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Postharvest quality of gherkin under different storage conditions

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Abstract

This study aimed to evaluate the effect of different temperatures and storage periods on the maintenance of postharvest quality of gherkin of the Do Norte cultivar. A completely randomized experimental design was adopted, in a factorial arrangement: storage temperatures (0, 10, 20 and 30 °C) and storage periods (0, 3, 6, 9 and 12 days), with five repetitions. The evaluations occurred in two harvesting periods, at 87 and 107 days after sowing. The fruits were stored at a relative humidity of 90 ± 5% during the entire experimental period. In addition to the days considered, an evaluation was performed at 16 days, where the fruits were kept for four days at 20 °C simulating the period of processing and commercialization. The pH, titratable acidity, soluble solids, ratio, luminosity, hue angle, reduction of transverse and longitudinal diameters, and mass loss were evaluated. The storage at temperatures of 20 and 30 °C contributed to an increase in the degradation reactions of the organoleptic characteristics. Gherkin stored at temperatures of 0 and 10 °C showed less changes in pH and acidity, and less mass loss compared to the harvest time. However, fruits stored at 0 °C showed darkening of the epidermis and the occurrence of disturbances caused by cold. Therefore, gherkin of the Do Norte cultivar has good storage capacity when kept at a temperature of 10 °C for a period of twelve days regardless of the harvest time.

Keywords: physicochemical characterization, conservation, *Cucumis anguria*, storage temperature

Introduction

The gherkin (*Cucumis anguria* L.) is a fruit-vegetable of African origin, belonging to the family Cucurbitaceae, with high adaptability to regions with tropical and subtropical climate (Malerbo-Souza et al., 2020). Its fruits present variations as to spiculosity and size, with mild flavor and rich in vitamins and minerals (Thiruvengadam & Chung, 2014).

In Brazil, the gherkin are intended for consumption in natura, in the form of pickles or in salads (Gomes et al., 2015). However, it is still considered an underutilized vegetable, due to the scarce studies related to the culture (Oliveira et al., 2014). Some recent studies focus on cultivation practices, such as determining the nutrient solution (Oliveira et al., 2018) and conduction system (Costa et al., 2019). Fruits have high perishability, which limits preservation and supply to consumers (Santana et al., 2018). Therefore, to be successful in commercialization, fruits must be offered with organoleptic qualities similar to the moment of harvest and losses minimized through forms of conservation.

In developing countries, about 30% of vegetable production is lost during postharvest, when including steps such as distribution and storage (Yahaya & Mardiyya, 2019). However, these losses can be minimized through proper storage temperature, because at high temperature an increase in respiration rate and metabolism occurs, accelerating degradation. However, excessive reduction can promote cellular imbalance and collapse, making the fruits susceptible to the occurrence of disorders (Megías, et al., 2016). In this aspect, temperature is the variable of the conservation conditions that has the greatest impact on storage life, besides being one of the simplest methods to extend the postharvest period of vegetables (Chitarra & Chitarra, 2005).

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The storage temperature of fruit-vegetables varies depending on the species, with cucumbers (*Cucumis sativus* L.) recommended at temperatures near 10 °C (Choi et al, 2015), for pumpkins (*Curcubita maxima* L.), the storage period is extended when conditioned at 4 °C (Manjunatha & Anurag, 2012), and in okra (*Abelmoschus esculentus* L.), organoleptic characteristics were maintained at 10 °C, with fruits stored at 5 °C showing cold damage (Mota et al., 2010). Also, for tomatoes (*Solanum lycopersicum* L.), storage temperatures from 10 to 24 °C are recommended, varying according to cultivar and maturation stage (Brackmann et al., 2007; Rinaldi et al., 2012). However, works that evaluate the period and temperature in the maintenance of quality during storage of gherkin fruits are scarce, limiting the use of products (Silveira et al., 2015).

The aim of this work was to evaluate the effect of different temperatures and storage periods on the maintenance of postharvest quality of gherkin of the Do Norte cultivar.

Material and Methods

The experiment was developed in the Food Processing Laboratory of Federal University of Pampa, Itaqui, RS, Brazil (coordinates 29° 09' 21.68'' S; 56° 33' 02.58'' W, altitude 74 m). Gherkin of the Do Norte cultivar from the experimental area of the institution were harvested in two periods, at 87 and 107 days after sowing, and transported quickly and carefully to the laboratory.

The fruits presented epidermis with predominant green coloration, with luminosity of 56.01 and hue angle of 123.26°, pH of 5.42, acidity of 0.17% citric acid and soluble solids of 3.32 °Brix for the first season. Fruits harvested in the second season had a luminosity of 54.47 and hue angle of 122.56°, pH of 4.94, acidity of 0.22% citric acid and soluble solids of 3.30 °Brix. In both seasons, classification was performed, eliminating the fruits that presented mechanical damage and injuries caused by pathogens, and sanitization with triple washing, initially by immersion in 2% chlorine solution for 10 minutes and then immersed in two periods of 10 minutes in water. The fruits were kept at room temperature for 20 minutes for drying and then the fruits were placed in low density polyethylene containers. The packages were stored in BOD type climatized chambers at temperatures of 10, 20 and 30 °C and in a freezer at 0 °C. A relative humidity of 90 ± 5% was maintained during the experimental period for all temperatures.

A completely randomized experimental design was adopted, in a factorial scheme, consisting of different storage temperatures (0, 10, 20 and 30 °C) and storage days (0, 3, 6, 9 and 12 days), with five repetitions, totaling 10 fruits per analysis. At the end of the storage period, a differentiated evaluation was performed, when five samples were taken from each of the four temperatures (0, 10, 20 and 30 °C) and stored in BOD with a temperature of 20 °C and relative humidity of 90 ± 5%, for four more days (totaling 16 days), and then, the fruits were evaluated, simulating the processing and marketing period.

The physical evaluations of the fruits consisted in determining the mass loss, reduction of the transversal and longitudinal diameter, luminosity and hue angle. The mass loss of the fruits was obtained by the difference in mass between the individual weighing of each fruit in each storage period compared to the initial weighing, on precision analytical scales. The reduction of the transversal and longitudinal diameters was obtained by the difference of diameter between the measurement of the fruits in each period of evaluation compared to the initial measurement, using a digital pachymeter. To determine the parameters of coloration, brightness and hue angle, a digital colorimeter CR-400 (Konica Minolta®) was used, and the evaluations were performed in the equatorial region of the fruit on the surface with greater green coverage.

Chemical evaluations to determine pH, total soluble solids, titratable acidity and ratio were performed by crushing the fruits in a juice extractor centrifuge. The pH values were obtained by direct reading in a potentiometer and the total soluble solids, expressed in °Brix, were determined using a digital refractometer. Titratable acidity was determined by extracting 10 mL of juice, which was diluted in 100 mL of distilled water and titrated with 0.1 N sodium hydroxide until the turning point using the phenolphthalein reagent, being expressed as a percentage of citric acid. and the ratio, obtained by the relation between soluble solids and acidity.

The results were submitted to analysis of variance and the means were compared using the Tukey test at 5% probability of error for the variables evaluated in the shelf-life period, and regression for the other periods, fitting the equations to the data obtained, adopting as criterion for choosing the model the interaction by the F test significant at 5% probability, using the statistical program Sisvar® (Ferreira, 2011).

Results and Discussion

There was interaction among the factors temperature and storage days in both harvest seasons for the variables acidity, pH, brightness, hue angle, transverse diameter and mass loss. For the longitudinal diameter, there was interaction between the factors only in the first harvest period, while for the soluble solids content and the ratio, there was interaction only in the second period.

The acidity of the gherkin varied as a function of time and storage temperature for the two harvest seasons (Figure 1A and 1B). The values in fruits stored at temperatures of 0 and 10 °C remained close to those obtained at the harvest time, while at higher temperatures, corresponding to 20 and 30 °C, there was a significant tendency for the acidity to increase from the third day of storage. The highest values of 0.4 and 0.5% citric acid were obtained in fruits kept at 30 °C in both seasons, with increases in acidity of 140.5 and 127.3% at nine and twelve days in relation to the harvest period for the first and second seasons, respectively.

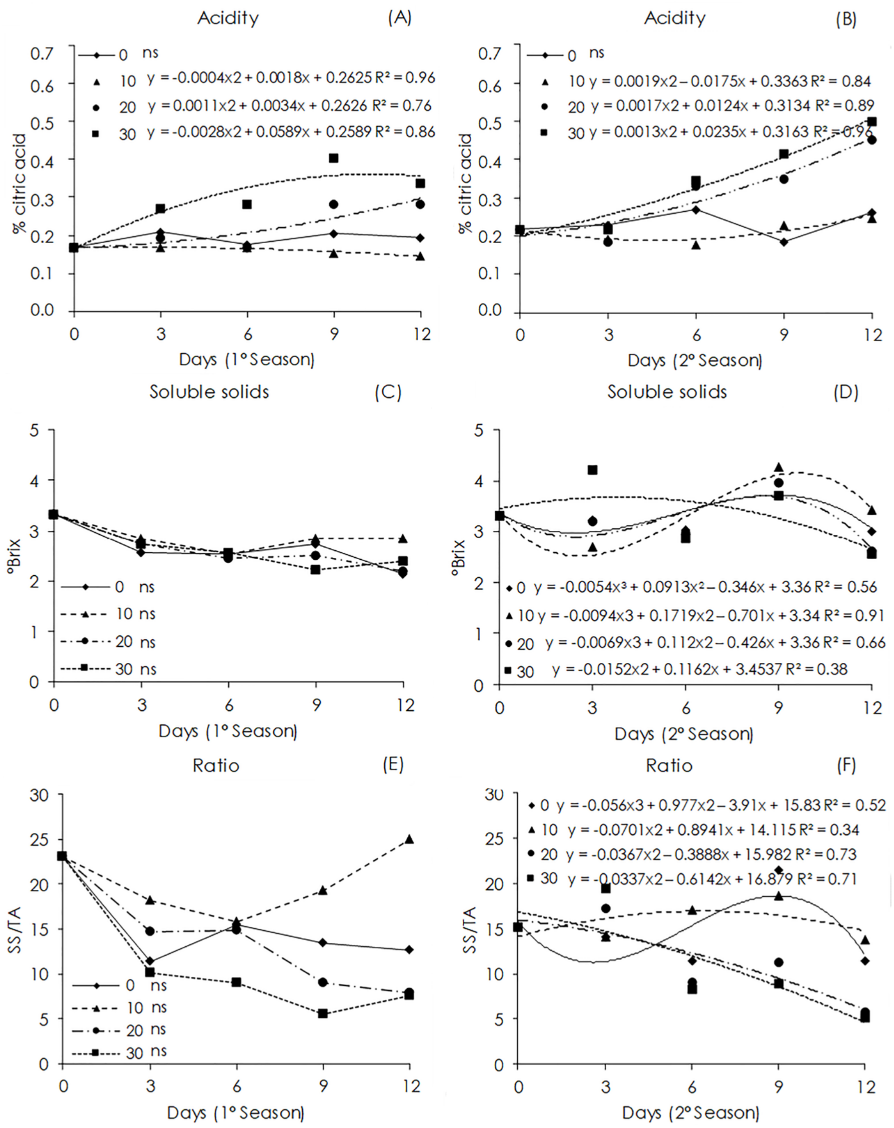


Figure 1. Quality of gherkin of the Do Norte cultivar during different storage periods and temperatures in two harvest seasons, Itaqui, RS, 2019.

The content of organic acids decreases with fruit ripening, due to the respiratory process or its conversion into sugars, although a small increase in the content of organic acids can be related to the increase in ripening (Chitarra & Chitarra, 2005). Furthermore, the increase in acidity due to the increase in storage temperature refers to the increase in the concentration of organic acids present in the cell juice, due to the greater loss of water observed under these conditions (Pinto et al., 2012). The values obtained justify this observation, and the fruits that presented higher acidity also presented a greater reduction in dimensions and fresh mass.

The soluble solids content was affected by the temperatures and storage periods only in the second season, with a quadratic trend for fruits stored at 30 °C, with maximum values at three days, 4.22 °Brix, and minimum at twelve days of storage, 2.56 °Brix, corresponding to a range of 60.7% in the contents during storage (Figure

1C and 1D). However, the other temperatures fitted the cubic polynomial regression, with a decreasing trend and minimum at three days and maximum at nine days, with subsequent decrease in the contents with the increase of the storage period.

The contents of soluble solids observed in this study are lower than those obtained by Silveira et al. (2015), who obtained values between 5.1 and 6.0 °Brix in gherkin stored for five days and found no effect of the use of propolis and corn starch in the conservation of fruits, since the increase of soluble solids indicates an increase in the degree of ripeness. The reduction of soluble solids during storage may be due to the consumption of sugars by the respiratory process of the fruits, and the respiratory rate is elevated as the temperature increases, leading to the acceleration of the speed of reactions, and consequently the increased consumption of sugars during the process (Morgado et al., 2015).

The ratio, which represents the balance between the content of sugars and acids in the fruits, presented significant differences only in the second season (Figure 1E and 1F). As the days of storage passed, there was a significant decrease in the ratio between soluble solids and acidity in fruits stored at 20 and 30 °C, due to the reduction of soluble solids and increase of acidity throughout storage.

Gherkin stored at 30 °C showed the greatest variation between storage periods, with ratios between 19.4 and 5.1, recorded at three and twelve days of storage, respectively, while the lowest variation was obtained in fruits stored at 10 °C, with ratios between 18.6 and 13.7, recorded at nine and twelve days, respectively. The maintenance of the ratio is desirable for obtaining and accepting fruits for consumption in natura, due to the physiological and biochemical changes that confer balance between aroma and flavor characters to the fruit during ripening (Oliveira et al., 2018).

As shown in Figures 2A and 2B, the pH values presented an inverse tendency to the acidity of the fruits, showing the highest levels in fruits stored at lower temperatures. The pH of the fruits stored in temperatures of 0 and 10 °C presented the highest values for the two seasons, with maximum increases of 9.1 and 18.4%, corresponding to a pH of 5.91 and 5.85, obtained at twelve days of storage for the first and second seasons, respectively. However, in fruits kept at 20 and 30 °C the values decreased throughout the storage period, obtaining the minimum values at twelve days at a temperature of 30 °C for both seasons, with a reduction of 22.4 and 15.4%, corresponding to a pH of 4.22 and 4.18, for the first and second seasons, respectively. The pH value of the fruits is very important when destined for processing, because values lower than 4.5 limit the development of microorganisms, while higher values demand a longer period of sterilization of the fruits in thermal processing, resulting in an increase in the expenditure of resources (Monteiro et al., 2008).

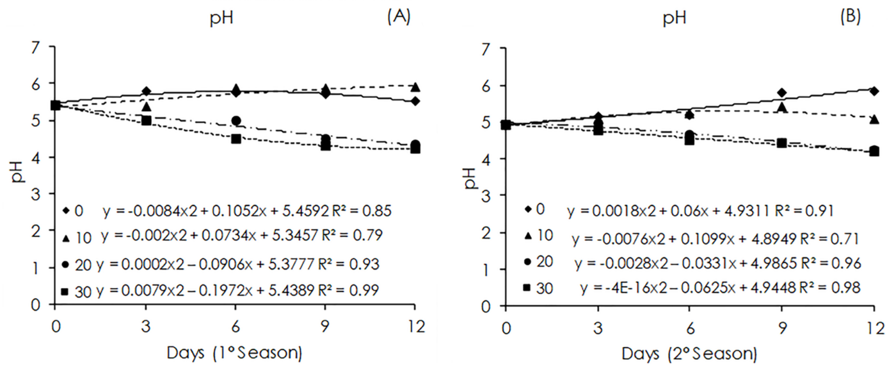


Figure 2. pH of gherkin of the Do Norte cultivar during different storage periods and temperatures in two harvest seasons, Itaqui, RS, 2019.

According to Sanches et al. (2017), the process of fruit senescence results in decreased acidity and increased pH, resulting from the metabolism of organic acids. However, due to the increasing increase in acidity throughout the period as the storage temperature increased, possibly caused by the higher water loss of the fruits, there was a decrease in pH levels according to the increase in temperature, even though there were characteristic changes of the senescence process in the epidermis of the fruits stored at the higher temperatures (Figure 2A and 2B).

Regarding the coloration of the epidermis of the gherkin, the luminosity and the hue angle showed a distinct trend between the temperatures throughout the periods considered in the two seasons evaluated (Figure 3). At 20 and 30 °C there was a quadratic and increasing trend for luminosity, with maximum values of 63.53 and 63.33 for the first and second seasons, respectively, and a decreasing trend for the hue angle, with minimum values of 114.62° and 106.42° for the first and second seasons, respectively. Fruits stored at 0 and 10 °C showed little variation at the end of twelve days for the hue angle, however, a decreasing trend of luminosity is noted since the beginning of storage, especially at 0 °C, with minimum values of 43.13 and 41.88 for the first and second seasons, respectively, which may be related to disturbances caused by mild temperatures in tropical fruits stored at low temperatures, especially by darkening of the epidermis.

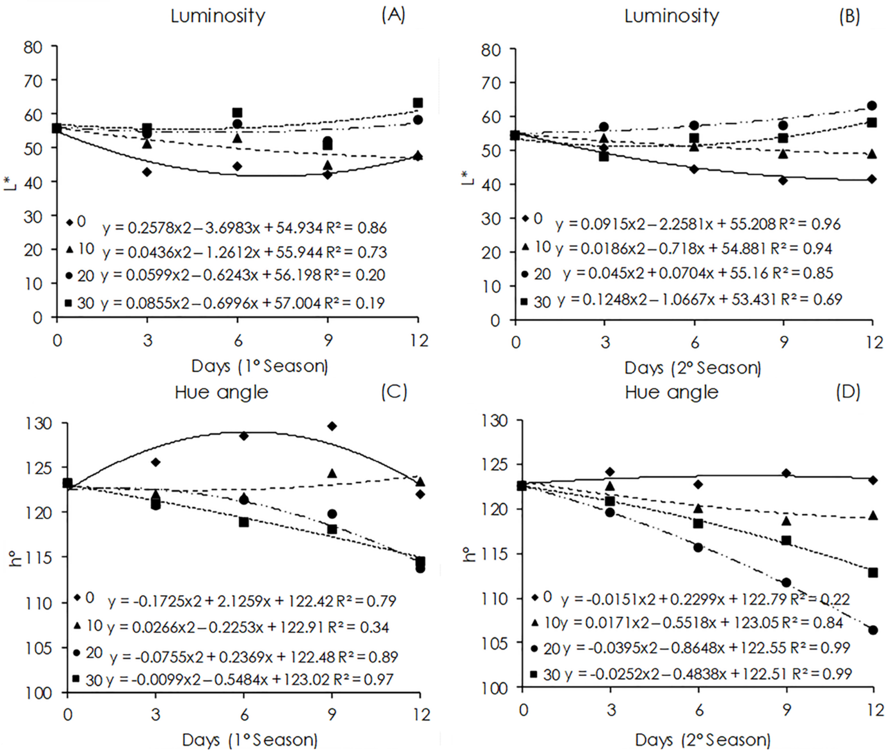


Figure 3. Color parameters of gherkin of the Do Norte cultivar stored during different periods and temperatures in two harvest seasons, Itaqui, RS, 2019.

The pigment responsible for the green color is chlorophyll, which is degraded with ripening, while there is synthesis of other pigments such as β-carotene, lycopene, xanthophyll and anthocyanin (Chitarra & Chitarra, 2005). However, tropical fruits show high sensitivity to mild temperatures, in short, close to 0 °C, which results in several physiological and biochemical changes, altering organoleptic and textural characteristics, notable mainly by the presence of internal degeneration, deterioration of flavor, incidence of rots, in addition to watery appearance and darkening of the epidermis (Quiroz-Gonzalez et al., 2017). These changes refer to the reduction of the conservation period in addition to the degradation of essential characteristics for the commercialization of the fruit.

The mass loss showed quadratic polynomial behavior for all temperatures and seasons throughout the storage period, and the losses were reduced as the temperature decreased (Figure 4A and 4B). Fruits stored at 30 °C had the greatest reduction in mass, being 23.5 and 23.7% for the first and second season, respectively. However, fruits stored at lower temperatures showed maximum mass losses at twelve days of 7.5 and 6.1%, corresponding to temperatures of 0 and 10 °C for the first and second seasons, respectively. The results can be attributed to increases in respiration and transpiration of the fruit resulting from metabolic changes caused by the loss of water from the fruit to the environment due to vapor pressure deficit, worsening as the temperature increases (Murmu & Mishra, 2016).

These results are lower than those obtained by Silveira et al. (2015), who, when evaluating the effect of preservation of gherkin coated with corn starch, obtained minimum mass losses of 30.29% at five days of storage at a temperature of 25 °C, and the addition of corn starch did not reduce mass loss. Santana et al. (2018) found that gherkin kept at room temperature showed mass loss of 80.8% at four days, and when kept for the same period stored at 4 °C, they showed mass loss of 32.9%. Mass loss is usually used as an indicator to determine the conservation period, and most fruits and vegetables become unsuitable for marketing if mass losses are too much higher than 5% (Youn et al., 2009), due to degradation of organoleptic properties and occurrence of wrinkling, undesirable parameters for storage and consumption.

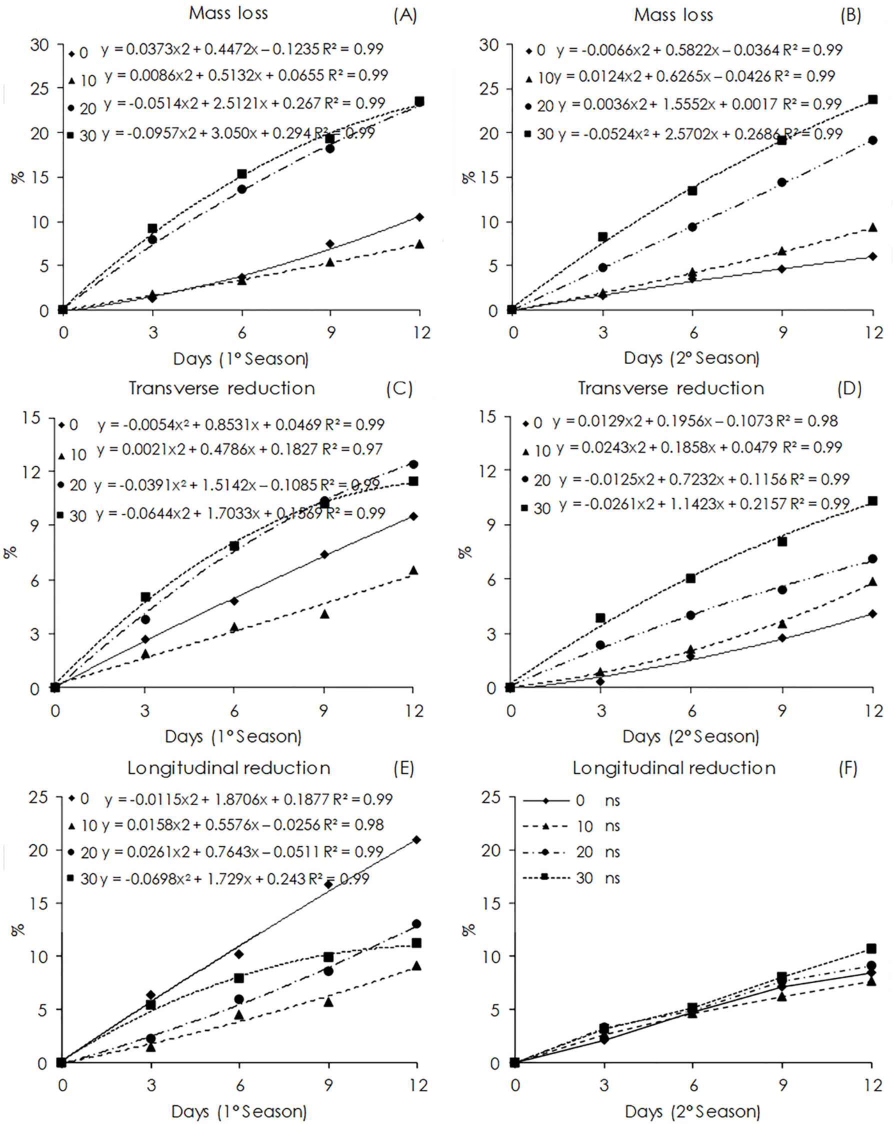
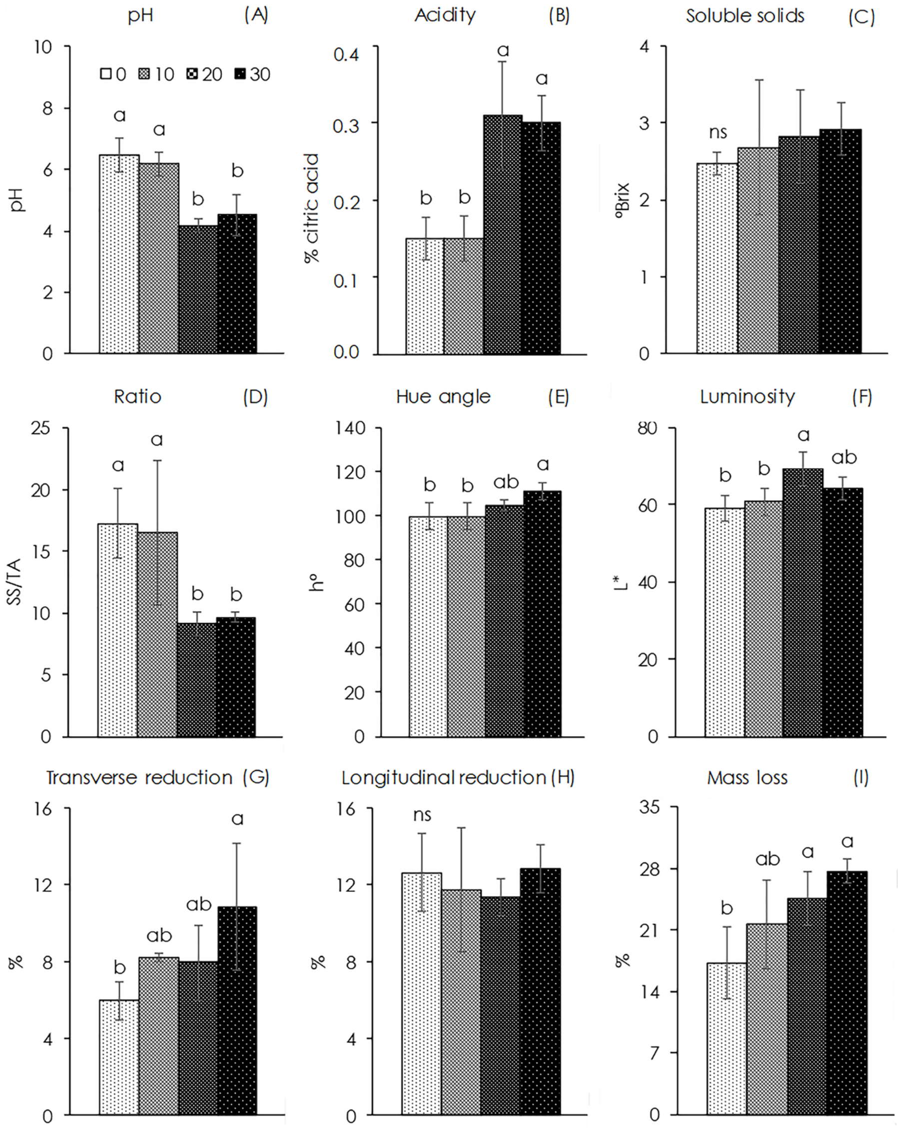


Figure 4. Mass loss and reduction of transverse and longitudinal diameters accumulated during different storage periods and temperatures of gherkin of the Do Norte cultivar at two harvest seasons, Itaqui, RS, 2019.

The reduction in transverse and longitudinal diameters showed similar behavior to the mass loss, showing an increasing and quadratic tendency throughout the storage period (Figures 4C, 4D, 4E and 4F). As the temperature and days of storage increased, the greater were the reductions in the transversal diameter, with fruits stored at 20 °C in the first season and at 30 °C in the second season presenting the greatest accumulated reductions, corresponding to 12.4 and 10.3%, respectively.

However, the greatest reductions in the longitudinal diameter of gherkin in the first season were related to the lowest storage temperature, with a maximum accumulated reduction of 20.9%, evidenced at 12 days of storage, although fruits stored at a temperature of 10 °C showed a reduction of 9.1%, characterized as the temperature that caused the smallest reduction in the longitudinal diameter (Figure 4E). However, there was no significant interaction between the factors evaluated for the longitudinal diameter in the second season, even though the fruits that presented the greatest reductions were those stored at the highest temperatures, thus the fruits stored at 30 °C presented a reduction of 10.7%, and the smallest reductions were evidenced in fruits stored at a temperature of 10 °C (Figure 4F). The reduction in fruit size is closely related to the loss of water by the fruit, because the greater the vapor pressure gradient between the fruit and the atmosphere, the greater the loss of water by the plant, reducing commercialization not only by the loss of fruit mass, but also by the incidence of wrinkling, loss of texture and wilting (Chitarra & Chitarra, 2005).

At the end of the storage period plus four days at a temperature of 20 °C and relative humidity of 90 ± 5%, the gherkin stored at temperatures of 0 and 10 °C showed the highest values of pH and ratio, and lowest values of citric acid, differing significantly from the other temperatures (Figure 5). However, the luminosity decreased as the temperature decreased, especially at 0 °C, which did not differ significantly from 10 and 30 °C, indicating that the occurrence of darkening of the epidermis is associated with disturbances caused by low temperatures during storage, although there was a tendency to yellowing according to the hue angle.



*Averages followed by the same lower-case letter do not differ among the different storage temperatures by Tukey's test at 5% probability. ns: non-significant difference

Figure 5. Physicochemical quality of gherkin of the Do Norte cultivar after twelve days of storage plus four days of shelf-life at 20 °C, Itaqui, RS, 2019.

The reduction in transverse diameter of the fruits was accentuated with the increase in storage temperatures, with the lowest values obtained in fruits stored at 0 °C, which did not differ significantly from the temperatures of 10 and 20 °C (Figure 5). Furthermore, the lowest losses of mass were provided by the milder temperatures, where the temperature of 0 °C did not differ significantly from 10 °C, even though there were considered increases in mass losses after storage in gherkin kept at low temperatures.

Campos et al. (2012) obtained similar results evaluating the conservation of guava (*Campomonesia adamantium*) stored at room temperature and under refrigerated conditions, using refrigeration at 11 °C for ten days followed by exposure of the fruits to room temperature. According to these authors, fruit shelf life was extended from six to thirteen days, although fruits exposed to room temperature after refrigerated storage showed significant growth in mass loss. Physical parameters such as color and mass, and chemical parameters, related to flavor, are generally considered by consumers when buying fresh and stored fruits, therefore, the conservation of fruit characteristics after storage is a key factor to reduce losses during marketing (Muhammad et al., 2011).

Conclusions

The gherkin of the Do Norte cultivar has good storage capacity when kept at a temperature of 10 °C for a period of twelve days regardless of the harvest time.

Storage at higher temperatures contributes to increased degradation reactions of organoleptic characteristics and reduction of fruit dimensions and mass, and storage at lower temperatures results in the occurrence of cold disturbances.

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