

## Postharvest Quality of Three Tomato Cultivars

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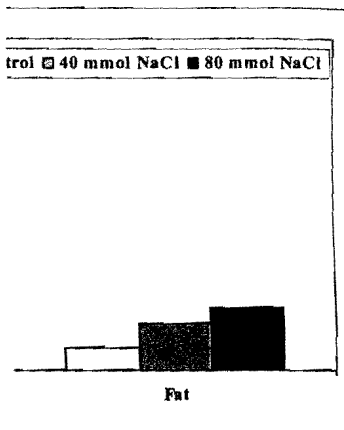
**Keywords:** long shelf life, firmness, glucose, fructose, flavour, 'Daniela'

### Abstract

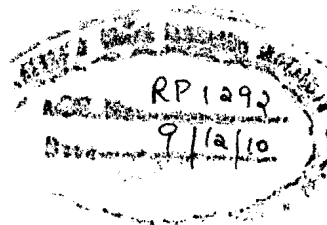
During the post-harvest life many biochemical changes occur affecting quality. These changes are due to many factors including the cultivar. In tomato, there are marked differences among cultivars regarding the duration of their post-harvest life. "Long Shelf Life" cultivars are characterized by a high firmness throughout the post-harvest period, but their organoleptic characteristics are not optimal. The aim of this study was to characterize changes in various parameters of fruit quality in three tomato cultivars. The experiment was conducted in a greenhouse (5,000 m<sup>2</sup>) during 2006-2007 in Southeast Spain. Fruits of cvs. Daniela, Rambo and Genma were harvested at turning stage. They were selected in homogeneous lots and an initial analysis was performed on 20 fruits per cultivar to assess fruit quality. The fruits were conserved at 12°C (±1°C) and 90% relative humidity. Every 7 days a batch of 20 fruits per cultivar was analyzed to determine refractive index (RI), firmness and glucose and fructose contents. At the same interval, another batch of 20 fruits was maintained at 20°C for 48 h to simulate conditions for marketing, after which their quality parameters were analyzed. At the time of harvest no differences were found for firmness, while R.I., glucose and fructose content were higher for cv. Rambo. The fruits of 'Daniela' were firmer than the rest and had a longer post-harvest life. 'Daniela' is a long life cultivar, which softens slowly. The soluble solids content declined gradually over the days of conservation. 'Daniela' fruit had a lower R.I., a sign of its low organoleptic quality and flavour. This gradual decline of R.I. during cold storage is normal and in principle is attributed to the phenomenon of respiration contributing to the consumption of sugar, the main component of this quality parameter. However, no significant differences were found among glucose and fructose contents during storage.

### INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most widely consumed fresh vegetables in the world. Tomato fruit quality has been assessed by analysis of parameters, such as colour, firmness, °Brix, acidity, sugars contents, etc. (Hernández-Suárez et al., 2008). All of these parameters contribute to tomato quality, although the decision of consumers in their first purchase is determined primarily by the external appearance of the product. The frequency and magnitude of the following purchases depend largely on the impression of taste quality (flavour, texture, soluble solids content). The best quality is achieved when tomato is ripe, but as such it is much more perishable and susceptible to mechanical damage during transportation and marketing. Tomato quality also depends on its chemical composition and maturity at harvest (Ferreira et al., 2005). This harvested tomatoes at green mature stage present lower soluble solids content and lower concentrations of lycopene and carotenoids. On the other hand, their chemical composition also depends on the variety (Gajc-Wolska et al., 2000; Valenzuela, 2002). Many investigators have reported that at mature-green stage tomatoes taste less sweet and



Plants growing under NaCl-salt stress in



have less vitamin C than the ones red ripe stage (Al-Mugharabi, 1994).

The usual practice in the horticultural chain is to harvest tomatoes when they reach the "breaker stage" and transport them refrigerated at the lowest temperature that will not induce damage. This practice may result in that tomatoes do not develop good colour, though they do maintain high firmness until the time of consumption. On the other hand, when tomatoes are transported over long distances or stored for a long time in shops, the firmness decreases and the fruits become soft.

The cold storage of tomatoes at temperatures below 10-12°C for a long time causes the appearance of chilling injury, whose symptoms range from the emergence of pitting and changes during the later ripening at room temperature to a higher incidence of rot, especially *Alternaria* (Valero and Valenzuela, 2003; Safdar et al., 2008). This chilling injury is an economically important postharvest problem that reduces the overall quality and marketability of the fruits. The effect of storage temperature on chilling induced quality changes in tomatoes varies with cultivar, duration of storage and ripeness of the fruits (Linares, 1996). In order to avoid the negative effects of low temperatures on tomatoes, some authors have noted that a period of warmth before cold storage can be beneficial. For example, Lurie and Klein (1992) observed that warming tomatoes to 38°C for three days before storage at 2°C for three weeks produces normal maturation without chilling injury, even after the fruits were stored for 5 days at 20°C. In this way, longer periods of storage were possible. In any case, it should be noted that the changes that may occur in the chemical composition, texture and flavour as well as susceptibility to damage during conservation depend largely on the tomato cultivar.

The damage caused by cold worsens when the fruit is ready for shelving in stores, but it is not visually apparent until 24 or 48 h later. This represents a challenge in the cold storage of tomato, which shall be taken into account. It is, therefore, of interest to study the changes in tomato fruits when they are placed at room temperature after a period of cold (López, 1999; Castaño, 2001). The aim of this study was to characterize changes in various parameters of fruits quality in three tomato cultivars after cold storage and 48 h storage at room temperature.

## MATERIALS AND METHODS

The experiment was conducted in a greenhouse (5,000 m<sup>2</sup>) in 2006-2007 in Southeast Spain. Fruits of cultivars Daniela, Rambo and Genma at turning stage were harvested, selected in homogeneous lots and an initial analysis was performed on 20 fruits per cultivar to assess fruit quality. The fruits were conserved at 12°C (±1°C) and 90% relative humidity. Every 7 days a batch of 20 fruits per cultivar was analyzed to determine refractive index (R.I.), firmness and glucose and fructose contents. At the same interval another batch of 20 fruits was maintained at 20°C for 48 h to simulate conditions for marketing, after which their quality parameters were analyzed. The cultivar Daniela was cold stored for three weeks, while the other two cultivars ('Genma' and 'Rambo') remained in cold storage two weeks because of their shorter post-harvest life.

RI was determined using an Atago digital refractometer and expressed as °Brix. Firmness was measured using a texture analyzer (TA-XT2 PLUS, Stable MicroSystems, Godalming, UK) as follows: the equatorial zone of the fruit was punctured in three regions with a 2 mm Ø probe. The fruit was punctured in the locular cavity and not on the septum. The probe speed before, during and after the test was of 10 mm s<sup>-1</sup> and the maximum peak of force was reached and expressed in kg. The sugars content was determined in the fruit juice. This juice was clarified with 5 ml Carrez reagent, then diluted 100 times and analyzed for glucose and fructose with an enzyme kit (Boehringer Mannheim).

## RESULTS AND DISCUSSION

Figure 1 shows the content of soluble solids (RI) of tomato fruits. At harvest time (day 0) 'Daniela' presented the lowest RI value while 'Genma' and 'Rambo' showed high ones of 6 °Brix or more. These values are similar to those found by other authors

(Ferreira, 2005) and show that 'Daniela' is quality.

During storage the RI for 'Daniela' fell as no significant differences were found for 'Genma' and 'Rambo' was different. 'Genma' week of conservation, but at 14 days this reaching values similar to those of 'Daniela' behaviour. The RI value was not only high, but

Figure 2 shows the behavior of RI when 48 h after cold storage. The RI values are similar to Figure 1. The greatest values of RI breakdown phenomena that occur during post-1993; Del Río et al., 1994). Texture is another firmness is one of the major textural characteristics eating quality. Tomato fruits continued softer softening was considerable during the first 'Rambo'. No softening was observed in 'Daniela'; the firmness dropped sharply. 'Rambo' showed firmness when the fruits are kept at room temperature. Naturally firmness was lower in all cultivars, experiment. It should be noted that there was a difference between 'Daniela' and 'Rambo' for firmness. It seems that 'Daniela' is quality after cold storage.

Fruit softening during ripening has been modifications that occur during ripening, the most important of the essential factors which affect fruit quality. 'Daniela' tomato is considered a long shelf life fruit, but it could increase the acceptability of the fruit, but also low, which has a negative effect on overall quality.

Figures 5 and 6 show the contents of carbohydrates. The contents of these carbohydrates in 'Genma', but lower than ones for 'Daniela'. Carbohydrate content in tomato fruits ranged from 10 to 15% in composition charts. These values are higher than glucose plus fructose, because we did not find similar to those of Loiudice et al. (1995): fructose similar value to glucose. However, the contents were lower than ones for the other two cultivars than glucose content. No differences were found except for fructose content in 'Genma' at harvest time. The contents of glucose and fructose were similar to those of Loiudice et al. (1995). It should be noted that there were differences between cultivars in the content of these carbohydrates we found after cold storage.

## CONCLUSION

Our data indicate that Rambo cultivar is higher and less affected by the storage. It is considered a cultivar which softens slowly.

## ACKNOWLEDGEMENTS

We thank Ms. Carmen Fernández for her assistance in the laboratory and Andrew T. for his original manuscript.

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quality.

During storage the RI for 'Daniela' fell after seven days and then remained stable  
as no significant differences were found for this parameter. The behaviour of RI for  
'Genma' and 'Rambo' was different. 'Genma' maintained a high RI value during the first  
week of conservation, but at 14 days this value dropped sharply by nearly 1 °Brix  
reaching values similar to those of 'Daniela'. 'Rambo' was the cultivar that had the best  
behaviour. The RI value was not only high, but also remained stable throughout storage.

Figure 2 shows the behavior of RI when the fruits are kept at room temperature for  
48 h after cold storage. The RI values are greater; all three cultivars follow a pattern  
similar to Figure 1. The greatest values of RI recorded at room temperature may be due to  
breakdown phenomena that occur during postharvest at high temperatures (Young et al.,  
1993; Del Río et al., 1994). Texture is another important quality index in tomato. Flesh  
firmness is one of the major textural characteristics of tomato and has a great effect on  
eating quality. Tomato fruits continued softening after harvest as shown in Figure 3. The  
softening was considerable during the first 2 weeks of cold storage for 'Genma' and  
'Rambo'. No softening was observed in 'Daniela' over the first 14 days, but after 21 days  
the firmness dropped sharply. 'Rambo' showed the lowest firmness. Figure 4 shows the  
firmness when the fruits are kept at room temperature for 48 h after cold storage.  
Naturally firmness was lower in all cultivars, but 'Daniela' remained firm throughout the  
experiment. It should be noted that there was no significant difference among 'Genma'  
and 'Rambo' for firmness. It seems that 'Genma' behaved worse when kept at room  
temperature after cold storage.

Fruit softening during ripening has been extensively studied. Among physiological  
modifications that occur during ripening, the solubility of pectic substances is regarded as  
one of the essential factors which affect fruit texture (Chayb, 2007; Chen et al., 2008).  
'Daniela' tomato is considered a long shelf life cultivar as it softens slowly. This feature  
could increase the acceptability of the fruit, but its RI is so low that sweetness and flavor  
are also low, which has a negative effect on overall quality.

Figures 5 and 6 show the contents of glucose and fructose in the fruits of studied  
cultivars. The contents of these carbohydrates were similar to that for 'Rambo' and  
'Genma', but lower than ones for 'Daniela'. Moreiras et al. (2005) found that the  
carbohydrate content in tomato fruits ranged between 3 and 3.5% according to the food  
composition charts. These values are higher than ones reported in the present study for  
glucose plus fructose, because we did not quantify other carbohydrates. Our data are  
similar to those of Louidice et al. (1995): fructose was the most abundant sugar but with a  
similar value to glucose. However, the contents of glucose and fructose for 'Daniela'  
were lower than ones for the other two cultivars, but 'Daniela' showed a higher fructose  
than glucose content. No differences were found for these parameters during cold storage,  
except for fructose content in 'Genma' at harvest, which was significantly lower. When  
the contents of glucose and fructose were analyzed in fruits that had been at room  
temperature for 48 h after the cold period (Figs. 7 and 8), the only noteworthy result is  
that there were differences between cultivars 'Genma' and 'Rambo'. Overall a higher  
content of these carbohydrates we found in the three cultivars after 48 h at room  
temperature.

## CONCLUSION

Our data indicate that Rambo cultivar presented better quality, since its RI was  
higher and less affected by the storage. However, it was less firm and cannot be  
considered a cultivar which softens slowly.

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assistance in the laboratory and Andrew Taylor for revising the English style of the  
original manuscript.

## Literature Cited

- Al-Mugharabi, M.A. 1994. A comparison between postharvest tomato quality of mature green and red-ripe sages produced in hydroponic. *J. King Saud. Univ. Agric. Sci.* 6(2):273-279.
- Castaño, 2001. Aplicación de pretratamientos térmicos en tomate "durinta" como técnica mejorante de la conservación. Memoria fin de carrera. Universidad de Almería, Spain.
- Chayb, J., Devaux, M.F., Grotte, M.G., Robini, K., Causse, M., Lahaye, M. and Marty, J. 2007. Physiological relationships among physical, sensory, and morphological attributes of texture in tomato fruits. *J. Exp. Bot.* 58(8):1915-1925.
- Chen, L., Raghavan, V., Charlebois, D., Charles, M.T. and Vigneault, C. 2008. Non-destructive measurement of color, firmness and lycopene content of tomato using visible and NIR Spectroscopy. The Canadian Society for Bioengineering (C.S.B.E.) 50<sup>th</sup> Annual Conference, Vancouver, 13-16 July, 2008.
- Del Río, A., López-Cantarero, I., Sánchez, A., Valenzuela, J.L. and Romero, L. 1994. Cambios fisiológicos durante el desarrollo y la maduración de frutos de tomate. In M.A. Albi (ed.), *Maduración y postrecolección '93. La calidad en frutos y hortalizas*. Diputación de Sevilla, Spain.
- Ferreira, M.D., Franco, A.T.O., Kasper, R.F., Oliveira, A.C., Honório, S.L. and Tavares M. 2005. Post-harvest quality of fresh-marketed tomatoes as a function of harvest periods. *Sci. Agric.* 62(5):446-451.
- Gajc-Wolska, J., Skqpski, H. and Szymczak, J.A. 2000. Physical and sensory characteristics of the fruits of eight cultivars of field grown tomato. *Act. Physiol Plant* 22(3):365-369.
- Hernández-Suárez, M., Rodríguez-Rodríguez, E.M. and Díaz-Romero, C. 2008. Chemical composition of tomato (*Lycopersicon esculentum*) from Tenerife, the Canary Islands. *Food Chem.* 106:1046-1056.
- Linares, M. 1996. La calidad en frutos de diversos cultivares de tomate. Su evolución durante el almacenamiento. Proyecto Fin de Carrera. Escuela Politécnica Superior, Universidad de Almería, Spain.
- Loidice, R., Impembo, M., Laratta, B., Villari, G., Lo Voi, A. and Siviero, P. 1995. Composition of San Marzano tomato varieties. *Food Chem.* 53:81-89.
- López, I. 1999. Tratamiento térmico mediante agua caliente para la conservación de tomate. Memoria fin de carrera. Escuela Politécnica Superior, Universidad de Almería, Spain.
- Lurie, S. and Klein, J.D. 1992. Ripening characteristics of tomatoes stored at 12°C and 2°C following a prestorage heat treatment. *Scientia Hort.* 51:55-64.
- Moreiras, O., Carvajal, A., Cabrera, L. and Cuadrado, C. 2005. *Tablas de composición de alimentos*. Editorial Pirámide, Madrid.
- Safdar, M., Morimoto, T. and Hatou, K. 2008. Postharvest heat stress application to reduce water loss and chilling injury in tomato during storage. *Elect. J. Environ. Agric. Food Chem.* 7(12):2582-2598.
- Valenzuela, J.L. 2002. Crecimiento y desarrollo de frutos de tomate de tres variedades. Evolución de la firmeza de los frutos, el contenido en sólidos solubles y los pigmentos. XI Reunión Latinoamericana de Fisiología Vegetal. Electronic book.
- Valero, D. and Valenzuela, J.L. 2003. Tratamientos térmicos post-cosecha en frutos de tomate. *Jornadas técnicas*. Ediciones Aerotécnicas, Madrid.
- Young, T.E., Juvik, J.A. and Sullivan, J.G. 1993. Accumulation of the components of total solids in ripening fruits of tomato. *J. Amer. Soc. Hort. Sci.* 118:286-292.

## Figures

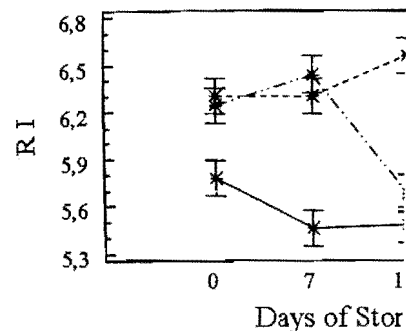


Fig. 1. Evolution of refractometric index (RI) expressed as °Brix. Interactions and 95% LSD intervals are presented.

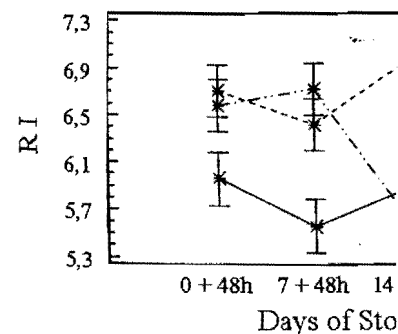


Fig. 2. Evolution of refractometric index (RI) 48 h after cold storage at 12°C. RI is expressed as °Brix. Interactions and 95% LSD intervals are presented.

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Charles, M.T. and Vigneault, C. 2008. Non-nness and lycopene content of tomato using adian Society for Bioengineering (C.S.B.E). -16 July, 2008.

z, A., Valenzuela, J.L. and Romero, L. 1994. ollo y la maduración de frutos de tomate. In: olección '93. La calidad en frutos y hortalizas.

.F., Oliveira, A.C., Honório, S.L. and Tavares, h-marketed tomatoes as a function of harvest

ymczak, J.A. 2000. Physical and sensory úvares of field grown tomato. Act. Physiol Plant

uez, E.M. and Díaz-Romero, C. 2008. Chemical *esculentum*) from Tenerife, the Canary Islands.

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Villari, G., Lo Voi, A. and Siviero, P. 1995. varieties. Food Chem. 53:81-89.

mediante agua caliente para la conservación de Escuela Politécnica Superior, Universidad de

g characteristics of tomatoes stored at 12°C and nent. Scientia Hort. 51:55-64.

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esarrollo de frutos de tomate de tres variedades, el contenido en sólidos solubles y los pigmentos. logía Vegetal. Electronic book.

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**Figures**

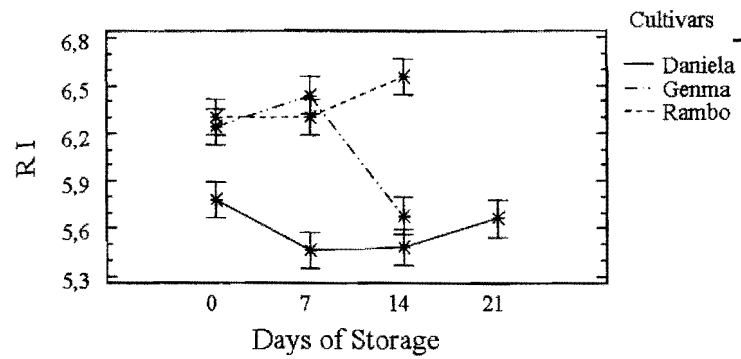


Fig. 1. Evolution of refractometric index (RI) during cold storage at 12°C. RI is expressed as °Brix. Interactions and 95% LSD intervals are presented.

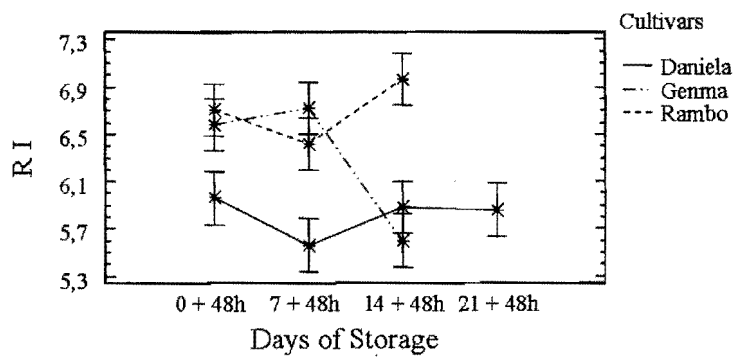


Fig. 2. Evolution of refractometric index (RI) of the fruits kept at room temperature for 48 h after cold storage at 12°C. RI is expressed as °Brix. Interactions and 95% LSD intervals are presented.

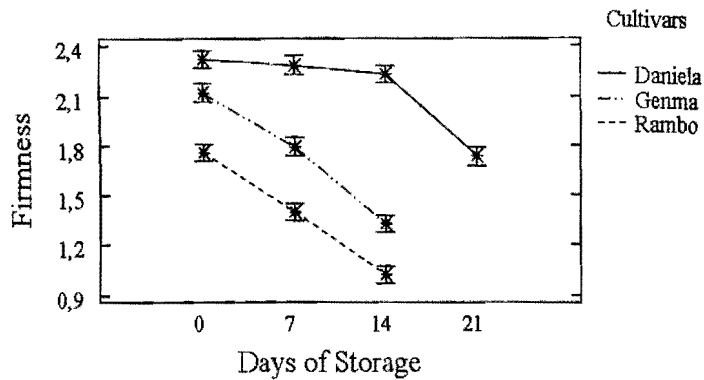


Fig. 3. Evolution of firmness during cold storage at 12°C expressed in kg. Interactions and 95% LSD intervals are presented.

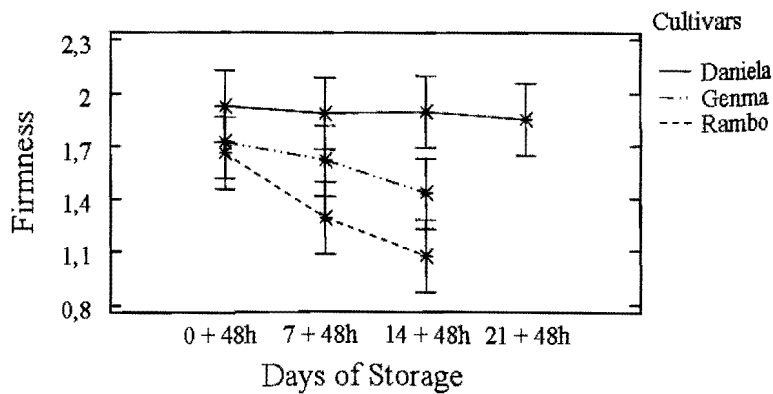


Fig. 4. Evolution of firmness of the fruits kept at room temperature for 48 h after cold storage at 12°C expressed in kg. Interactions and 95% LSD intervals are presented.

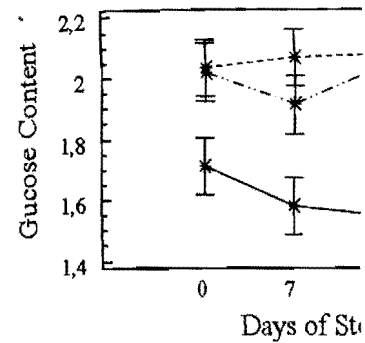


Fig. 5. Evolution of glucose content during cold storage. Interactions and 95% LSD intervals are presented.

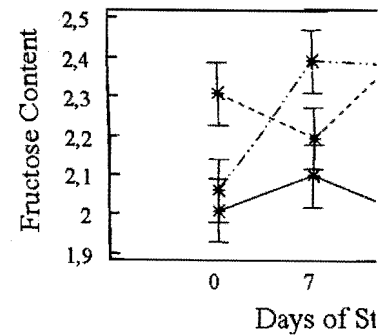
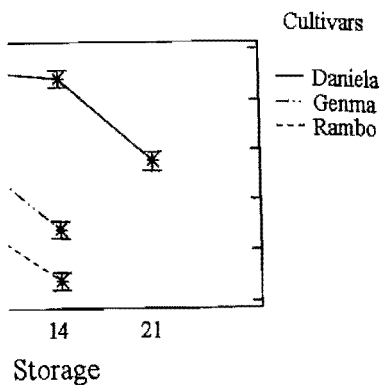
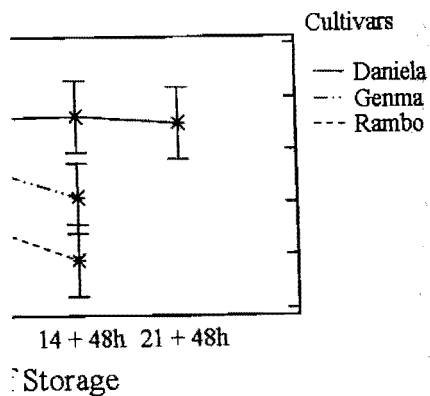


Fig. 6. Evolution of fructose content during cold storage. Interactions and 95% LSD intervals are presented.



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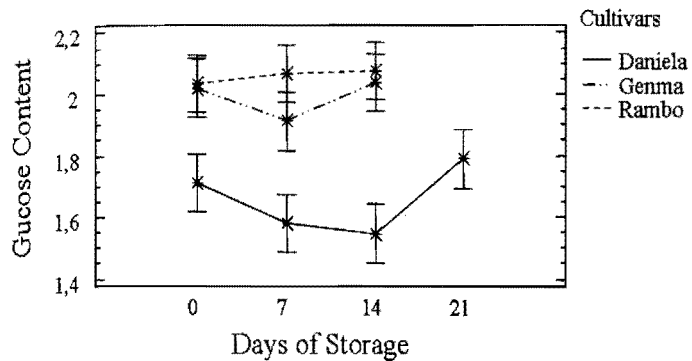


Fig. 5. Evolution of glucose content during cold storage at 12°C expressed as g/100 ml. Interactions and 95% LSD intervals are presented.

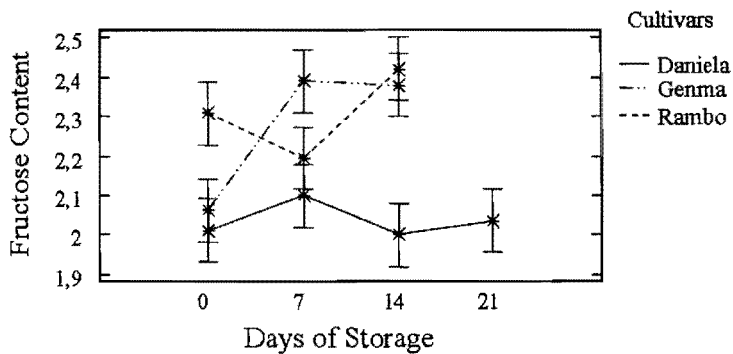


Fig. 6. Evolution of fructose content during cold storage at 12°C expressed as g/100 ml. Interactions and 95% LSD intervals are presented.

