. To evaluate the mentioned activity, the inhibition percentage was obtained according to Equation (1):

$$AA = \frac{Abs_c - Abs_s}{Abs_c} \times 100 \quad (1)$$

Where: AA is the antioxidant activity (%); Abs<sub>c</sub> is the reading of the absorbance of the control, and Abs<sub>s</sub> is the reading of the absorbance of the sample.

The Lyc content was quantified according to the methodology described by Leão et al., (2006). The extract obtained with the described methodology was transferred to a volumetric flask of 100 ml, whose volume was completed up to 80 ml and then taken for reading to a spectrophotometer UV-VIS (E225 D, single-beam, United States). In the specific wave length for Lyc, 470 nm. Equation (2) was used to calculate the Lyc content in µg g<sup>-1</sup>:

$$Lyc = \frac{A \times V \times 10^{-6}}{A_{1cm1\%} \times M} \times 100 \quad (2)$$

Where: A is the absorbance measure; V is the final solution volume (L); A<sub>1cm1%</sub> is the pigment extinction coefficient in a specific solvent = 3450; and M is the mass of the sample (kg) (in wet base).

The experiment used a completely randomized split plot in time design, for the following variables: loss in mass, soluble solid ratio, total titratable acidity and firmness. With regard to total phenolic content, antioxidant activity and Lyc content, since the analysis was carried out solely at the beginning and at the end of the storage, only the completely randomized design was used. All analyses were carried out in five replications.

The plots were formed by the glycerol concentration used in each treatment, and the subplots by the storage times of the fruits. Three treatments of the fruits with filmogenic solution coating (T1, T2 and T3) and a treatment without coating (C = control) were contemplated. Ten storage periods were considered (0, 2, 4, 6, 8, 10, 12, 14, 16 and 18 days). The results were submitted to variance analysis at 5% probability (p<0.05). To describe the characteristics of the samples in function of the storage periods, we carried out first and second degree regression analyses, the choice of the best model being made through observation of the significance of the F test for each model at 5% level. To make the statistical analyses, the software SAS - Statistical Analysis System, version 9.1,

licensed to the Federal University of Viçosa was used (SAS, 1999). The degree of adjustment of the regression model considered the magnitude of the determination coefficient (R<sup>2</sup>), the magnitude of the relative average error (P) and the standard deviation of the estimate (SE). The relative average error and the standard deviation of the estimate for each model was calculated using Equations (3) and (4), respectively.

$$P = \frac{100}{n} \sum_{i=1}^n \frac{|Y - Y_0|}{Y} \quad (3)$$

$$SE = \sqrt{\frac{\sum_{i=1}^n (Y - Y_0)^2}{GLR}} \quad (4)$$

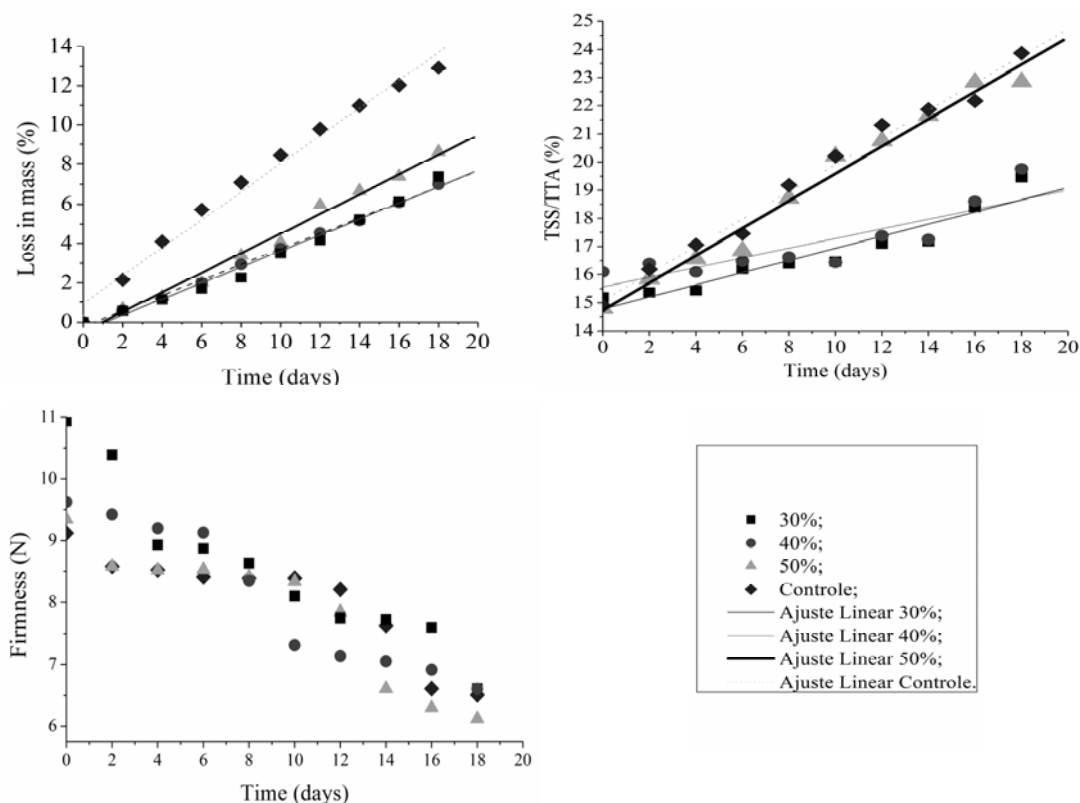
Where: Y is the experimentally observed value, Y<sub>0</sub> is the value calculated by the model, n is the amount of experimental observations, and GLR is the number of degrees of freedom of the model.

## RESULTS AND DISCUSSION

The interaction between glycerol variation and storage time was significant (Figure 1A; p<0.01) for the variables loss in mass and ratio (Table 1). At 18 days of storage, tomatoes treated with 30, 40 and 50% glycerol had a reduction of loss in mass of, 46, 43 and 33% respectively, compared with those that got no filmogenic solution, that is, being thus the treatment with 30% glycerol with the smallest loss in fresh mass (Figure 1A, p<0.01).

Pereira et al. (2006) evaluated the effect of cassava starch coating (1, 2 and 3%) on the loss in mass of the 'Formosa' variety of papaya and detected that the treatments had no effect on that variable. However, Scanavaca Júnior et al. (2007) confirmed that edible coatings with 1, 2 and 3% cassava starch were efficient in reducing the loss in mass of the 'Surpresa' mango variety stored at room temperature.

In the present study, 7.5% yam starch reduced the loss in mass of the tomatoes, regardless of the glycerol amount. This can be associated with the low water solubility index of yam starch (1.78%; Reis et al., 2010), when compared to the 'Manteiga' variety of cassava starch (4.52%; Nunes et al., 2009), since the loss in water can be lower in coatings that use low water solubility starch. When comparing the adopted treatments, one notices that the plasticizer had some effect on the loss in mass of the tomatoes. According to Mali et al. (2004), glycerol is a hydrophilic plasticizer that is much used in the making of biodegradable films. This hydrophilicity causes bigger interaction with water and therefore higher solubility of the coating, which explains that the treatment with higher glycerol percentage causes a greater loss in mass when compared with the other treatments (except for the control treatment). However, the loss in mass of all the treatments with coating was much lower than that of the control, showing that coating is an effective way of slowing down this parameter in the cherry tomato.



$LM_C = 0.96 + 0.71D^*$ ;  $R^2 = 99.24\%$ ;  $P = 2.53\%$ ;  $SE = 0.31$ ;  
 $LM_{30\%} = -0.21 + 0.39D^*$ ;  $R^2 = 99.87\%$ ;  $P = 0.13\%$ ;  $SE = 0.02$ ;  
 $LM_{40\%} = -0.45 + 0.40D^*$ ;  $R^2 = 99.13\%$ ;  $P = 0.96\%$ ;  $SE = 0.12$ ;  
 $LM_{50\%} = -0.47 + 0.49D^*$ ;  $R^2 = 99.38\%$ ;  $P = 1.03\%$ ;  $SE = 0.13$ ;  
 $TSS/TAA_C = 14.74345 + 0.48473D^*$ ;  $R^2 = 98.97\%$ ;  $P = 10.22\%$ ;  $SE = 0.89$ .  
 $TSS/TAA_{30\%} = 14.78267 + 0.2154D^*$ ;  $R^2 = 90.52\%$ ;  $P = 6.02\%$ ;  $SE = 0.60$ ;  
 $TSS/TAA_{40\%} = 15.56909 + 0.17155D^*$ ;  $R^2 = 86.54\%$ ;  $P = 15.44\%$ ;  $SE = 0.99$ ;  
 $TSS/TAA_{50\%} = 15.08 + 0.48258D^*$ ;  $R^2 = 99.30\%$ ;  $P = 9.53\%$ ;  $SE = 0.70$ ;  
 Where: \* is significant at 5% probability for test F;  $LM_C$  is the loss of mass of the treatment without covering;  $LM_{30\%}$  is the loss in mass of the treatment with 30% glycerol;  $LM_{40\%}$  is the loss in mass of the treatment with 40% glycerol and;  $LM_{50\%}$  is the loss in mass of the treatment with 50% glycerol;  $TSS/TAA_C$  is the ratio between TSS and TTA of the treatment without covering;  $TSS/TAA_{30\%}$  is the ratio between TSS and TTA of the treatment with 30% glycerol;  $TSS/TAA_{40\%}$  is the ratio between TSS and TTA of the treatment with 40% glycerol;  $TSS/TAA_{50\%}$  is the ratio between TSS and TTA of the treatment with 50% glycerol and; D is the storage in days.

**Figure 1.** A. Loss in mass; 1-B. Ratio of total soluble solids (TSS) and total titratable acidity (TTA) and 1-C Firmness of the cherry tomatoes submitted to the treatments without coating, with 50, 40 and 30% glycerol with 7,5% yam starch during the storage time for 18 days at  $25 \pm 1^\circ\text{C}$  (Figure 1-A. Loss in mass; 1b. Value of total soluble solids (TSS) and titratable acidity (TTA) and 1-C Firmness of cherry tomatoes subjected to uncoated treatments, 50% 40 and 30% glycerol for 18 days at  $25 \pm 1^\circ\text{C}$ ). Viçosa, Centreinar-UFV. 2010.

Higher values of TSS/TTA were found in the treatment without coating over time, meaning that the treatment with 30 and 40% glycerol slowed down the maturation of the evaluated tomatoes, followed by the treatment with 50% plasticizer (Figure 1B,  $p \leq 0.01$ ). The studied relationship got lower values for the treatments with 30 and 40% plasticizer, due to the influence of the plasticizer. There was no visual difference between the treatment with 50% glycerol and the treatment without coating. The total soluble solid content (TSS) and the total titratable acidity (TTA) determine the TSS/TTA ratio

for fruits ( $^\circ\text{Brix}/\%$  citric acid). Thus, a high value of the ratio indicates a mild flavor, whereas low values indicate an acid flavor (Bolzan, 2008). The firmness data of the analyzed tomatoes did not follow any trend to linear or quadratic regression adjustments. It was found that, in all the treatments, firmness diminishes with conservation time (Figure 1C).

Pereira et al. (2006) evaluated the maturation at room temperature of 'Formosa' papaya fruits coated with edible cassava starch-based film, which was applied through immersion of the entire fruits in suspensions of 1, 2 and

**Table 1.** Total phenolic compounds, antioxidant activity and lycopene content of tomatoes freshly harvested and after 18 days without coating and with different treatments with different glycerol content (30, 40% and 50%) in the coating. Viçosa, Centreinar-UFV. 2010.

Treatment	Total phenolic compounds (mg EAG100 g <sup>-1</sup> )	Antioxidant activity (%)	Lycopene (µg g <sup>-1</sup> )
Freshly harvested	278 <sup>a</sup> ± 3.9	41 <sup>a</sup> ± 2.2	29 <sup>a</sup> ± 3.3
7.5% starch + 30% glycerol	213 <sup>b</sup> ± 4.2	36 <sup>ab</sup> ± 2.7	25 <sup>b</sup> ± 2.1
7.5% starch + 40% glycerol	158 <sup>c</sup> ± 2.8	33 <sup>b</sup> ± 3.4	23 <sup>c</sup> ± 4.0
7.5% starch + 50% glycerol	101 <sup>d</sup> ± 2.7	25 <sup>c</sup> ± 2.9	19 <sup>d</sup> ± 3.2
Without coating	48 <sup>e</sup> ± 3.3	20 <sup>c</sup> ± 4.1	14 <sup>e</sup> ± 4.2

\*Same letters in the column do not differ statistically at the level of 5% probability.

3%. Results showed that the coatings with 1 and 3% extended the useful postharvest life by four days, maintaining the quality. The treatments slowed down the maturation of the fruits, whose alterations of skin color, pulp firmness, soluble solids and titratable acidity were significantly slower than in the untreated fruits. The same alterations were perceived in the present study.

With time fixed and treatment type analyzed, it was found that treatments, including control, differ during the conservation time. In the analyses of phenolic compounds and lycopene, at 18 days of storage, tomatoes treated with 30, 40 and 50% glycerol, without coating and freshly harvested.

In the analysis of phenolic compounds, lower values were detected in the treatments at 18 days of storage, in relation to the initial average value of the fruit (Table 1). As for the fruits that received no coating, the total phenol content decreased 83% in relation to the initial time. On the other hand, the treatments with 30, 40 and 50% decreased by 24, 44 and 64%, respectively.

Rocha and Silva (2011) evaluated the total phenol content in conventional (Alambra cultivar) and organic (Debora cultivar) tomatoes by the Folin-Ciocalteu method and found values of 59.89 and 45.89 mg 100 g<sup>-1</sup>, respectively. Such values are lower than those of the cherry tomato in the present study. Phenolic compounds in fruits and vegetables can have beneficial effects for eliminating free radicals (Chun et al., 2003). So phenolic compounds can help to protect cells against the oxidative damage caused by free radicals (Wada and Ou, 2002). For analysis of the antioxidant activity, the treatment with 30% glycerol did not differ from the freshly harvested tomato nor from the treatment with 40% glycerol, but comparison of the freshly harvested tomato and the tomato treated with 40% glycerol showed a difference significant at 5% probability for the same analysis. There was a reduction of 12, 40, 20 and 51 51, 40, 20 and 12% of the antioxidant activity in the treatments with 30, 40, 50% glycerol and without coating, respectively, in relation to the freshly harvested cherry tomato. Thus, the treatment with 30% glycerol got the value of antioxidant activity closest to the freshly harvested cherry tomato, that is, the best preservation of the activity was observed

in this treatment (Table 1).

Robles- Sánchez et al. (2013) studied the content of phenolic compounds with antioxidant capacity of the fresh-cut Kent mangoes coated with sodium alginate, which when compared with the treatment they received no coating showed the same behavior for the two analyzes. The same authors have also included in ascorbic acid and citric acid coating, which increased both the phenolic content as the antioxidant activity of the sleeves in court.

Researches point out that the antioxidant activity of food is related to the phenolic compound content (Martinez-Valverde, 2002; Cheung et al., 2003). Monteiro et al. (2008) analyzed the antioxidant activity of the Italian tomato and found values of 8.65 and 5.94% for tomato pulp and for the entire tomato, respectively, values lower than those we got in this study (Table 1). Lycopene content diminished by 14, 21, 35 and 48% in the treatments with 30, 40, 50% glycerol and without coating stored for 18 days, respectively, in relation to the freshly harvested tomato. We believe that the coating formed a wall and minimized the lycopene oxidation in relation to the uncoated tomatoes, since, according to Baldwin (1999), edible coatings have the capacity to reduce the dehydration and oxidation of the coated product that, consequently, harm its color, taste and texture.

Lycopene appears currently as one of the most powerful antioxidant substances, being recommended to prevent carcinogenesis and atherogenesis by protecting molecules as lipids, low-density lipoproteins (LDL), proteins and DNA (Shami and Moreira, 2004).

Malacrida et al. (2006) reported reduction in lycopene accumulation in tomatoes during the normal maturation and Perkins-Veazie and Collins (2004) pointed out that the lycopene total content was not significantly modified in any cultivar stored for two days at 2°C. The treatment with 30% glycerol got closer values of phenolic compounds, antioxidant activity and lycopene in relation to the initially analyzed fruit. This means that the treatment with coating was the one that best kept the characteristics of the freshly harvested fruit, and it may be considered the most efficient treatment for the conservation of the cherry tomato, since it got the lowest

loss in mass, the lowest ratio of total soluble solids and total titratable acidity (showing lower maturation of the fruit, even if the results did not follow any trend for the variable firmness) in comparison to the other treatments used. Moreover, visually, this treatment delayed the appearance by 8 days in relation to the control.

### Conflict of Interest

The authors have not declared any conflict of interest.

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