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Respiration rate and its effect on mass loss and chemical qualities of 'Fuyu' persimmon fruit stored in controlled atmosphere

Taxa respiratória e seu efeito na perda de massa e qualidades químicas de caqui 'Fuyu' armazenado em atmosfera controlada

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- NOTE -

ABSTRACT

The objective of this research was evaluate the effect of two CO_2 partial pressures in ultra-low oxygen on the mass loss in function of respiration, oxygen consumption, respiratory rate and other characteristics of 'Fuyu' persimmon during 12 weeks in controlled atmosphere (CA) storage at temperature of -0,5°C. For thus, one experiment was carried out with the followed CA condition: [1] 0.15 kPa O_2 plus 2.0 kPa CO_2 and [2] 0.15 kPa O_2 plus 6.0 kPa CO_2. On this study was verified that the respiration (carbon dioxide production) was responsible for 24% of total mass loss. The total mass loss is significantly affected by the controlled atmosphere storage. The 2.0 kPa CO_2 promotes changes in the respiratory quotient during the storage period and keep higher mass loss in function of respiration (CO_2 losses) and lower soluble solids after storage.

Key words: ***Diospyrus kaki***, *postharvest, oxygen uptake, CO_2 losses, soluble solids*.

RESUMO

O objetivo deste trabalho foi avaliar o efeito de duas pressões parciais de CO_2 em ultrabaixo oxigênio sobre a perda de massa em função da respiração, consumo de O_2, taxa respiratória e outras características de caqui 'Fuyu', durante 12 semanas de armazenamento, em atmosfera controlada na temperatura de -0,5°C. Para tanto, um experimento foi conduzido com as seguintes condições de AC: [1] 0,15 kPa O_2 mais 2,0 kPa CO_2 e [2] 0,15 kPa O_2 mais 6,0 kPa CO_2. A respiração (produção de gás carbônico) foi responsável por 24% do total de perda de massa. A perda de massa é significativamente afetada pelas condições de atmosfera controlada. 2,0 kPa CO_2 promove mudanças no quociente respiratório durante o armazenamento, proporciona maior perda de massa em função da respiração e menor concentração de sólidos solúveis depois do armazenamento.

Palavras-chave: ***Diospyrus kaki***, *pós-colheita, consumo de oxigênio, perda de CO_2, sólidos solúveis*.

During storage time, one of the most important events of fruit is the respiration, where oxygen (O_2) uptake and carbon dioxide (CO_2) production occurs at the same scale, in aerobic conditions (STEFFENS et al., 2007).With the respiration process occurs soluble solids and titratable acidity consumption. The decrease in respiratory rates during Postharvest life of the fruit can be achieved by reducing the temperature and use of controlled atmosphere storage (STEFFENS et al., 2007; BRACKMANN et al., 2008). Throughout the storage, CO_2 partial pressure has significant effect in respiration rate at aerobic condition, but in ultra-low oxygen (ULO) condition its effect is not clear and more researches are needed.

Furthermore, the respiration rate influences the mass loss, because there are carbon losses. However, the major part of mass loss is in function of water vapor loss. Some authors reported that mass loss is an important contributor to the maintenance of high quality during postharvest in apples (MAGUIRE et al., 2000; BRACKMANN et al., 2007) and peaches

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(PINTO et al., 2012). However, these studies do not distinguish the effect of water loss and dioxide carbon losses on total mass loss and are not accompanied by the respiration (CO_2 production) and O_2 uptake in real time throughout the controlled atmosphere storage period.

The objective of this research was to evaluate the effect of two different CO_2 partial pressures associated to ULO storage, on the mass loss in function of respiration, oxygen uptake, respiratory rate and other variables of 'Fuyu' persimmons stored during 12 weeks in CA at -0.5°C.

The experimental material was obtained from a commercial orchard located in the city of Farroupilha, Rio Grande do Sul (Brazil), in 2012. At the harvest, the fruit showed 0.83meq 100mL^{-1} titratable acidity, soluble solids of 15.5 °Brix, 1.21mL CO_2 kg^{-1} h^{-1} respiration rate, 14.2mL CO_2 L^{-1} internal CO_2. The fruits were selected by eliminating injured fruit and were stored under two controlled atmosphere conditions: [1] 0.15 kPa of O_2 plus 2.0 kPa of CO_2 and [2] 0.15 kPa of O_2 plus 6.0 kPa of CO_2 at the temperature of -0,5°C, during three months in chambers of 0.233m^3. The relative humidity in the chambers was maintained at 95% (±1%).Completely randomized statistical scheme was used, with fourteen replications with ten fruits each.

The variables evaluated were: a) respiratory rate (evaluated by CO_2 production during storage) and b) O_2 uptake during storage, which were evaluated with a gas analyzer during all the days of storage, the results were expressed in mL CO_2 kg^{-1} h^{-1} and mL O_2 kg^{-1} h^{-1}, respectively; c) respiration quotient: obtained by the quotient of CO_2 production and O_2 consumption ($\Delta CO_2/\Delta O_2$); d) total mass loss: obtained by weighting the fruit before and after the storage. The data were expressed in percentage of the initial mass; e) mass loss in function of respiration: calculated by the relation between mass loss because of respiration, in function of CO_2 accumulation in the chamber, and its contribution on total mass loss. Data expressed in percentage of total mass loss; f) mass loss in function of water vapor loss: obtained by subtraction between total mass loss and mass loss in function of respiration, data expressed in percentage of total mass loss; g) soluble solids: evaluated by refractometry from the juice of the samples, data expressed in °Brix; h) titratable acidity: determined by titration of a solution of 10mL fruit juice diluted in 100mL of distillated water, with NaOH 0.1N. The results were expressed in meq 100mL^{-1}.

For each variable, was done a variance analysis (ANOVA), being the means submitted to regression analysis and Tukey test with 5% of probability of error. The data expressed in percentage were transformed with the formula arc.sin $((x/100)^{0,5})$ before submitted to variance analyses.

During storage, respiration rate was completely different on the two CO_2 partial pressures (Figure 1A and 1D). On the lowest CO_2 partial pressure (2.0 kPa) the respiratory rate increased with the storage time. However, when fruit were stored in 6.0kPa CO_2 the respiration rate decreased with the storage time. These results indicated that the higher CO_2 partial pressure reduced respiration even under ULO condition. The table 1 shows that the respiratory rate was lower in the higher CO_2 level. This lower respiratory rate occurs because the CO_2 is produced in tricarboxylic acid cycle, and the increase of partial pressure in the storage chamber reduced the CO_2 production pathways (TAIZ & ZEIGER, 2009). Another study demonstrated reduction in respiration with the increased of CO_2 partial pressure (STEFFENS et al., 2007).

The O_2 uptake was similar on both treatments, where occurs a linear decreasing during the storage time (Figure 1B and 1E), but fruit stored at 2.0kPa CO_2 have a higher angular coefficient (-0.0105) than fruit stored at 6.0 kPa CO_2 (-0.0049). The higher angular coefficient indicated that the fruit stored at 2.0 kPa CO_2 showed a marked decreasing in O_2 uptake during storage than fruit stored at 6.0 kPa CO_2. However, the total O_2 uptake was significantly higher in fruit stored in the lowest CO_2 partial pressure (Table 1).These decreasing in O_2 uptake linked with increasing CO_2 production throughout the storage, increased the respiratory quotient on the fruit stored at this condition (2.0 kPa CO_2) (Figure 1C).Similar results were reported in apples (SAQUET & STREIF, 2002).The result indicated that fruit stored at this CO_2 level increased the anaerobic metabolism from the onset to the end of storage, because higher respiratory quotient values showed greater anaerobic metabolism (SAQUET & STREIF, 2002). However, when fruits were stored in 6.0 kPa CO_2 the anaerobic metabolism on the beginning and end was the same, because the respiratory quotient was the same during storage time (Figure 1F). After three months of storage the average respiratory quotient was similar in both CO_2 partial pressures (Table 1).

Some studies have suggested that higher mass loss can keep higher postharvest quality, because it increases the gas exchange in apples (BRACKMANN et al., 2007) and peaches (PINTO et al., 2012). However, not all mass loss increases the gas exchange in fruit, but only the mass loss as a

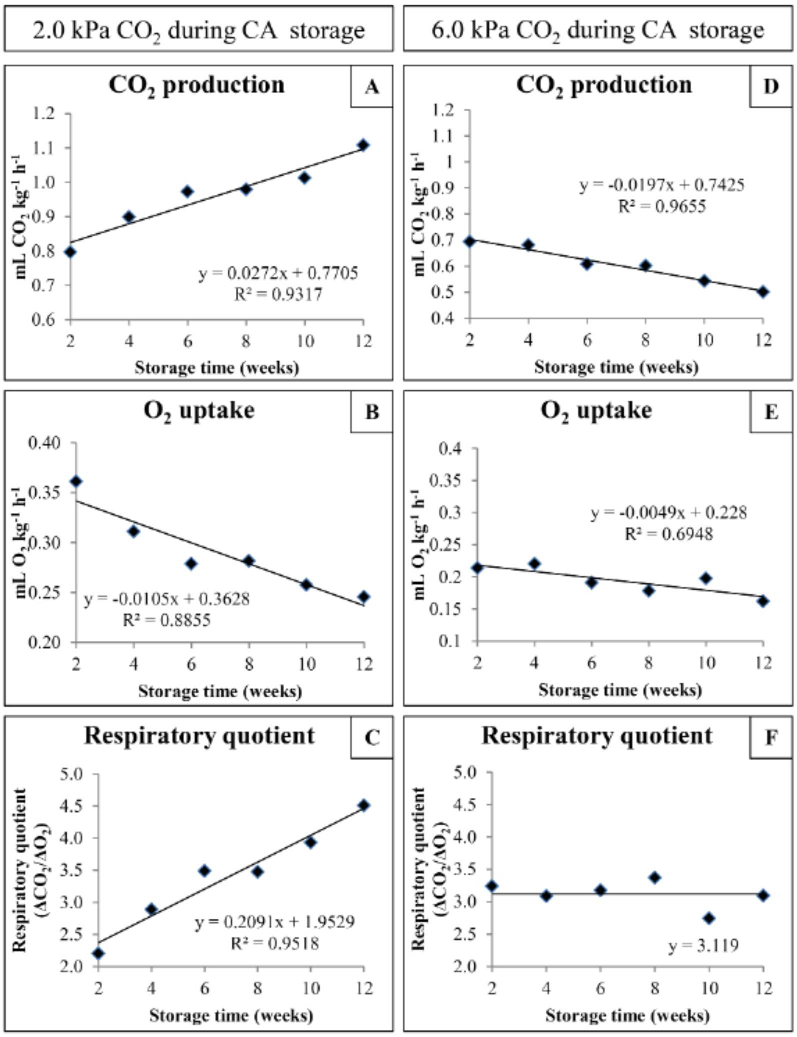

Figure 1 - CO_2 production (respiratory rate), O_2 uptake and respiratory quotient of 'Fuyu' persimmon fruits stored in controlled atmosphere with 0.15kPa O_2 during 12 weeks, in temperature of -0.5°C. Santa Maria, Brazil, 2012. *Means submitted to regression analysis with 5% probability of error.

result of water vapor loss. At this study it was verified that the respiration have a significant effect on mass loss, being responsible for 24% of the total mass loss, and the result were similar than the obtained in apples stored at the same relative humidity, in which about 20% of mass is in function of respiration rate (MAGUIRE et al., 2000). The table 1 shows that the higher respiratory rate on fruit stored with 2.0 kPa CO_2 culminated in higher mass loss in function of respiration rate. Inverse result was obtained with 6.0 kPa CO_2 in relation to mass loss resulted from water vapor losses. The total mass loss was higher in fruit stored with 2.0 kPa CO_2 as a result of the higher respiration rate of this treatment.

The higher respiratory rate and O_2 uptake of fruit stored with 2.0 kPa of CO_2 (Table 1) result in chemical changes in fruit. Significant effect was verified in soluble solids contents, which showed a reduction in fruits stored with 2.0 kPa CO_2. However, the soluble solids contents are higher on fruit submitted to 6.0 kPa CO_2 because there is higher mass loss in function of water vapor loss. Another studies showed that the mass loss as a result of water loss increased de accumulation of soluble solids during storage (BRACKMANN et al., 2004; BRACKMANN et al., 2007; PINTO et al., 2012). In general, the persimmon fruits have low acidity and its concentration does not change during the storage, and is not affected by the CO_2 concentration (Table 1).

Table 1 - Respiratory rate, oxygen uptake rate, respiratory quotient, mass loss in function of respiration, mass loss in function of water loss, soluble solids and titratable acidity in 'Fuyu' persimmon during 12 weeks in controlled atmosphere storage, means of all days of storage. Santa Maria, Brazil, 2012.

Variable	----------Unit--------	-----Controlled atmosphere (O_2 + CO_2 kPa)-------	
		0.15 + 2.0	0.15 + 6.0
Respiratory rate	mL CO_2 kg^{-1} h^{-1}	0.96a*	0.60b
Oxygen uptake rate	mL O_2 kg^{-1} h^{-1}	0.29a	0.19b
Respiratory quotient	$\Delta CO_2/\Delta O_2$	3.42a	3.11a
Mass loss in function of respiration**	%	24.07a	20.97b
Mass loss in function of water loss**	%	75.93b	79.03a
Total mass loss of fruit	%	1.85a	1.34b
Soluble solids	°Brix	15.13b	16.06a
Titratable acidity	meq $100mL^{-1}$	0.63a	0.64a

*Means followed by equal letters, in the line, do not differ by Tukey test, at 5% probability of error.
** Percentage of mass loss in relation of total mass loss of fruits.

In 'Fuyu' persimmon the total mass loss is significantly affected by controlled atmosphere storage conditions. 2.0 kPa CO_2 promotes changes in respiratory quotient during storage time, keep higher mass loss in function of respiration (CO_2 losses) and lower soluble solids after storage. Titratable acidity is not affected by the two CO_2 partial pressures under ULO treatments.

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