Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.65521

CC BY

Effect of cold storage on shelf life of sour passion fruit progenies

Valtânia Xavier NUNES[1], Luciana Domiciano Silva ROSADO[1], Fernanda Cristina Silva RIBEIRO[1], Fernando Luiz FINGER[1], Carlos Eduardo Magalhães dos SANTOS[1]*

Abstract

The present study aimed to evaluate the storage fruit potential of sour passion fruit progenies at temperatures of 7, 14 and 25 °C. The fruits were harvested at 30% yellow peel color, selected, sanitized and stored under refrigeration in chambers with relative humidity of 80% (± 5%) for a period of 12 days. The experiment was installed in a factorial scheme (3 × 3 × 4), with three progenies selected in the breeding program (P42, P45 and P49), three storage temperatures (7, 14 and 25 ° C) and four evaluation periods (0, 4, 8 and 12 days after storage). Analyzes of fruit mass, pulp mass, pericarp mass, pulp yield, pericarp thickness, water loss, soluble solids content, titratable acidity and ascorbic acid content were performed. There were significant differences among the studied progenies, P49 showed better traits than the other progenies, mainly regarding the resistance to water loss, the main trait that affects the quality of the fruits. Storage at 14 °C for twelve days is feasible to maintain the quality of sour passion fruit. The temperature of 7 °C inhibits the ripening of the fruits and promotes dehydration, confirming the non-recommendation of storage in this condition.

Keywords: breeding; chilling injury; *Passiflora edulis*; refrigeration.

Practical Application: The sour passion fruit can be stored for up to twelve days at a temperature of 14 °C.

1 Introduction

The sour passion fruit (*Passiflora edulis* Sims) is native to South America and widely cultivated in tropical and subtropical countries (Bernacci et al., 2008). In 2019, Brazil produced 593,429 t of fruit in a harvested area of 41,584 ha (Instituto Brasileiro de Geografia e Estatística, 2021). The benefits of consuming this fruit are reduction of glucose levels and metabolic control of diabetes mellitus in humans (Queiroz et al., 2012; Sousa et al., 2021), in addition to anti-inflammatory action (Silva et al., 2011).

The consumption of sour passion fruit has increased in recent years, due to consumer demand for fruit for the preparation of juice or by the processed juice industries, this increase in demand leads to an increase in marketing prices, attracting more and more producers to cultivate the fruit. However, in commercialization there are some limitations, with consumer preference for larger, sweet, low-acid and attractive-looking fruits (Abreu et al., 2009).

Sour passion fruit is classified as a climacteric fruit (Pongener et al., 2014), with high ethylene production at the beginning of ripening, reducing as senescence occurs, which causes rapid loss of water and reduced postharvest life (Winkler et al., 2002; Rinaldi et al., 2017). The water loss from the fruits during their commercialization promotes dehydration of the pericarp, and consequent withering, giving the fruits a wrinkled aspect, thus making them commercially devalued (Enamorado et al., 1995; Hertog et al., 2015). This, coupled with the lack of adequate technology for handling and conservation, causes great losses in the post-harvest quality of these fruits (Favorito et al., 2017).

In order to improve fruit conservation and extend the marketing period, many techniques can be used, such as refrigeration, coating with waxes or wrapping with plastic films, hydrothermal treatment, among others, and can be used in combination to enhance their effects (Arruda et al., 2011; Venâncio et al., 2013; Rotili et al., 2013; Rinaldi et al., 2017).

The extension of the shelf life of sour passion fruit may favor its commercialization, both in the Brazilian market, as well as the export of the fruit to countries in North America, Asia and Europe. One of the ways to enable this extension of the shelf life is storage at low temperature, as it is an efficient technology in maintaining quality and increasing the post-harvest life, reducing the metabolic activity of the fruits (Singh et al., 2014).

Controlling temperature and humidity are the most important factors for preserving fruit during storage (Wei et al., 2021). In general, low temperatures and high relative humidity reduce the respiratory rate, water loss and loss of fresh fruit mass (Siddiqui, 2015). The moisture loss by the transpiration process is the main reason for the fruit mass loss during storage, with respiration being a secondary factor (Kim et al., 2021; Lufu et al., 2021). Moisture loss basically occurs due to the epidermis permeability to water governed by a vapor concentration gradient between the fruit and the storage atmosphere (Xanthopoulos et al., 2017; Wei et al., 2021).

Refrigerated storage reduces the respiratory rate and fresh mass loss of fruits (Siddiqui, 2015), maintaining their organoleptic characteristics (Zhang et al., 2017). Therefore, the refrigeration

Received 16 Aug., 2021
Accepted 03 May, 2022
[1] *Department of Agronomy, Universidade Federal de Viçosa – UFV, Viçosa, MG, Brasil*
*Corresponding author: carlos.magalhaes@ufv.br

during postharvest storage is the most basic and efficient technique to extend the fruits shelf life (Lufu et al., 2021; Yugandhar et al., 2021). However, as tropical fruits are sensitive to cold, the management of post-harvest temperature requires attention because, at subcritical temperatures, the disturbance known as chilling injury will manifest itself, compromising the sensory quality of the product (Mustafa et al., 2016; Yugandhar et al., 2021).

Sour passion fruit fruits are sensitive to high temperatures, as it accelerates the rate of ripening and water loss, making them dry and unattractive. At the same time, as it is a tropical fruit, it is susceptible to damage by the cold action. A study by Arjona et al. (1992) shows a rapid deterioration of the external appearance and high loss of fresh mass at temperatures of 5 and 15 °C for sour passion fruit stored for 15 days, it is not advisable to store these fruits below 5 °C. In purple passion fruit, Maniwara et al. (2015) found that storage in a modified atmosphere with refrigeration (10 ± 1 °C) reduced water loss and delayed fruit wrinkling, allowing storage life extension up to 51 days.

For this reason, Strano et al. (2021) report the identification of the most suitable selections in the genetic breeding for storage at low temperature, that can be useful to obtain a high-quality product with an extended shelf life, and suggest the best cultivars to be planted. The passion fruit breeding programs in Brazil have selected cultivars with high productivity and good quality, with an increase in the length of the fruit storage period. In this sense, the objective of the study was to evaluate fruits behavior of sour passion fruit progenies at different temperatures of storage over 12 days.

2 Materials and methods

Fruits of three progenies of complete siblings of sour passion fruit from the Genetic Breeding Program of the Federal University of Viçosa, showed in Table 1, were harvested in the orchard of Department of Agronomy (Araponga, Brazil, 20°39’18”S, 42°31’18”W, about 885 m above mean sea level).

The fruits were harvested with 30% of the yellow peel color and still adhered to the mother plant. Subsequently, the sour passion fruits were sorted accordingly to their uniformity in size, color, and lack of defects (blemishes, lesions and/or rot symptoms). For experimental evaluation, the fruits were stored under refrigeration in cold chambers at 7 °C, 14 °C and 25 °C (± 1 °C) and relative humidity of 80% (± 5%) for a period of 12 days. Fruits storage in 25 °C to the 12 days were fully ripe with 100% yellow peel color.

At the beginning of the experiment, the fruit, pulp and pericarp mean mass was determined for each progeny, in a digital balance, with results expressed in grams (g); the fruit pericarp thickness by reading with a digital caliper in the median portion of the cut fruits in the equatorial region, with values expressed in millimeters (mm); and the fruit pulp yield percentage was also calculated using the ratio of the pulp mass (with seeds) to the fruit mass, with results expressed as percentage (%).

To determine fruits water loss, a batch of fruits was separated and weighed in a semi-analytical balance at the beginning of storage and at 4, 8 and 12 days, the results were obtained by the difference among the initial mass and the fruit mass each evaluation period, expressed as percentage (%).

In all evaluation periods (0, 4, 8 and 12 days), the pulp soluble solids content was obtained by means of a digital refractometer, analyzing the pulp juice of each fruit, with results expressed in °Brix; the titratable acidity, determined by titration with 0.2 N NaOH and 1% phenolphthalein as indicator, with results expressed in mg of citric acid per $100g^{-1}$ of juice; and the ascorbic acid content, determined by titration with 2.6 dichlorophenolindophenol (DFI), until a permanent light pink color is obtained, using 2g of the pulp diluted in 50 mL of 1% oxalic acid, with results expressed in mg of ascorbic acid per $100g^{-1}$.

The experiment was installed in a factorial scheme (3 × 3 × 4), with three progenies (P42, P45 and P49), three storage temperatures (7, 14 and 25 °C) and four evaluation periods (0, 4, 8 and 12 days). The design used was completely randomized, with 4 replications and 3 fruits per experimental unit, totaling 12 fruits per treatment, both in destructive analysis and fruits water loss. Linear model was used to explore the relationships between water loss and storage time in progenies stored at 7, 14 and 25 °C. The data were subjected to analysis of variance using the F test and the means were compared using the Tukey test at 5% probability, and analyzed by the GENES program (Cruz, 2013).

3 Results and discussion

There was significant variation among the progenies studied for the traits such as fruit mass, pericarp mass, pulp mass, pulp yield and pericarp thickness. Progeny 49 had higher averages for all traits evaluated compared to the other progenies (Table 2).

Table 1. Sour passion fruit progenies evaluated in the experiment.

Progenie	Ancestry*	
	Female parent (♀)	Male parent (♂)
P42	Mutant genotype with low photoperiod and temperature requirement (UFVM7.1)	Mutant genotype selected with resistant to the isolates of *F. oxysporum* f sp. passiflorae (UFVM54)
P45	Mutant genotype with low photoperiod and temperature requirement (UFVM7.1)	BRS SC1
P49	BRS SC1	Mutant genotype with low photoperiod requirement and temperature (UFV-M7.2)

*UFVM7.1 and UFVM7.2 – progenies selected, and UFVM 54 – elite progeny of the Passion Fruit Genetic Breeding Program at UFV; BRS SC1 – Commercial cultivar developed by Empresa Brasileira de Pesquisa Agropecuária.

Table 2. Mean values of mass (fruit, pulp and pericarp), pulp yield and pericarp thickness in the three progenies of sour passion fruit from the UFV Genetic Breeding Program.

Trait	Progenies			CV (%)*
	P42	P45	P49	
Fruit mass (g)	107.45b	127.13ab	153.17a	21.69
Pericarp mass (g)	60.37b	72.03b	93.59a	16.27
Pulp mass (g)	47.08b	55.09b	88.71a	40.31
Pulp yield (%)	42.26b	41.32b	53.01a	16.42
Pericarp thickness (mm)	4.60b	4.95b	6.73a	18.52

Mean followed by the same letter on the line do not differ by Tukey's test at 5% probability. *CV – coefficient of variation.

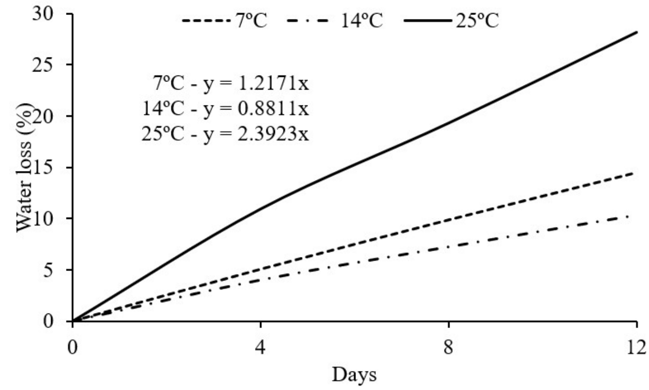

Figure 1. Water loss in fruits of sour passion fruit progenies stored at 7, 14 and 25 °C with RH 80% (± 5%) for up to 12 days.

These results show genetic variability among the studied progenies, being advantageous in the genetic breeding of sour passion fruit, because it provides genetic gains and selection of more promising progenies according to the purpose of the fruits.

The fruit mass presented values ranging from 107.45 to 153.17g, due to the fact that the progenies were still in selection phases in the breeding program, in addition to being originated from parents selected for low photoperiod and temperature requirements.

The preference of consumers when choosing fruits is generally for those of larger size and with attractive coloring, thus establishing certain patterns for commercialization by consumer markets. Thus, the consumer seeks to select larger fruits for greater juice yield.

Thus, analyzing the fruit pulp yield, it is observed that, P49 showed high pulp yield (53.01%), superior to the other progenies. Pereira et al. (2018) when evaluating the FB200 cultivar, found yield averages of 40.6%.

Krause et al. (2012) searching IAC 275, IAC 277, FB 100, FB 200, BRS SC1, BRS GA1 and BRS OV1 cultivars found fruit pulp (seeds with aril) yield values of 41.7%, 45.7%, 37.5%, 37.9%, 38.3%, 36.6% and 36.6%, respectively. Therefore, it appears that in the present study P49 demonstrates superiority regarding the other cultivars presented by the authors, previously, demonstrating that the selection practiced in the UFV breeding program has provided improvements in this trait, surpassing even the standard stipulated by the industry, around 40%.

In Figure 1, it can be seen that there was an increase in water loss from the fruits due to the temperatures and throughout the storage period. According to the estimated linear equations, based on the slope, the largest losses were obtained at a temperature of 25 °C, followed by 7 °C and 14 °C.

Passion fruit respiratory rate and fresh mass loss is high and its quality deteriorates rapidly after harvest (Li et al., 2020), especially at higher temperatures. The percentage of fresh mass loss of passion fruit stored at 14 °C was lower when compared to those stored at 25 °C. However, at the end of storage, curiously the fruits stored at 7 °C remained green and dehydrated. These results demonstrate that very low temperatures are not necessarily able to contain the dehydration process and fruits wilting, probably due to chilling injuries, as also reported in passion fruit by Diaz et al. (2012) and Arjona et al. (1992).

Passiflora setacea fruits stored at a temperature of 6 °C for 21 days observed the appearance of chilling injury (Rinaldi et al., 2017). Arjona et al. (1992) also found a rapid deterioration of the external appearance and high loss of fresh mass at a temperature of 5 °C for sour passion fruit stored for 15, 30 and 45 days. In papaya, also a tropical species, fruits stored below of 7 °C had their maturation inhibited and induce chilling injury (Zou et al., 2014).

The reduction of passion fruit water loss and wrinkling is important, as its commercialization is carried out by the fruit mass and external appearance. When analyzing the progenies in each evaluation period (Figure 2), we verified that there are differences among them, presenting the P49 lower water loss among the progenies evaluated for all temperatures, highlighting the water loss after 12 days of storage of 8.51% at 14 °C. Thus, breeding programs in their selection stages must incorporate the assessment of resistance to water loss, with the possibility of obtaining progenies with greater conservation capacity throughout the marketing period.

According to the Federação da Agricultura do Estado do Paraná (2020), passion fruit is considered to be wither from a fresh weight loss of 8% of its initial weight, as it impairs the appearance, depreciating its commercial value. Taking as a reference the water loss of 8%, only the fruits of P49 stored at 14 °C could be marketed until the 12th day.

As for the content of soluble solids, there were differences among the progenies regardless of the temperature in the initial evaluation period (Figure 3A), with superiority of P49. On the eighth day of storage (Figure 3C), progenies 42 and 49 interacted with storage temperatures, with P49 expressing its highest soluble solids content at 14 °C, while for P42 this occurs at 7 °C.

In general, the soluble solids content was not influenced by storage, remaining with little variation over the evaluation periods. Arruda et al. (2011), also did not observe the temperature and storage time effects on fruits of sour passion fruit.

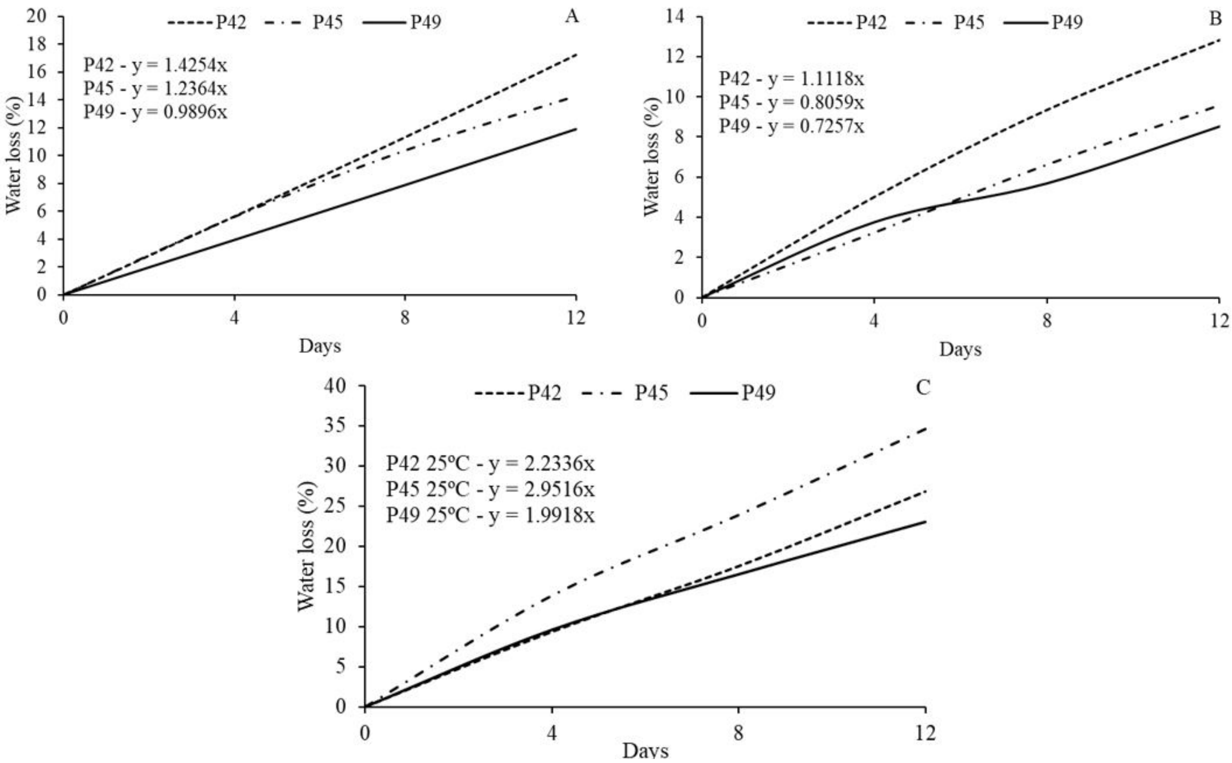

Figure 2. Water loss in fruits of three sour passion fruit progenies (P42, P45 and P49) stored at 7 (A), 14 (B) and 25 °C (C) with RH 80% (± 5%) for up to 12 days.

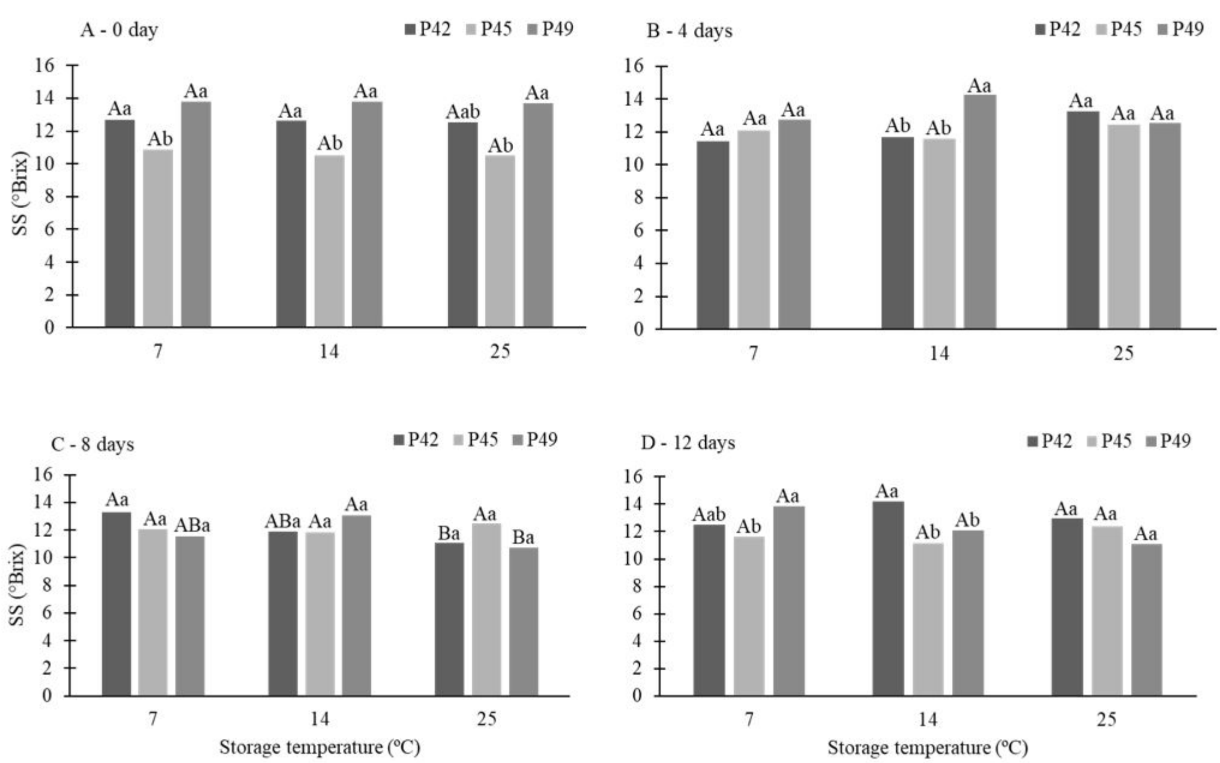

Figure 3. Soluble solids content (SS) in fruits of three sour passion fruit progenies stored at 7, 14 and 25 °C with RH 80% (± 5%) for up to 12 days. Upper case letters compare temperature within each progenies in each stored day, lowercase letters compare progenies within each temperature in each stored day. Means followed by the same letter are statistically equal according to Tukey test ($p \leq 0.05$).

At the end of the evaluation period (12th day – Figure 3D), the P42 progeny had a higher content of soluble solids (14.22 °Brix) compared to the others, at 14 °C. In the literature, the average values of soluble solids content vary considerably. Pereira et al. (2018) found mean values of 10.59 °Brix, while, Krause et al. (2012) found average values of soluble solids content for FB 200 cultivar of 13.9 °Brix. These differences in the soluble solids content reported in different studies with sour passion fruit are due to the variability of cultivation conditions and environment.

On 4th and 8th days of the storage, there was a reduction in the titratable acidity content due to temperature rise (Figure 4). On the eighth day of storage, the fruits stored at 7 °C showed higher titratable acidity contents, thus showing the temperature effect on the fruits metabolism reduction, and on the 12th day of storage there is no more difference among the progenies (Figure 4D). The reduction in acidity with the rise in temperature is due to organic acids degradation in the respiratory process of fruit ripening (Shahkoomahally & Ramezanian, 2015; Cha et al., 2019), thus, the passion fruit ripening process is supported by the organic acids consumption, since the fruit has no starch reserves.

The progenies showed different behavior in each storage temperature, on the 4th and 8th day of evaluation there were no significant differences among the progenies for the temperatures of 14 and 25 °C, however for the temperature of 7 °C there was a difference among the progenies on the 4th day, P49 showed a higher titratable acidity mean (Figure 4B).

Regarding the progenies titratable acidity content as a function of the evaluation periods, in general there was a decrease in the titratable acidity over time at all temperatures evaluated. The lowest acidity content was observed at 25 °C on the last evaluation day in all progenies (Figure 4D), which reflects the higher metabolic activity in the fruits with the increase in temperature and throughout the evaluation periods. Arruda et al. (2011) to assess the effect of chemicals and storage temperature on disease incidence in sour passion fruit, checked the ascorbic acid content reduction in higher temperatures due to increased metabolic activity.

As for the ascorbic acid content, there were significant differences among progenies in each storage temperature in the evaluation periods (Figure 5), with the exception of 12 days at 25 °C. At a temperature of 25 °C, evaluating the progenies in each evaluation period, it is observed that P42 had a higher ascorbic acid content in the periods of 0, 4 and 8 days, and equaling the other progenies at the end of storage (12th day).

Evaluating each progeny throughout the experimental period, a very different behavior is observed among them. The ascorbic acid content remained constant among temperatures over the experimental period for P42. While for P45, at 12 days, and P49, at 8 and 12 days, there are differences among

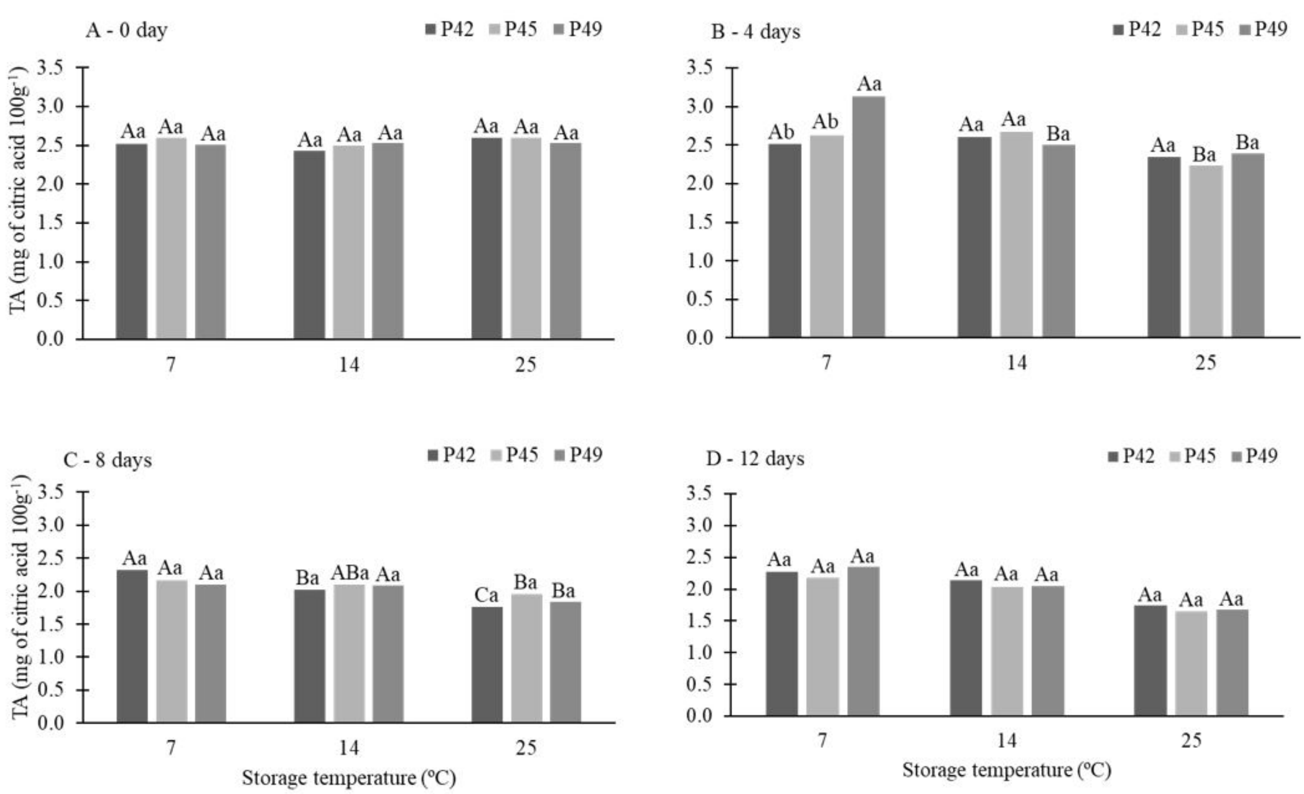

Figure 4. Titratable acidity (TA) in fruits of three sour passion fruit progenies stored at 7, 14 and 25 °C with RH 80% (± 5%) for up to 12 days. Upper case letters compare temperature within each progenies in each stored day, lowercase letters compare progenies within each temperature in each stored. Means followed by the same letter are statistically equal according to the Tukey test ($p \leq 0.05$).

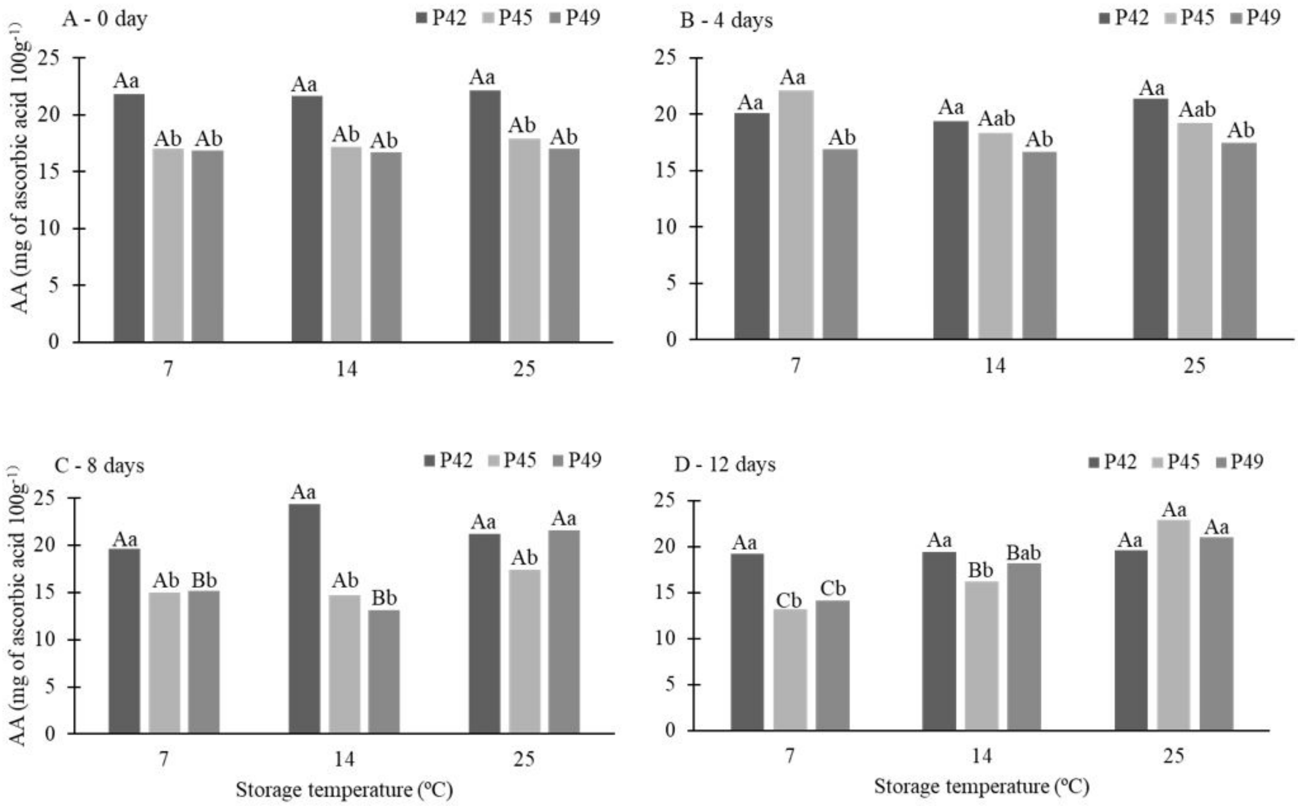

Figure 5. Ascorbic acid in fruits of three sour passion fruit stored at 7, 14 and 25 °C with RH 80% (± 5%) for up to 12 days. Upper case letters compare temperature within each progenies in each day of stored, lowercase letters compare progenies within each temperature in each stored day. Means followed by the same letter are statistically equal according to the Tukey test ($p \leq 0.05$).

temperatures, with higher levels at 25 °C. Among the progenies at the evaluated temperatures, P42 superiority was observed in the storage periods.

At 25 °C, there is degradation of the ascorbic acid content over the storage periods for P42, while for P45 and P49 an irregular behavior was observed, with elevation at 8 and 12 days. Rotili et al. (2013) when evaluating the chemical characteristics of sour passion fruit packed or not in PVC film and stored at 5 °C, observed a significant increase in the ascorbic acid content until the 20th day of storage, followed by a decrease until the 40th day. In a study by Arruda et al. (2011) in order to assess the effect of chemicals and storage temperatures on the incidence of disease, the ascorbic acid content was influenced by the storage period, with a reduction of approximately 10% after 10 days.

In acerola fruit harvested at different stages of maturation and stored refrigerated, the 'Flor Branca' cultivar showed a reduction in the ascorbic acid content at 8 °C regarding higher storage temperatures (10 and 12 °C) at 14 days of evaluation (Ribeiro & Freitas, 2020). Nunes et al. (1998) showed that inhibiting water loss by wrapping strawberries with PVC film reduced ascorbic acid degradation, reported to be more important that temperature control. Thus, variations in results may be due to numerous factors, such as: genetic influences, fruit size, maturity, cultivation conditions and environment.

The present study indicates the importance of characterizing the postharvest behavior of passion fruit progenies, reflecting that the breeding programs should not only select for fruits quality, and should consider conservation, especially if they are subjected to long periods of storage for reach distant consumers market.

4 Conclusions

1. P49 progeny show better aptitude for cold storage, especially regarding the resistance to water loss during postharvest storage;
2. Storage at 14 °C for twelve days provides less water loss of sour passion fruit;
3. Temperature of 7 °C inhibit the fruits ripening and promote dehydrated, the storage of sour passion fruits in this condition is not recommend.

Acknowledgements

The authors are grateful to the National Council for Scientific and Technological Development (CNPq, Brazil) for granting a scholarship to the first author, the Coordination of Improvement of Higher Level Personnel (CAPES, Brazil) – Finance code 001, for the financial support granted to carry out the research and the Foundation for Research Support of the State of Minas Gerais (FAPEMIG, Brazil) for financial support APQ-02286-16.

References

Abreu, S. P. M., Peixoto, J. R., Junqueira, N. T. V., & Sousa, M. A. F. (2009). Características físico-químicas de cinco genótipos de maracujazeiro-azedo cultivados no Distrito Federal. *Revista Brasileira de Fruticultura*, 31(2), 487-491. http://dx.doi.org/10.1590/S0100-29452009000200024.

Arjona, H. E., Matta, F. B., & Garner, J. O. (1992). Temperature and storage time affect quality of yellow passion fruit. *HortScience*, 27(7), 809-810. http://dx.doi.org/10.21273/HORTSCI.27.7.809.

Arruda, M. C., Fischer, O. H., Jeronimo, E. M., Zanette, M. M., & Silva, B. L. (2011). Efeito de produtos químicos e temperaturas de armazenamento na pós-colheita de maracujá-amarelo. *Semina: Ciências Agrárias*, 32(1), 201-208. http://dx.doi.org/10.5433/1679-0359.2011v32n1p201.

Bernacci, L. C., Soares-Scott, M. D., Junqueira, N. T. V., Passos, I. R. S., & Meletti, L. M. M. (2008). Passiflora edulis Sims: the correct taxonomic way to cite the yellow passion fruit (and of others colors). *Revista Brasileira de Fruticultura*, 30(2), 566-576. http://dx.doi.org/10.1590/S0100-29452008000200053.

Cha, G. H., Kumarihami, H. M. P. C., Kim, H. L., Kwack, Y. B., & Kim, J. G. (2019). Storage temperature influences fruit ripening and changes in organic acids of kiwifruit treated with exogenous ethylene. *Horticultural Science & Technology*, 37(5), 618-629.

Cruz, C. D. (2013). Programa Genes: aplicativo computacional em genética e estatística. *Acta Scientiarum*, 35(3), 271-276.

Diaz, R. O., Moreno, L., Pinilla, R., Carrillo, W., Melgarejo, L. M., & Martines, O. (2012). Postharvest behavior of purple passion fruit in xtend® bags during low temperature storage. *Acta Horticulturae*, 934, 727-731.

Enamorado, H. E. P., Finger, F. L., Barros, R. S., & Pushmann, R. (1995). Development and ripening of yellow passion fruit. *Journal of Horticultural Science*, 70(4), 573-576. http://dx.doi.org/10.1080/14620316.1995.11515329.

Favorito, P. A., Villa, F., Taffarel, L. E., & Rotili, M. C. C. (2017). Qualidade e conservação pós-colheita de frutos de maracujá-amarelo sob armazenamento. *Scientia Agrária Paranaensis*, 16(4), 449-453.

Federação da Agricultura do Estado do Paraná – FAEP. (2020). *Classificação do maracujá-amarelo.* Retrieved from http://www.faep.com.br/comissoes/frutas/cartilhas/frutas/maracuja.html

Hertog, M. L. A. T. M., Vollebregt, M., Unzueta, I., Hoofman, R. J. O. M., & Lammertyn, J. (2015). From sensor output to improved product quality. *Acta Horticulturae*, (1091), 165-173. http://dx.doi.org/10.17660/ActaHortic.2015.1091.20.

Instituto Brasileiro de Geografia e Estatística – IBGE. (2021). *Produção agrícola municipal.* Retrieved from https://sidra.ibge.gov.br/tabela/1613

Kim, M., Kang, S. B., Yun, S. K., Kim, S. S., Joa, J., & Park, Y. (2021). Influence of excessively high temperatures on the fruit growth and physicochemical properties of shiranuhi mandarin in plastic-film greenhouse cultivation. *Plants (Basel)*, 10(8), 1525. http://dx.doi.org/10.3390/plants10081525. PMid:34451570.

Krause, W., Neves, L. G., Viana, A. P., Araújo, C. A. T., & Faleiro, F. G. (2012). Produtividade e qualidade de frutos de cultivares de maracujazeiro-amarelo com ou sem polinização artificial. *Pesquisa Agropecuária Brasileira*, 47(12), 1737-1742. http://dx.doi.org/10.1590/S0100-204X2012001200009.

Li, C., Xin, M., Li, L., He, X., Liu, G., Li, J., Sheng, J., & Sun, J. (2020). Transcriptome profiling helps to elucidate the mechanisms of ripening and epidermal senescence in passion fruit (*Passiflora edulis* Sims). *PLoS One*, 15(9), e0236535. http://dx.doi.org/10.1371/journal.pone.0236535. PMid:32976483.

Lufu, R., Ambaw, A., & Opara, U. L. (2021). The influence of internal packaging (Liners) on moisture dynamics and physical and physiological quality of pomegranate fruit during cold storage. *Foods*, 10(6), 1388. http://dx.doi.org/10.3390/foods10061388. PMid:34208467.

Maniwara, P., Boonyakiat, D., Poonlarp, P. B., Natwichai, J., & Nakano, K. (2015). Changes of postharvest quality in passion fruit (*Passiflora edulis* Sims) under modified atmosphere packaging conditions. *International Food Research Journal*, 22(4), 1596-1606.

Mustafa, M. A., Ali, A., Seymour, G., & Tucker, G. (2016). Enhancing the antioxidant content of carambola (*Averrhoa carambola*) during cold storage and methyl jasmonate treatments. *Postharvest Biology and Technology*, 118, 79-86. http://dx.doi.org/10.1016/j.postharvbio.2016.03.021.

Nunes, M. C. N., Brecht, J. K., Morais, A. M. M. B., & Sargent, S. A. (1998). Controlling temperature and water loss to maintain ascorbic acid levels in strawberries during postharvest handling. *Journal of Food Science*, 63(6), 1033-1036.

Pereira, L. D., Valle, K. D., Souza, L. K. F., Assunção, H. F., Bolina, C. C., Reis, E. F., Salazar, A. H., & Silva, D. F. P. (2018). Caracterização de frutos de diferentes espécies de maracujazeiro. *Revista Brasileira de Agropecuária Sustentável*, 8(2), 21-28. http://dx.doi.org/10.21206/rbas.v8i2.502.

Pongener, A., Sagar, V., Pal, R. K., Asrey, R., Sharma, R. R., & Singh, S. K. (2014). Physiological and quality changes during postharvest ripening of purple passion fruit (*Passiflora edulis* Sims). *Fruits*, 69(1), 19-30. http://dx.doi.org/10.1051/fruits/2013097.

Queiroz, M. S. R., Janebro, D. I., Cunha, M. A. L., Medeiros, J. S., Sabaa-Srur, A. U. O., Diniz, M. F. F. M., & Santos, S. C. (2012). Effect of the yellow passion fruit peel flour (*Passiflora edulis* f. *flavicarpa* deg.) in insulin sensitivity in type 2 diabetes mellitus patients. *Nutrition Journal*, 11(1), 89. http://dx.doi.org/10.1186/1475-2891-11-89. PMid:23088514.

Ribeiro, B. S., & Freitas, S. T. (2020). Maturity stage at harvest and storage temperature to maintain postharvest quality of acerola fruit. *Scientia Horticulturae*, 260, 1-11. http://dx.doi.org/10.1016/j.scienta.2019.108901.

Rinaldi, M. M., Costa, A. M., Faleiro, F. G., & Junqueira, N. T. V. (2017). Conservação pós-colheita de frutos de *Passiflora setacea* DC. submetidos a diferentes sanitizantes e temperaturas de armazenamento. *Brazilian Journal of Food Technology*, 20(0), 1-12. http://dx.doi.org/10.1590/1981-6723.4616.

Rotili, M. C., Vorpagel, J. A., Braga, G. C., Kuhn, O. J., & Salibe, A. B. (2013). Atividade antioxidante, composição química e conservação de maracujá-amarelo embalado com filme de PVC. *Revista Brasileira de Fruticultura*, 35(4), 942-952. http://dx.doi.org/10.1590/S0100-29452013000400004.

Shahkoomahally, S., & Ramezanian, A. (2015). Changes in physico-chemical properties related to quality of kiwifruit (*Actinidia deliciosa* cv. Hayward) during cold storage. *International Journal of Fruit Science*, 15(2), 187-197. http://dx.doi.org/10.1080/15538362.2015.1017423.

Siddiqui, M. W. (2015). *Postharvest biology and technology of horticultural crops: principles and practices for quality maintenance* (1st ed.). Boca Raton: CRC Press.

Silva, D. C., Freitas, A. L. P., Pessoa, C. D. S., Paula, R. C. M., Mesquita, J. X., Leal, L. K. A. M., Brito, G. A. C., Goncalves, D. O., & Viana, G. S. B. (2011). Pectin from *Passiflora edulis* shows anti-inflammatory action as well as hypoglycemic and hypotriglyceridemic properties in diabetic rats. *Journal of Medicinal Food*, 14(10), 1118-1126. http://dx.doi.org/10.1089/jmf.2010.0220. PMid:21554121.

Singh, V., Hedayetullah, M., Zaman, P., & Meher, J. (2014). Postharvest technology of fruits and vegetables: An Overview. *Journal of Postharvest Technology*, 2(2), 124-135.

Sousa, D. F., Araújo, M. F. M., Mello, V. D., Damasceno, M. M. C., & Freitas, R. W. J. F. (2021). Cost-effectiveness of passion fruit albedo versus turmeric in the glycemic and lipaemic control of people with type 2 diabetes: randomized clinical trial. *Journal of the American College of Nutrition*, 40(8), 679-688. PMid:33141635.

Strano, M. C., Di Silvestro, S., Allegra, M., Russo, G., & Caruso, M. (2021). Effect of cold storage on the postharvest quality of different Tarocco sweet orange clonal selections. *Scientia Horticulturae*, 285, 1-7. http://dx.doi.org/10.1016/j.scienta.2021.110167.

Venâncio, J. B., Silveira, M. V., Fehlauer, T. V., Pegorare, A. B., Rodrigues, E. T., & Araújo, W. F. (2013). Tratamento hidrotérmico e cloreto de cálcio na pós-colheita de maracujá-amarelo. *Científica*, 41(2), 122-129.

Wei, S., Mei, J., & Xie, J. (2021). Effects of edible coating and modified atmosphere technology on the physiology and quality of mangoes after low-temperature transportation at 13 °C in vibration mitigation packaging. *Plants (Basel)*, 10(11), 2432. http://dx.doi.org/10.3390/plants10112432. PMid:34834795.

Winkler, L. M., Quoirin, M., Ayub, R., Rombaldi, C., & Silva, J. (2002). Produção de etileno e atividade da enzima ACCoxidase em frutos de maracujá-amarelo (*Passiflora edulis* f. *flavicarpa* Deg.). *Revista Brasileira de Fruticultura*, 24(3), 634-636. http://dx.doi.org/10.1590/S0100-29452002000300014.

Xanthopoulos, G. T., Templalexis, C. G., Aleiferis, N. P., & Lentzou, D. I. (2017). The contribution of transpiration and respiration in water loss of perishable agricultural products: The case of pears. *Biosystems Engineering*, 158, 76-85. http://dx.doi.org/10.1016/j.biosystemseng.2017.03.011.

Yugandhar, G., Bhagwan, A., Kiran, K. A., & Cheena, J. (2021). Different bio-chemical changes at low temperature storage on chilling injury and storage life of commercial cultivars of mango *Mangifera indica* L. *International Journal of Chemical Studies*, 9(1), 2872-2876. http://dx.doi.org/10.22271/chemi.2021.v9.i1an.11668.

Zhang, Z. K., Zhu, Q. G., Hu, M. J., Gao, Z. Y., An, F., Li, M., & Jiang, Y. M. (2017). Low-temperature conditioning induces chilling tolerance in stored mango fruit. *Food Chemistry*, 219, 76-84. http://dx.doi.org/10.1016/j.foodchem.2016.09.123. PMid:27765262.

Zou, Y., Zhang, L., Rao, S., Zhu, X., Ye, L., Chen, W., & Li, X. (2014). The relationship between the expression of ethylene-related genes and papaya fruit ripening disorder caused by chilling injury. *PLoS One*, 9(12), e116002. http://dx.doi.org/10.1371/journal.pone.0116002. PMid:25542021.