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Nota/Note

Storage temperature for postharvest conservation of tangor cv. URSBRS Hada

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SUMMARY

The tangor cv. URSBRS Hada [*Citrus unshiu* Marc. × *C. sinensis* (L.) Osb.] produces late ripening fruits, the harvest is carried out from October to December in Rio Grande do Sul, Brazil. Little is known about the postharvest behavior of these fruits, thus the aim of this work is to evaluate the effect of storage temperature and rootstocks on postharvest fruit conservation. Fruits were harvested from 16-year-old plants in a commercial orchard in Butiá, Rio Grande do Sul, Brazil (30° 07'58" S, 51° 51' 22" W). After harvest, fruits were treated with imazalil ($2gL^{-1}$) and stored according to the different treatments. The experiment was carried out in a completely randomized design in factorial scheme 3^3 (temperature × rootstock × storage time), with three replicates with 10 fruits. It was conducted at temperatures of 0 °C, 3 °C and 5 °C (RH 90±5%), the rootstocks Rangpur lime, Swingle citrumelo and Sunki tangerine were used, and the storage time of 30, 60 and 90 days. Fruits evaluations were weight loss (%), rot incidence (%) and physical-chemical analysis such as juice content, soluble solid content, titratable acidity and maturity index color. Rootstocks did not affect the weight loss and rot incidence. However, the temperature influenced the fruit preservation, and they can be stored at 0 °C for at least 90 days, maintaining the fruits quality for consumption, without decay and with a low weight loss (<10%).

Index terms: fruit yield, fruit quality, alternaria brown spot.

Temperatura de armazenamento para conservação pós-colheita do tangor URSBRS Hada

RESUMO

O tangoreiro cv. URSBRS Hada [*Citrus unshiu* Marc. × *C. sinensis* (L.) Osb.] produz frutos de amadurecimento tardio, com a colheita sendo realizada de outubro a dezembro no Rio Grande do Sul, Brasil. Pouco se sabe sobre o comportamento pós-colheita dessas frutas, por isso o objetivo deste trabalho foi avaliar o efeito da temperatura de armazenamento e de porta-enxertos na conservação pós-colheita da fruta. As frutas foram colhidas de plantas de 16 anos em um pomar comercial em Butiá, Rio Grande do Sul, Brasil (30° 07'58" S, 51° 51'22" W). Após a colheita, os

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frutos foram tratados com imazalil (2g L^{-1}) e armazenados de acordo com os diferentes tratamentos. O experimento foi realizado em um delineamento inteiramente casualizado no esquema fatorial 3^3 (temperatura × porta-enxertos × tempo de armazenamento), com três repetições com 10 frutos. Foi conduzido a temperaturas de 0 °C, 3 °C e 5 °C (90 UR ± 5%), os porta-enxertos: limoeiro Cravo, citrumeleiro Swingle e a tangerineira Sunki e o tempo de armazenamento de 30, 60 e 90 dias. As avaliações das frutas foram: perda de massa (%), incidência de podridão (%) conteúdo de suco, teor de sólidos solúveis, acidez titulável e índice de cor da casca. O porta-enxerto não afetou a perda de massa e incidência de podridão. No entanto, a temperatura influenciou a preservação da fruta, e podem ser armazenados a 0 °C por pelo menos 90 dias, mantendo a qualidade das frutas para consumo, sem deterioração e com baixa perda de massa (<10%).

Termos de indexação: produtividade de frutas, qualidade da fruta, mancha marrom de alternaria.

The tangor cv. URSBRS Hada [*Citrus unshiu* Marc. × *C. sinensis* (L.) Osb.] produces late-ripening fruits, and its optimal harvest period is from October to December under the conditions of the South of Brazil. The cultivar presents tolerance to diseases such as citrus canker, black spot and alternaria brown spot. It produces large fruits with average weight of 150 g, high soluble-solids and acidity contents, either for juice or for fresh consumption (Gonzatto et al., 2015).

One way to extend the period of fruits supply is by the cold storage use. Low temperatures may contribute to maintain the quality and also to inhibit the pathogens development (Usall et al., 2016). For citrus fruits, the cold storage period depends on the species or cultivar and, also, on the temperature and humidity. Because, on more sensitive fruits, the low temperatures may cause chilling injuries. Besides, it may induce alterations on metabolic routs of soluble sugar, for example (Zhu et al., 2011).

Temperatures between 4 °C and 7 °C and relative humidity (RH) from 90 to 95% are considered optimum to cold storage of tangerines. Being that, in this conditions, fruits could be stored for a period of two to four weeks (Kluge et al., 2007). However, Montenegrina tangerines stored at 3 °C and RH 90% had its physical-chemical characteristics preserved up to eight weeks, with low incidence of rots. In conditions of RH of 96% or in cold storage period over twelve weeks, lost occurred by rots may be significant (Brackmann et al., 2008).

The cultivation of tangor cv. URSBRS Hada is relatively recent and there is little information regarding its postharvest behavior. Therefore, this study was conducted with the purpose of evaluating the effect of different storage temperatures on the postharvest conservation of fruits.

The present work was carried out in the Postharvest Laboratory, at Faculdade de Agronomia of the Universidade Federal do Rio Grande do Sul (UFRGS). The fruits were harvested in November, 2012, from 16-year-old plants of an orchard located in Butiá, Rio Grande do Sul, Brazil (30° 07' 58" S, 51° 51' 22" W).

The experimental design was completely randomized, consisting of three replicates, each replication being composed of 10 fruits. The treatments were arranged in a factorial scheme 3^3 (rootstock × temperature × storage time). The fruits were collected from plants grafted on the rootstocks Rangpur lime, Swingle citrumelo and Sunki tangerine; the refrigerated storage temperatures were 0, 3 and 5°C, under the condition of relative air humidity (RH) of 85 to 95%; and three assessment periods, 30, 60 and 90 days. Prior to the refrigerated storage, the fruits were submitted to treatment of immersion into an aqueous solution of imazalil (2 g L^{-1}).

In each evaluation was performed the counting of rotted fruits in each sample, obtaining the rot incidence by the ratio of rotted fruits and the total from the sample. The fruits were also evaluated regarding to their physical-chemical characteristics, such as juice content (JC), soluble solid contents (SS), titrable acidity (TA), and maturation index (SS/TA) (AOAC, 1990) and the skin color index (Jimenez-Cuesta et al., 1981).

Data were submitted to Analysis of Variance (ANOVA) using PROC MIXED on SAS 9.4® (SAS Institute Inc, Cary, USA). When appropriate, the means were separated using the Tukey's test ($P<0.05$).

Fruits harvested from plants on different rootstocks did not show difference to juice content and color index in the beginning of the experiment. However, fruits from Swingle citrumelo had higher SS than Rangpur lime and Sunki mandarin, while fruits of Rangpur lime had lower TA than the other ones (Table 1).

After 90 days in cold storage, fruits at 3 °C had TA higher than fruits stored at 0 and 5° C. tangor cv. URSBRS Hadafruits grafted on Rangpur lime showed the lowest values of TA and the highest SS/TA ratios (Table 2), maintaining the behavior similar to the observed at

harvest (Table 1). In others tangerines, Rangpur lime also induced to the canopy fruits with lower TA and, consequently, higher values of SS/TA (Silva et al., 2013; Carvalho et al., 2016).

The different rootstocks did not influence weight loss and rot incidence, during cold storage (Figure 1). After 30 days of storage the weight loss were of 2.3%, 4.5% and 2.5% for the temperatures 0 °C, 3 °C and 5 °C, respectively for fruits of Montenegrina tangerine, treated with imazalil and stored for 20 days at 5 °C, losses of 6.0% were observed (Montero et al., 2010).

Yet, in the conditions of 3 °C and 5 °C, the values of weight loss were over 10% from 60 days of storage. After 90 days of storage, the weight loss was 24.4% at 5 °C. Still, fruits kept at 0 °C had losses of maximum 9.1% after three months of storage (Figure 1).

When stored at 5 °C for 90 days, the incidence of rots on the tangor cv. URSBRS Hada fruits were 17.8%, while during the entire verified period the fruits stored at 0 °C and 3 °C had the maximum of 1.1% of fruits affected (Figure 1).

Cold storage is a common postharvest technique utilized in order to reduce metabolic processes and to conserve horticultural products (Chitarra & Chitarra, 2005). During the postharvest, citrus are affected by the conditions of the storage environment, which, if

Table 1. Juice content (JC), soluble solids (SS), titratable acidity (TA), maturation index (SS/TA) and color index (CI) of tangor cv. URSBRS Hada fruits in the beginning of the experiment. Porto Alegre, RS, Brazil[a]

Rootstock	JC	SS	TA	SS/TA	CI
	(%)	(°Brix)	(%)		
Rangpur lime	52.0	13.8 a	1.44 a	9.5 b	7.52
Swingle citrumelo	52.9	14.7 b	1.65 b	8.9 ab	7.45
Sunki mandarin	47.2	13.7 a	1.58 b	8.7 a	8.58
P	ns	**	**	*	ns

Means followed by equal letters do not differ significantly according to Tukey (P<0.05). [a]* P<0.05; ** P<0.01; ns: non-significant (p>0.05).

Table 2. Juice content (JC), soluble solids (SS), titratable acidity (TA) and maturation index (SS/TA) of tangor cv. URSBRS Hada tangor fruits after 90 days in cold storage at different temperatures and rootstock origins. Porto Alegre, RS, Brazil[a]

Temperature	Rootstock	JC (%)	SS (°Brix)	TA (%)	SS/TA
0 °C	Rangpur lime	45.5	14.4 α	1.40 a	10.3 b
	Swingle citrumelo	42.9 β	15.0	1.64 b	9.1 a
	Sunki mandarin	46.2	15.3	1.62 b	9.4 a
	Mean	44.9	14.9	1.56 A	9.6
3 °C	Rangpur lime	47.6	16.3 β	1.59 a	10.2 b
	Swingle citrumelo	50.5 α	15.7	1.81 b	8.7 a
	Sunki mandarin	50.1	15.4	1.72 b	8.9 a
	Mean	49.4	15.8	1.71 B	9.3
5 °C	Rangpur lime	46.4	14.6 α	1.43 a	10.2 b
	Swingle citrumelo	48.0 αβ	14.7	1.61 b	9.1 a
	Sunki mandarin	44.6	15.1	1.53 b	9.8 a
	Mean	46.3	14.8	1.52 A	9.7
Effects			p-value (F test)		
Temperature		**	***	**	ns
Rootstock		ns	ns	***	***
Temperature*Rootstock		*	*	ns	ns

Uppercase letters compare storage temperatures, whereas lowercase letters compare rootstocks according to Tukey's test, at 5% probability. Greek letters (α, β) compares a same rootstock in different storage temperatures. [a] * P<0.05; ** p<0.001; *** p<0.0001; ns: non-significant (p>0.05).

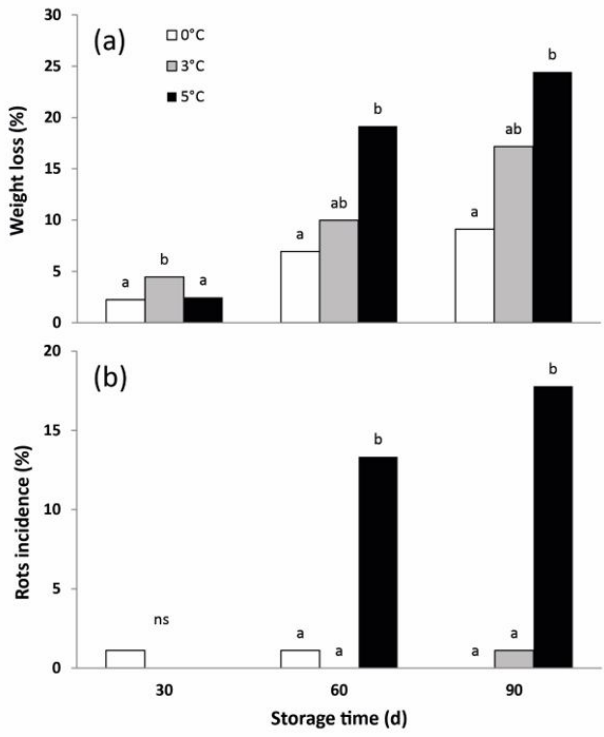

Figure 1. Weight loss (a) and rots incidence (b) of tangor cv. URSBRS Hada after storage at different temperatures and times. Columns, in the same storage time, with different letters are significantly different according to Tukey's test ($p < 0.05$).

not adequate, can compromise their quality. Especially in the case of tangerines, which are more sensitive and have a shorter shelf-life than oranges and other types of citrus fruits (Yun et al., 2010). This higher sensibility of tangerines may be due to the characteristics of the anatomical structures of the vascular system responsible for the transport of water and nutrients between the pulp and the peel, which may influence on the senescence (Ding et al., 2015).

In general, citrus are susceptible to low temperatures and may present chilling injury when exposed to temperatures below 5 °C (Lepedus et al., 2005; Ghasemnezhad et al., 2008). However, tangor cv. URSBRS Hada did not present chilling injury characteristics when stored at 0 °C for up to 90 days.

The temperature affects the conservation of the tangor cv. URSBRS Hada fruits, and under the conditions in which this study was conducted, the fruits maintained itself able for consumption after 90 days of storage at 0 °C. Thus, enabling the provision of this cultivar in a period of citrus deficiency.

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