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# Cold storage of peaches cv. Aurora grown in the Zona da Mata Mineira, Minas Gerais State, Brazil<sup>1</sup>

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## ABSTRACT

This study aimed to evaluate the postharvest behavior of peach cv. Aurora 1 harvested in the Zona da Mata region of Minas Gerais in two ripening stages and kept under different storage temperatures. Fruits on mid-ripe and fully ripe stages were stored at three temperatures:  $5.6 \pm 1.57$  °C and  $72.8 \pm 3.8\%$  RH;  $10.4 \pm 0.5$  °C and  $95.8 \pm 5.5\%$  RH;  $21.04 \pm 1.63$  °C and  $96.9 \pm 2.6\%$  RH up to 28 storage days (SD). During storage, fruits stored at  $21.04 \pm 1.63$  °C were evaluated every two days until 8 SD, and every four days for fruits stored at other temperatures. The harvest day was assigned as day zero. The variables evaluated were CO<sub>2</sub> production, color of the pericarp and pulp, fresh mass loss, flesh firmness, total soluble solids, titratable acidity, contents of ascorbic acid and carotenoids. The fresh mass loss increased during storage, peaking at 5.6 °C. The reduction in ascorbic acid content was higher in fully ripe fruits at all temperatures. Mid-ripe fruits reached the end of the storage period with better quality. The temperature of 10.4 °C was the most efficient in keeping postharvest quality of peach cv. Aurora 1 harvested in the Zona da Mata region.

**Key words:** *Prunus persica*, ripening stage, fruit quality.

## RESUMO

### Conservação refrigerada de pêssego cv. Aurora, cultivado na Zona da Mata Mineira

Este trabalho teve como objetivo avaliar o comportamento pós-colheita de frutos de pessegueiro ‘Aurora 1’, colhidos na região da Zona da Mata Mineira, em dois estádios de maturação, mantidos sob diferentes temperaturas de armazenamento. Lotes de frutos nos estádios de maturação “de vez” e maduro foram armazenados em três temperaturas:  $5,6 \pm 1,57$  °C e  $72,8 \pm 3,8\%$  UR;  $10,4 \pm 0,5$  °C e  $95,8 \pm 5,5\%$  UR;  $21,04 \pm 1,63$  °C e  $96,9 \pm 2,6\%$  UR, por até 28 dias de armazenamento (DA). Durante o armazenamento, os frutos foram avaliados a cada dois dias, até o 8º DA, para frutos armazenados em  $21,04 \pm 1,63$  °C, e a cada quatro dias, para frutos armazenados nas demais temperaturas, sendo o dia zero o dia da colheita dos frutos. Foram avaliados a produção de CO<sub>2</sub>, a coloração do pericarpo e da polpa, a perda de massa de matéria fresca, a firmeza da polpa, o teor de sólidos solúveis, a acidez titulável, o teor de ácido ascórbico e o teor de carotenóides. A perda de matéria fresca aumentou durante o armazenamento, sendo mais acentuada na temperatura 5,6 °C. A redução do teor de ácido ascórbico foi maior nos frutos maduros, para todas as temperaturas em estudo. Frutos no estágio de maturação “de vez” chegaram ao final do período de armazenamento com melhor qualidade, sendo a temperatura de 10,4 °C a mais eficiente na manutenção da qualidade pós-colheita de frutos de pêssego ‘Aurora 1’, colhidos na região da Zona da Mata Mineira.

**Palavras-chave:** *Prunus persica*, estágio de amadurecimento, qualidade do fruto.

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## INTRODUCTION

Progress in peach genetic improvement for subtropical regions has been highly significant. As a result, the production of peaches for industry and fresh consumption extended to new areas in subtropical regions as well as the marketing period (Wagner Jr. *et al.*, 2011).

Cultivar Aurora 1 has a low requirement of cold temperature to break dormancy (under 100 hours) and fruits of high sensory quality. Fruit is oblong shaped and weight is around 90-110 g. The skin color is red (80% color over yellow background). The flesh is firm, pale yellow, adhered to the stone. Soluble solids are, on average, 14 ° Brix, with low acidity (Cunha Júnior *et al.*, 2007).

The ripening stage at harvest is crucial for postharvest life as well as for storage potential. Thus, when the fruits are harvested before physiological maturity they will not ripen, will become shriveled and ooze sap, or if ripening occurs, leads to a poor quality fruits. Overripe fruits deteriorate rapidly and cannot be stored and/or marketed in distant locations (Silva *et al.*, 2012).

Chilling is among the methods used to extend the postharvest life of fruits (Silva *et al.*, 2009). According to Souza *et al.* (2009), refrigerated storage slows the plant metabolism by decreasing the respiratory rate and the enzymatic activity. Peach has a climacteric respiratory pattern and after harvesting the fruit physiologically ripe, changes triggered by ethylene production and increased respiratory rate occur rapidly (Brackmann *et al.*, 2009). Fruits of cv. Aurora 1 grown in the municipality of Taiúva - SP and stored for 35 days at 2 °C, 6 °C and 12 °C, showed no sensitivity to cold (Cunha Júnior *et al.*, 2010).

Little is known about the effects of cold storage at different stages of maturation of peaches grown in subtropical regions. The experimental conditions used by many authors are quite varied with regard to the place of cultivation, cultivars and storage temperatures. In southern Brazil, the technology of cold storage for temperate fruits is widespread. For Minas Gerais State to gain ground in this market with efficiency, the development and improvement of farming and postharvest techniques are needed to increase shelf life and, at the same time, ensure fruit quality to the final consumer.

Thus, establishing the appropriate harvest point and optimum temperature for stone fruit storage can minimize quality loss during storage. Therefore, this study aims to evaluate the quality of peaches cv. Aurora 1 under different storage temperatures, when harvested at different ripening stages.

## MATERIALS AND METHODS

Fruits of peach (cv. Aurora 1) were collected from trees growing in the municipality of Barbacena - MG (located at 21° 13' 33" S and 43° 46' 25" O, 1.164 m altitude). The climate is highland tropical (CWB), with cold winters and mild summers. The average annual temperature is 17 °C, with a maximum average of  $24.17 \pm 1.75$  °C and minimum average of  $13.58 \pm 2.27$  °C.

Mid-ripe and fully ripe fruits were harvested on October 25, 2011, in the early hours of the day. Visually, mid-ripe fruits were considered those with green color background and no, or little, red color covering the skin. When picked, they had coordinate b for skin color of 12.43; hue angle of 92.10 and soluble solids were 8.73 °Brix. Fully ripe peaches were considered those changing background skin color from green to creamy-white and abundant red color covering the skin (Seibert *et al.*, 2008). When picked, they had coordinate b for skin color of 19.49; hue angle of 74.140 and soluble solids were 9.56 °Brix.

After harvest, fruits were transported in cardboard boxes, in a refrigerated car, to the laboratory of Fruit Analysis at the Universidade Federal de Viçosa - MG. Fruits were sorted and sized by suture ( $44.8 \pm 3.6$ ), equatorial ( $43.0 \pm 3.9$ ) and polar ( $51.5 \pm 3.5$ ) diameters, ripening stage (mid-ripe and fully ripe), lack of decay and mechanical damage. They were washed in 0.2% detergent solution, treated with fungicide Prochloraz ( $49.5 \text{ g } 100 \text{ L}^{-1}$  water) for 5 min and allowed to air dry.

Then the peaches were separated by the instrumental method of skin color in lots containing mid-ripe (hue angle  $87.16 \pm 3.06$  °) and fully ripe (hue angle  $78.41 \pm 8.58$  °) fruits. According to Cunha Júnior *et al.* (2007), peaches are considered mid-ripe when reaching values between 98 and 110 ° and fully ripe when reaching values between 90 and 110 °.

Peaches were packed in polystyrene trays (220 mm x 140 mm x 40 mm) and stored at three temperatures:  $5.6 \pm 1.57$  °C and  $72.8 \pm 3.8\%$  RH;  $10.4 \pm 0.5$  °C and  $95.8 \pm 5.5\%$  RH; and  $21.04 \pm 1.63$  °C and  $96.9 \pm 2.6\%$  RH for 28 days. During storage, fruits stored at  $21.04 \pm 1.63$  °C were evaluated every two days and fruits stored at the other temperatures were evaluated every four days. The harvest day was assigned as day zero.

The experiment was conducted in a split plot arrangement, with the temperatures (three levels) in the main plots, the ripening stages in the subplots (two levels) and the evaluation days (eight levels) in the subsubplots, in a completely randomized design with three replicates of five fruits per experimental unit.

Fruits were analyzed for CO<sub>2</sub> production by gas chromatography, using a Gow Mac Series 550P gas chromatograph equipped with a thermal conductivity

detector and aluminium column filled with Porapak Q. The working conditions were: helium flow rate of 40 mL per minute, as the carrier gas, electric current of 150 mA, column, detector and injector temperatures were 50, 70 and 80 °C, respectively, and room temperature between 20 and 23 °C. The results were expressed in % or in mg of CO<sub>2</sub> kg<sup>-1</sup> h; fresh matter loss (gravimetric method), color of skin and pulp (digital colorimeter); pulp consistency (digital penetrometer probe of 12 mm), soluble solids expressed in ° Brix (digital refractometer), titratable acidity (TA) (titration with NaOH and the results expressed as % malic acid) according to the methodology described in AOAC (1997), vitamin C (titration reagent Tillman 2,6 dichlorophenolindophenol) according to the methodology described in AOAC (1997) and the results expressed in mg 100g<sup>-1</sup> of pulp, carotenoids (approximately 2.0 g ground in a mortar with washed sand, acetone 80% and a pinch of CaCO<sub>3</sub>). The ketone extract was filtered through filter paper and the volume was completed to 25 mL. The absorbance was determined at 470, 646.8 and 663.2 nm and the levels of carotenoids calculated using the equations of Lichtenthaler (1987), in mg 100g<sup>-1</sup> of pulp.

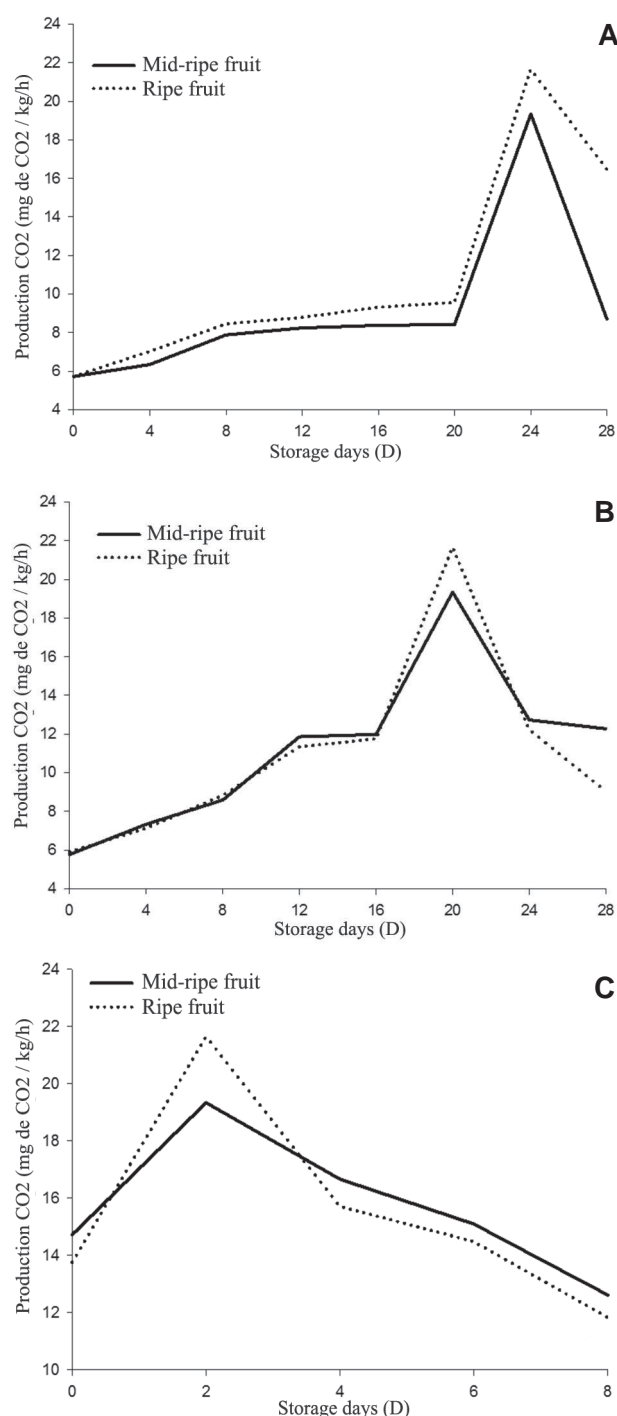
Unfolding was used for data analysis, regardless of whether there was significant interaction or not, to demonstrate the behavior throughout the experimental period. Factor means were subjected to regression analysis. The models were chosen based on the significance of the regression coefficients, using the “t” test, the coefficient of determination (R<sup>2</sup>) and the potential to explain the biological phenomenon. The descriptive statistical analysis was used for CO<sub>2</sub> production.

## RESULTS AND DISCUSSION

The respiratory peak of mid-ripe fruits stored at 5.6 °C occurred after 24 days (SD), with 18.7 mg of CO<sub>2</sub> kg<sup>-1</sup> h<sup>-1</sup>; for fruits stored at 10.4 °C, the peak occurred on day 20 SD (Figures 1A and 1B). Fruits stored at 21.04 °C reached the climacteric peak on day 6 SD, with mid-ripe and fully ripe fruits with 15.1 and 14.5 mg of CO<sub>2</sub> kg<sup>-1</sup> h<sup>-1</sup>, respectively (Figure 1C). Peaches cv. Douradão harvested at the commercial ripening stage and stored at 0 °C reached the peak on day 5 SD with 25 mg of CO<sub>2</sub> kg<sup>-1</sup> h<sup>-1</sup> (Souza *et al.*, 2009).

The loss of fresh matter had a linear decrease with days of storage (Figure 2). On day 8 SD, the mass loss was 15.2, 6.0 and 16.0% for mid-ripe fruits stored at 5.6, 10.4 and 21.04 °C, respectively (Figures 2A, 2B and 2C). Fruits stored at 10.4 °C had, at the end of storage (28 days), accumulated mass loss of 21.1 and 19.5% for mid-ripe and fully ripe stages, respectively (Figure 2B). Despite displaying more than 5% loss, the fruits showed no symptoms of shriveling, which would prevent its commercialization. Seibert *et al.* (2008) observed that

peaches cv. Chimarrita after 10 and 30 days of refrigerated storage, when brought to 20 °C, showed slight wilting in the shoulder region. This symptom was a little more intense in peaches harvested at ripe stage. The mass losses were greater than 5% and led to shriveling, especially in peaches harvested at mid-ripe stage and after 20 days of storage. Shriveling was observed in ripe peaches cv. Chiripá after 20 days at 0 °C. Mitchell (1992) reported 5%

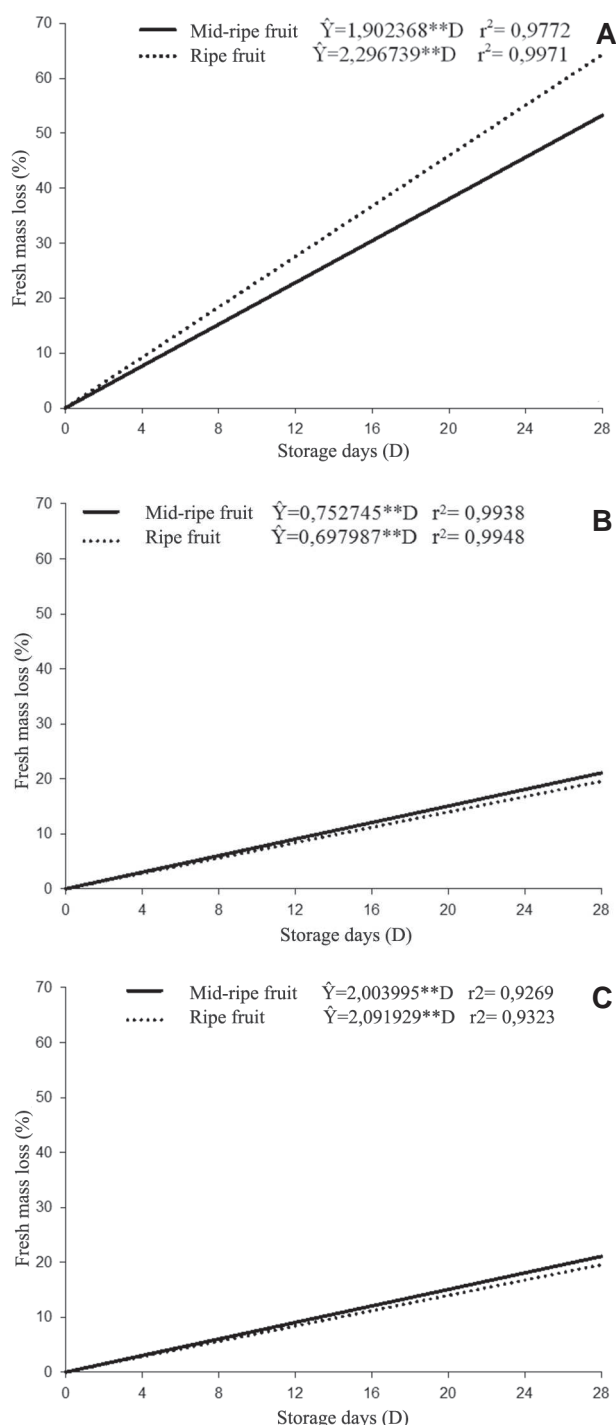


**Figure 1.** CO<sub>2</sub> production in peaches cv. Aurora 1 harvested at mid-ripe and fully ripe stages during storage at different temperatures (A: 5.6 °C; B: 10.4 °C; and C: 20.04 °C).

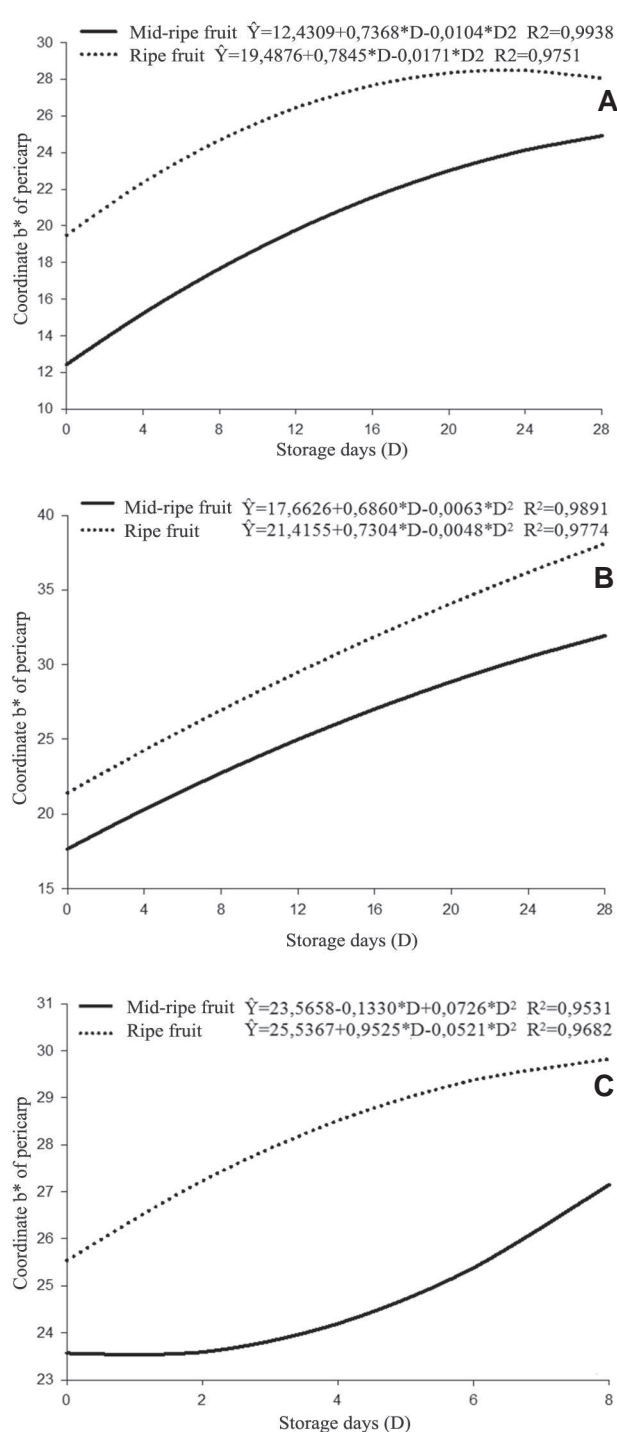
mass loss as a limit, before the peaches loose quality. For Crisosto *et al.* (2004), mass losses of 5% are normal for peaches and shriveling symptoms are noticed when they exceed 10%. For the cultivars Chimarrita and Chiripá, a loss limit of 5% and higher percentages can lead to symptoms of shriveling (Seibert *et al.*, 2008).

Peaches harvest at the different ripening stage presented similar trend regarding skin and pulp color

(Figures 3, 4, 5 and 6) and the temperature of 5.6 °C resulted in the smaller changes. The skin color of mid-ripe fruit stored at 10.4 °C had little change from the first day of evaluation (harvest day), which may allow extend the marketing period up to 28 days, without compromising the visual quality of the fruit. Mid-ripe fruit stored at 5.6 °C, had minor changes in skin color, however, there was impairment of fruit visual quality



**Figure 2.** Fresh mass loss of peaches cv. Aurora 1 harvested at mid-ripe and fully ripe stages during storage at different temperatures (A: 5.6 °C; B: 10.4 °C; and C: 20.04 °C).

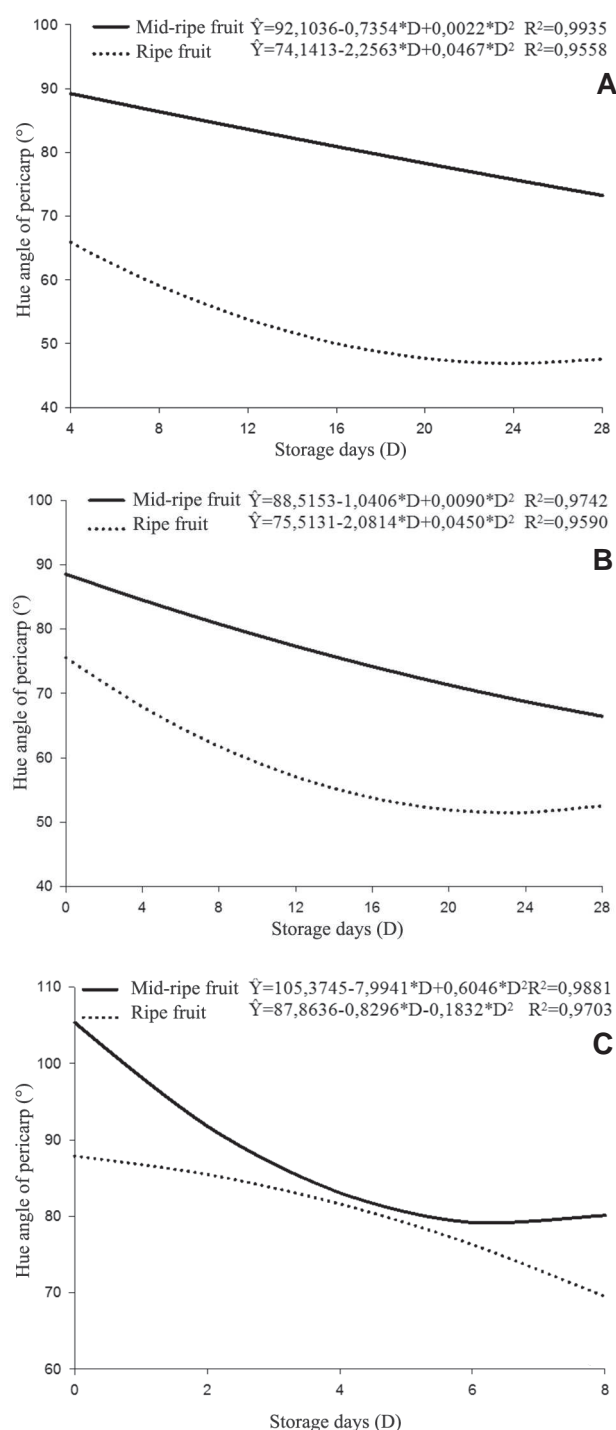


**Figure 3.** Coordinate b\* of pericarp of peaches cv. Aurora 1 harvested at mid-ripe and fully ripe stages during storage at different temperatures (A: 5.6 °C; B: 10.4 °C; and C: 20.04 °C).

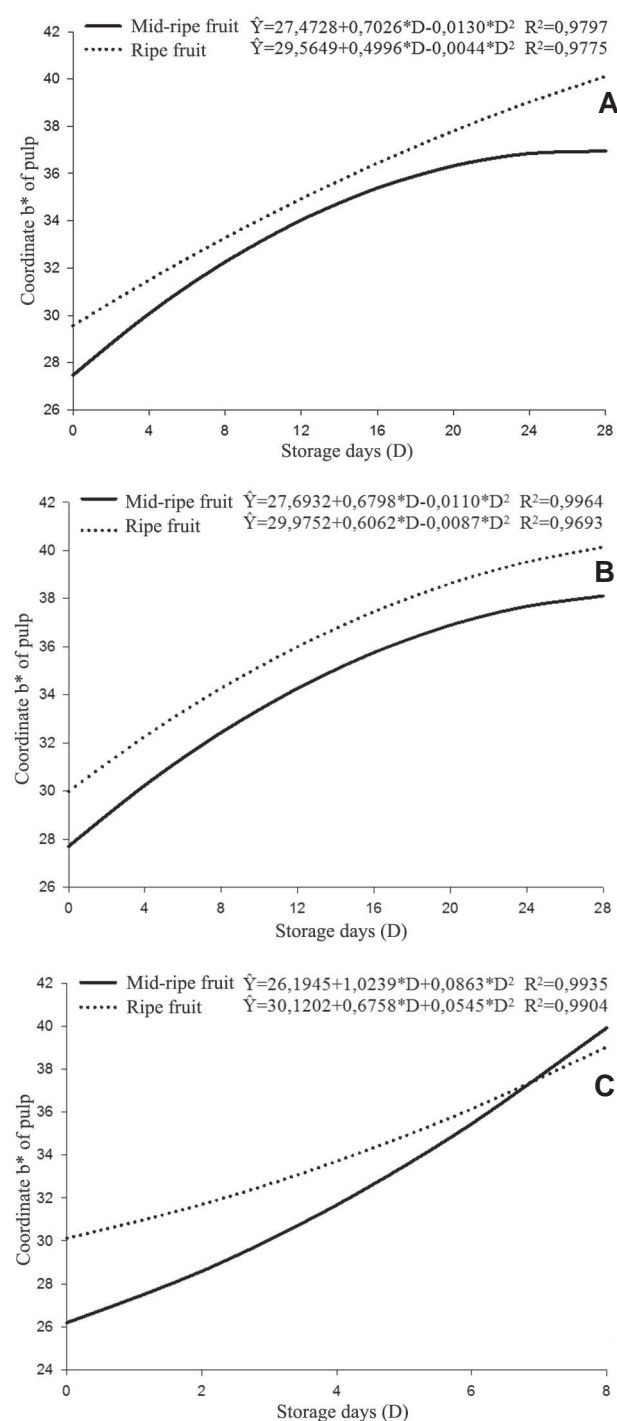


because of the high loss of fresh mass at the end of storage. A trend for color maintenance at low temperatures was also observed by Bron *et al.* (2002), who reported decreased levels of hue angle in fruits of cultivars Aurora 1 and Golden 2 with storage, as well as that fruit stored at lower temperatures resulted in less reduction of this variable compared with those stored at room temperature.

Fruits of all treatments showed a decrease of pulp consistency during storage, regardless of the temperature and the ripening stage (Figure 7). On day 8 SD, fruits stored at 21.04 °C showed consistency of 21.58 and 10.33 N for mid-ripe and fully ripe fruit stages, respectively, while for mid-ripe fruit stored 5.6 and 10.4 °C, consistency over the same period was 47.49 and 44.58 N, respectively, which demonstrates the potential of lower temperatures to con-



**Figure 4.** Hue angle of pericarp of peaches cv. Aurora 1 harvested at mid-ripe and fully ripe stages during storage at different temperatures (A: 5.6 °C; B: 10.4 °C; and C: 20.04 °C).

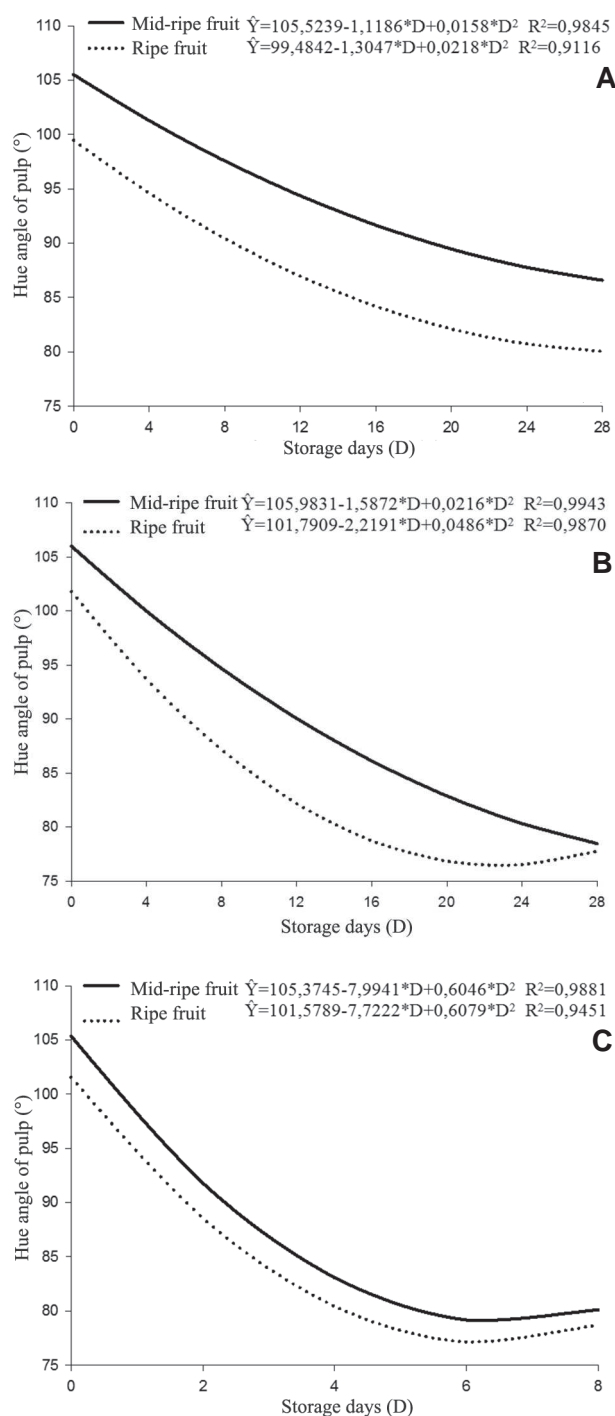


**Figure 5.** Coordinate b\* of pulp of peaches cv. Aurora 1 harvested at mid-ripe and fully ripe stages during storage at different temperatures (A: 5.6 °C; B: 10.4 °C; and C: 20.04 °C).

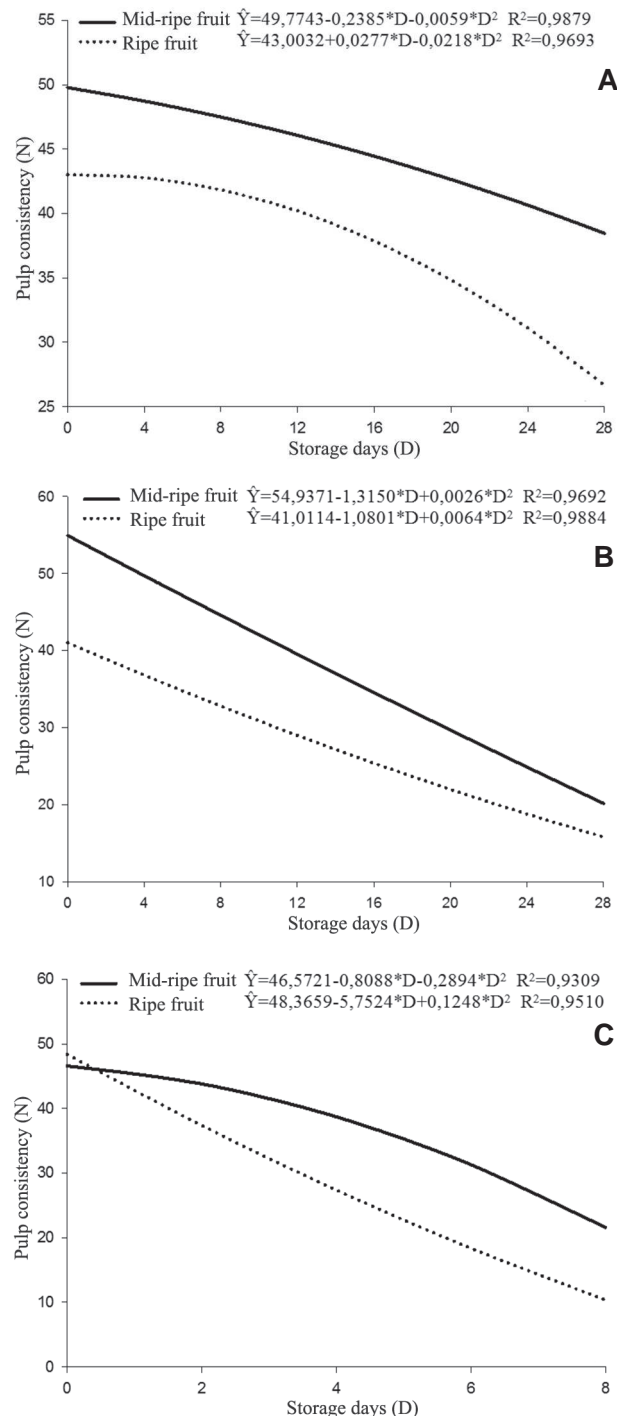
serve the fruit for longer periods. Cunha Júnior *et al.* (2010), studying the cold storage of peaches cv. Aurora 1 produced in Taiúva - SP, observed that ripe fruit stored at 12 °C had a sudden reduction in firmness, reaching 14 days SD with 7.9 N. Mid-ripe peaches had initial values of 46.5 N, 21.1 N in the same period. In this work, we observed that the ripe fruit stored at 10.4 °C had consistency of 25.37 N on day 16 SD, while mid-ripe fruits

had consistency of 34.56 N. Peaches with low firmness have a lower transport resistance and, consequently, shorter shelf life (Toebe *et al.*, 2011).

Both mid-ripe and fully ripe fruit reached at the end of storage SS contents of 16 and 21.1 °Brix, respectively (Figure 8). However, these levels of SS are due to the high fresh matter loss on day 28 SD, reaching 53.3 and 64.3% cumulative loss for mid-ripe and fully ripe fruit, respectively.



**Figure 6.** Hue angle of pulp of peaches cv. Aurora 1 harvested at mid-ripe and fully ripe stages during storage at different temperatures (A: 5.6 °C; B: 10.4 °C; and C: 20.04 °C).



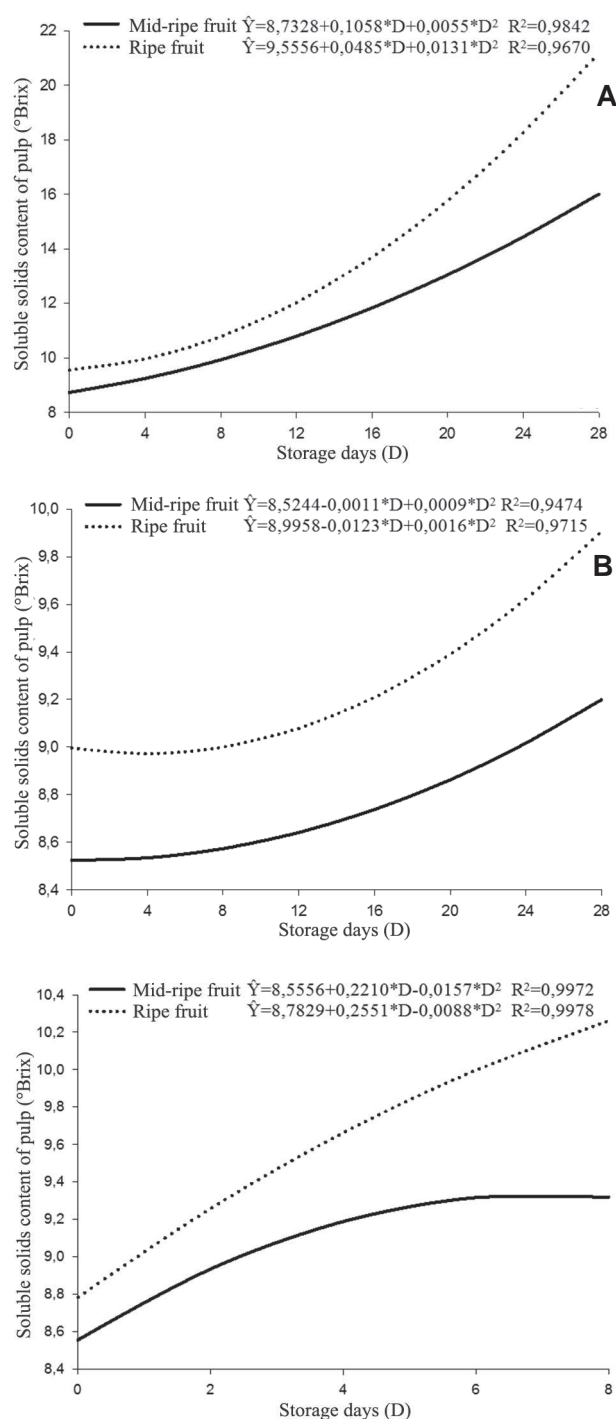
**Figure 7.** Pulp consistency of peaches cv. Aurora 1 harvested at mid-ripe and fully ripe stages during storage at different temperatures (A: 5.6 °C; B: 10.4 °C; and C: 20.04 °C).

At the other temperatures in this study, these levels were between 8.5 and 10.3 °Brix. Similar results were found by Cunha Júnior *et al.* (2010), who working with cv. Aurora 1, observed that mid-ripe fruits had lower SS (10.9 °Brix) than fully ripe fruits (11.6 °Brix).

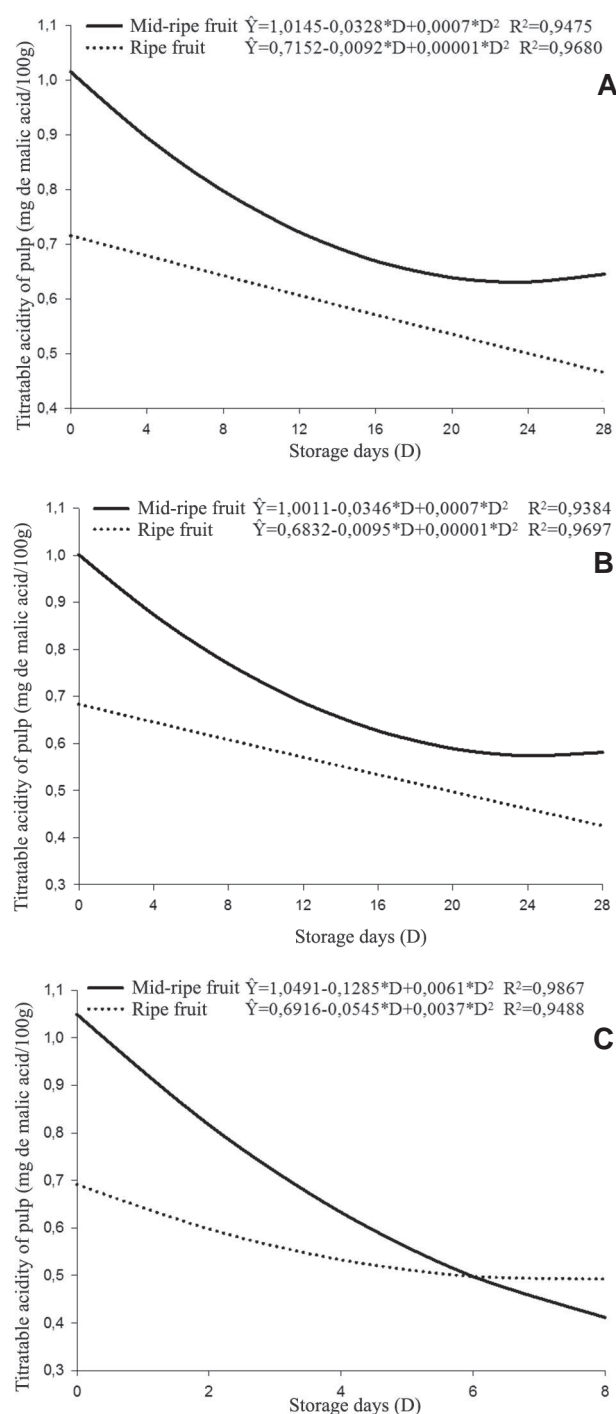
The titratable acidity (TA) had a quadratic behavior along the days in all treatments (Figure 9). Ripe fruits showed lower TA when compared with mid-ripe fruits. According to Silva

*et al.* (2010), the levels of organic acids, with few exceptions, tend to decrease with fruit ripening, due to the respiratory process or their conversion into sugars.

The vitamin C content decreased according the quadratic model throughout the storage (Figure 10). Ripe fruits showed lower ascorbic acid content when compared with mid-ripe fruits, and that the greatest losses occurred at 20.04 °C, when the ascorbic acid content of mid-ripe



**Figure 8.** Soluble solids content of pulp of peaches cv. Aurora 1 harvested at mid-ripe and fully ripe stages during storage at different temperatures (A: 5.6 °C; B: 10.4 °C; and C: 20.04 °C).



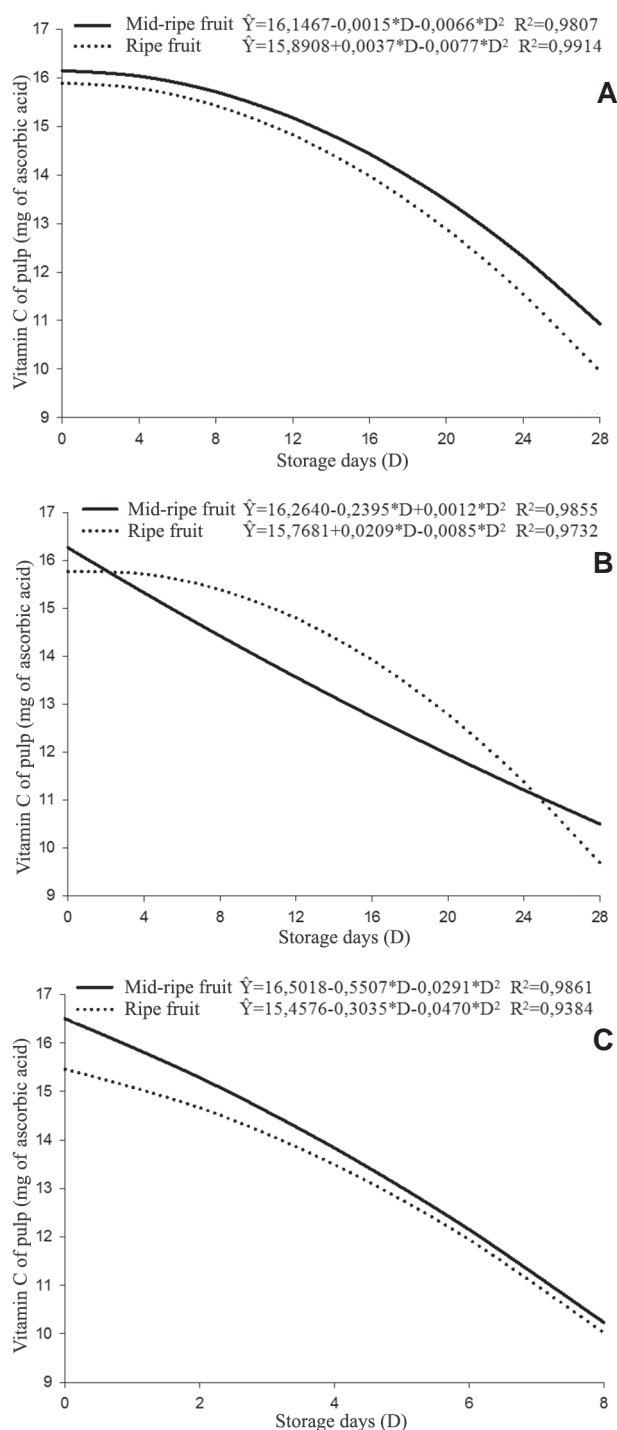
**Figure 9.** Titratable acidity of pulp of peaches cv. Aurora 1 harvested at mid-ripe and fully ripe stages during storage at different temperatures (A: 5.6 °C; B: 10.4 °C; and C: 20.04 °C).



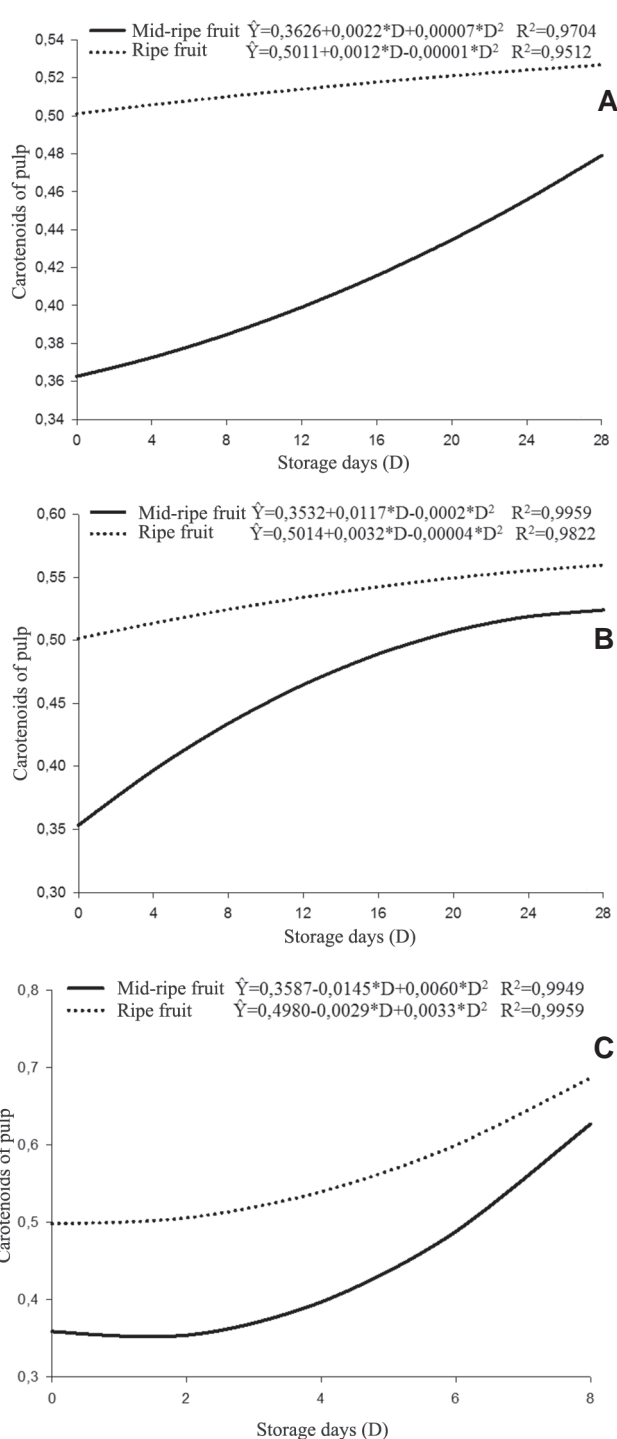
fruits decreased from 16.50 mg, on the harvest day, to 10.23 mg 100 g<sup>-1</sup> on day 8 SD. In most fruits, the vitamin C content tends to decrease during the ripening process. Silva *et al.* (2012) attributes this decrease to the action of ascorbic acid oxidase (ascorbate oxidase). The activity of this enzyme is larger in ripe fruits than in unripe fruits, which may explain the losses during the fully ripe stage. Segantini *et al.* (2012), characterizing the pulp of different

peach cultivars, found ascorbic acid content of 16.02 mg 100 g<sup>-1</sup> for fully ripe fruit of cv. Aurora 1.

The content of carotenoids was higher in ripe fruits and there was increase in their amounts in all treatments (Figure 11). The content of carotenoids increases during fruit ripening and color intensification is due to the loss of chlorophyll (Melendez-Martinez, 2004). The content of total carotenoids increased during the ripening of many



**Figure 10.** Vitamin C of pulp of peaches cv. Aurora 1 harvested at mid-ripe and fully ripe stages during storage at different temperatures (A: 5.6 °C; B: 10.4 °C; and C: 20.04 °C).



**Figure 11.** Carotenoids of pulp of peaches cv. Aurora 1 harvested at mid-ripe and fully ripe stages during storage at different temperatures (A: 5.6 °C; B: 10.4 °C; and C: 20.04 °C).

fruits, when carotenogenesis is enhanced (Lima *et al.*, 2002), as in mango (Silva *et al.*, 2012).

## CONCLUSION

For the characteristics evaluated in this study, the best efficiency in maintaining postharvest quality of peaches cv. Aurora 1, cultivated in the Zona da Mata region, Minas Gerais, was obtained with fruits harvested at the mid-ripe stage and kept at the temperature of 10.4 °C.

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