

## ALTERNATIVE FOR REDUCING PHYSIOLOGICAL DISORDERS IN 'BARTLETT' PEARS<sup>1</sup>

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**ABSTRACT** - 'Bartlett' pears from different harvest dates were assessed regarding to cold storage potential and reduction of physiological disorder incidence. Three harvests, the first (HD1), second (HD2), and third (HD3), were carried out at weekly intervals. The pears were assessed after the harvest, with no exposition to the temperature conditioning, after 20, 40, 60, 80, 100 and 120 days at  $0 \pm 1$  °C and  $90 \pm 5\%$  RH and after three and six days at room temperature ( $20 \pm 1$  °C). Fruit from the early harvest (HD1) showed the smallest incidence of physiological disorder during both cold and room temperature storage. The disorder symptoms became apparent in HD1 fruit after 20 days at cold storage followed by three days at 20 °C, whereas HD2 and HD3 fruit showed the symptoms before being kept in a cold room. 'Bartlett' pears harvested at 70.75 N flesh firmness can be stored at  $0 \pm 1$  °C for up to 40 days and preferably commercialized within three days, when they reach the firmness for eating. The extension of cold storage as well as the trade period can result in higher physiological disorder incidence and loss of sensorial quality.

**Index terms:** *Pyrus communis* L., cold storage, flesh firmness and acceptance.

## ALTERNATIVA PARA REDUZIR DISTÚRBIOS FISIOLÓGICOS EM PERAS 'BARTLETT'

**RESUMO** - Diante dos prejuízos causados pelos distúrbios fisiológicos, objetivou-se avaliar diferentes datas de colheita em relação ao potencial de armazenamento e diminuição da incidência de distúrbios fisiológicos em peras 'Bartlett'. Foram realizadas três colheitas com intervalos semanais, primeira data de colheita (DC1) realizada em 25 de janeiro, segunda data de colheita (DC2) efetuada em 01 de fevereiro e terceira data de colheita (DC3) realizada em 08 de fevereiro. As peras foram avaliadas logo após a colheita, ou seja, sem o efeito de refrigeração e após 20, 40, 60, 80, 100 e 120 dias de em armazenamento refrigerado  $0 \pm 1$  °C e umidade relativa  $90 \pm 5\%$  e após três e seis dias em ambiente simulado com temperatura de  $20 \pm 1$  °C. Peras 'Bartlett' colhidas com firmeza de polpa de 70,75N (DC1) podem ser armazenadas em ambiente refrigerado por até 40 dias e comercializados preferencialmente até três dias. A extensão do armazenamento refrigerado resulta em altas incidências de distúrbios fisiológicos e perdas da qualidade sensorial.

**Termos para indexação:** *Pyrus communis* L., armazenamento refrigerado, firmeza de polpa e aceitabilidade.

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## INTRODUCTION

Physiological disorders in pears are characterized by the softening and darkening of the pulp, being responsible for the reduction in the post harvest quality of fruit (FRANCK et al., 2003). The darkening is due to the enzymatic oxidation of the phenolic compounds to *o*-quinones by the activity of polyphenol oxidase. Because they are highly reactive, *o*-quinones form polymers which make the pulp brown in color (VILLALOBOS-ACUÑA & MITCHAM, 2008). According to Franck et al. (2003), the term 'physiological disorder' is used in general, as there are different forms and symptoms of internal and external darkening which are usually described differently among authors. After the damage spreads, it is no longer possible to identify the initial and final region of the enzymatic modification, which makes the term 'physiological disorder' broadly used (FRANCK et al., 2003).

Some cultivars of pears have higher susceptibility to the occurrence of physiological disorders, including the 'Bartlett' pear (SUGAR & POWERS, 1994; TRINCHERO et al., 2004; YAZDANI et al., 2011).

Post harvest factors that influence the development of physiological disorders were studied by Baritelle et al. (2001); Trinchero et al. (2004); Fu et al. (2007); Yazdani et al. (2011); Mattheis & Rudell, (2011). Among the major post harvest factors, the duration and temperature of cold storage as well as the maturity stage at harvest can be highlighted (FRANCK et al., 2003). Alternatives may be used to decrease the intensity of physiological disorders and to extend the storage duration. Among them, harvesting of fruit with high values of flesh firmness, early harvest, stands out (CRISOSTO et al., 1994).

In general, the fruit harvested later are more susceptible to physiological disorders (FRANCK et al. 2003). In the State of California, USA, Crisosto et al. (1994) conducted two harvests of 'Ya Li' pears with an interval of seven days. The fruit from the first harvest, those harvested early, showed no physiological disorder after being stored for 28 days at 0°C and kept at room temperature at 20°C for seven days. In contrast, 100% of the fruit from the second harvest presented physiological disorder when stored at the same conditions.

The purpose of this study was to evaluate different harvest dates regarding to storage potential and reduction of physiological disorder incidence in 'Bartlett' pears produced in Brazil.

## MATERIALS AND METHODS

'Bartlett' pears were harvested from a commercial orchard in São Francisco de Paula, RS, Brazil, in the 2009-2010 season. The plants were grafted on 'Adams' quince and the conduction system of the orchard is in central leader, with spacing of 0.5 m between plants and 4.0 m between rows, totaling 5,000 plants per hectare.

The fruit were pre-selected in the field according to the size and the absence of damage caused by pests and/or disorders. Next, they were placed in divider trays, and these in vented plastic boxes, model CN-60, with capacity of 60L and dimension of 28x32x52cm, protected internally by bubble wrap plastic to prevent mechanical damage during transport.

At the lab, pears were submitted to another selection to remove fruit with any kind of defect, and to homogenize the lot in the caliber.

Prior to the harvest, the monitoring of flesh firmness was performed for about a month by sampling 20 pears randomly collected each week in the orchard. Three harvests were performed at weekly intervals. The fruit from the first harvest date (HD1), on January 25, showed firmness of 70.75 N, the second harvest (HD2), on February 1, showed firmness of 59.03 N and the third harvest (HD3), held on February 8, showed values of 62.28 N.

Each harvest date constituted an experiment, which was analyzed according to a completely randomized model in a 7 x 3 factorial design and four replicates. The levels of the first factor were seven periods of cold storage at 0 ± 1°C and 90 ± 5% RH (0, 20, 40, 60, 80, 100 and 120 days). The levels of the second factor were periods at room temperature (end of the cold storage), three and six days at 20 ± 1°C, in order to simulate the period and the normal marketing conditions.

The occurrence of physiological disorders was determined by the percentage of fruit with symptoms compared to the total.

The flesh firmness was measured on both sides in the equatorial region of each fruit (observation unit), removing a small area from the skin. An analog penetrometer was used (Mc Cornick, model FT327) fitted with an 8mm probe. Data was showed in Newton (N).

To obtain the index of starch degradation, cross-sectional slices from the middle part of the fruit were partially immersed in a 1.2% metallic iodine and 2.4% potassium iodide solution for two minutes. After this period, the slices were kept for about ten minutes at continuous airflow and classified

according to the 1-10 scale, proposed by Avelar et al. (1999).

A homogenized juice sample of all fruit from each replicate and a digital refractometer (Atago, PR-101 Pallet) were used to measure the soluble solids content. To determine the loss of weight over time, the following formula was used:  $LFW: \{(IFW - FFW) * 100 / IFW\}$  where: LFW: Loss of fresh weight (%); IFW: Initial fresh weight (g) and FFW: Final fresh weight (g).

The data of the physical and chemical attributes, such as flesh firmness (N), soluble solids ( $^{\circ}$ Brix) and weight loss (%) from the three trials were analyzed by ANOVA. According to the results of test F for main effects and interaction, analyzes of polynomial regression for the period in cold storage and Tukey test for comparison of time at  $20 \pm 1^{\circ}\text{C}$  were performed.

For sensory analysis, the pears were evaluated by at least 30 untrained panelists of both genders aged between 18 and 65 years. The pears were sliced just a few minutes before tasting to prevent enzymatic darkening and, consequently, any interference in the acceptance of the product. The coded samples were randomized and served to the panelists. An Acceptance Test was carried out as described by Ferreira et al. (2000), using a 7-point hedonic scale, where 1 = totally disliked, 2 = disliked very much, 3 = disliked, 4 = did not like, nor dislike, 5 = liked, 6 = liked very much, 7 = totally liked. Besides the scale, the panelists were asked to report the striking characteristics that were perceived at the time of the sensory evaluation. Frequencies ( $F_i, i=1, 2, \dots, 7$ ) into the hedonic scales classes resulted from the sensory evaluation of samples per treatment by at least 30 panelists. An acceptance index, represented by  $I_a$ , the amplitude of which ranges from 0 (unacceptable) to 100 (maximum acceptance) came from the distribution of frequencies of each treatment. This measure, adapted from Czereminski (1999), was adopted in order to associate the treatments to a quantitative response that allowed comparison and calculation of the differences among them in a continuous scale.

## RESULTS AND DISCUSSION

The fruit harvested earlier (HD1) had lower incidence of physiological disorders during cold storage and ripening at room temperature. HD1 pears not submitted to temperature conditioning and evaluated on third and sixth days showed no disorder. The symptoms became evident in the HD1 fruit after twenty days of temperature conditioning followed

by three days at room temperature. In those fruit, there was an increase in the incidence of the disorder during storage, which resulted in 100% fruit after 80 days of cold storage followed by six days in a room temperature (Figure 1).

The later harvest date (HD3), even before being stored at low temperature, 8% of the fruit showed physiological disorder after three days in a room temperature. In harvest dates 2 and 3, after six days of permanence in a room temperature, 58% of the fruit showed physiological disorder. After 40 days of cold storage followed by six days in a room temperature, 100% of HD3 fruit showed physiological disorder. This fact was repeated at 60 days of cold storage followed by three days in a room temperature (Figure 1).

The incidence of physiological disorders in harvested fruit from HD2 was lower when compared to the fruit of the last harvest (HD3); however, 72% and 100% of the fruit presented physiological disorder after 60 days of cold storage followed by three and six days in a room temperature, respectively (Figure 1).

The results are in accordance with Crisosto et al. (1994) who stated that fruit harvested early have lower incidence of physiological disorders and, consequently, they support longer cold storage. Bower et al. (2003) also found that fruit harvested early, after storage for 90 days at  $0^{\circ}\text{C}$  followed by four days in a room temperature with a temperature of  $20^{\circ}\text{C}$ , showed only 2% of disturbance, while the fruit harvested later showed 58% of physiological disorders incidence.

The results are also consistent with Calvo (2004), who evaluated 'Bartlett' pears in Argentina. The author observed that the fruit harvested when flesh firmness reached 81.63N and that were kept for 60 days in cold storage, followed by seven days at room temperature, showed 80% of physiological disorders, whereas 100% of the fruit harvested with firmness of 68.79N were compromised after 30 days of cold storage, followed by seven days at room temperature.

The reason for the occurrence of higher physiological disorder in fruit harvested late, according to Franck et al. (2003), is possibly due to the reduction of air diffusion to the center of the fruit. While the fruit remain on the plant, there is a trend of increasing in size, so they become more susceptible to physiological disorders due to the greater distance to be traversed by the air to the center of the fruit. The lack of oxygen inside the fruit means that there is a deficit in aerobic respiration, causing imbalance between the oxidative and reductive processes.

The occurrence of physiological disorders in fruit at advanced ripening stage is the reduction of compounds responsible for the capture of free radicals that cause damage to cell membranes and make the fruit more susceptible to disorders. The occurrence of membrane damage and leakage of solutes in the intercellular spaces limits the transport of air inside the cell, making the breathing process harder and causing fermentation that possibly result in greater susceptibility to internal damage in the pulp (FRANCK et al. 2003).

In relation to flesh firmness, interaction between the factors evaluated (cold storage and room temperature) was significant ( $p < 0.05$ ) at different harvest dates (Figure 2). Fruit harvested in HD1, after three days in a room temperature, showed no significant changes in firmness compared to the initial assessment, but when evaluated after six days, the fruit were significantly reduced, even before being stored at cold storage (Figure 2A). For the following harvest dates (HD2 and HD3), three days of fruit standing in a simulated environment were sufficient to significantly reduce the flesh firmness (Figures 2B and 2C). The reduction of firmness can occur without the fruit being subjected to cold conditioning; however, according to Agar et al. (1999) certain cultivars have reduced sensory quality.

'Bartlett' pears feature ideal flesh firmness for consumption when they reach values between 10 and 18N (VILLALOBOS-ACUNA et al. 2011). Fruit from HD1 did not reach the recommended values of firmness after being held for three and six days in a simulated environment, without prior cold storage. However, after 20 days of cooling followed by three days in a simulated environment, the fruit showed significant firmness reduction, enough to reach the recommended values for consumption. The organoleptic quality is influenced by several attributes, although flesh firmness exerts great interference with optimal quality for consumption (VILLALOBOS-ACUNA et al. 2011).

Due to the high incidence of physiological disorders, the disposal of replications with over 50% of fruit commitment was established, which occurred at different harvest dates. For this reason, not all assessment periods provided in Figure 2 are listed.

The rate of starch degradation at the time of harvest for the fruit from HD1 was lower than the values obtained in subsequent years (5.00, 7.05 and 8.54 for HD1, HD2 and HD3, respectively). The fruit reached the maximum range of starch degradation after twenty days of cold storage, for the three harvest dates. The related index may be used as a parameter to perform the harvest, since the fruit of

the first harvest showed a lower value in relation to the fruit from the following harvests (HD2 and HD3) conducted after one and two weeks, respectively.

The interaction between the factors evaluated (cold storage and room temperature) was not significant for the soluble solids content of the fruit coming from the different harvest dates, so these factors were studied separately (Figure 3). Polynomial models were adjusted for the soluble solids content of the fruit from HD2 and HD3, which showed peak values after 38 and 40 days of cold storage, respectively. After these periods, there was a reduction in the levels for both harvest dates (Figure 3B and 3C).

Only samples from HD1 presented significant differences ( $p < 0.05$ ) between the levels of room temperature as to the soluble solids content. The fruit evaluated after leaving storage presented the lowest values (11.44 °Brix), followed by those evaluated at day three (11.89 °Brix) and those evaluated at day six (12.13 °Brix). The soluble solids content found at harvest was higher than those recommended by Benitez et al. (2005), who consider content above 10° Brix at harvest as ideal.

As occurred with the soluble solids content, the weight loss showed no significant interaction between the factors evaluated (cold storage and room temperature).

It was estimated that the weight loss of the fruit from HD1 and HD2 after 80 days of cold storage was 2.87% and 5.78%, respectively (Figures 3D and 3E). The weight loss of the fruit in different harvest dates is within the limit of 6.00% reported by Mahajan et al. (2010), so that damage to the overall appearance of pears will not occur. This percentage may vary according to the cultivar, since some support greater weight losses showing no loss of quality, while others with smaller weight losses present damage to the appearance.

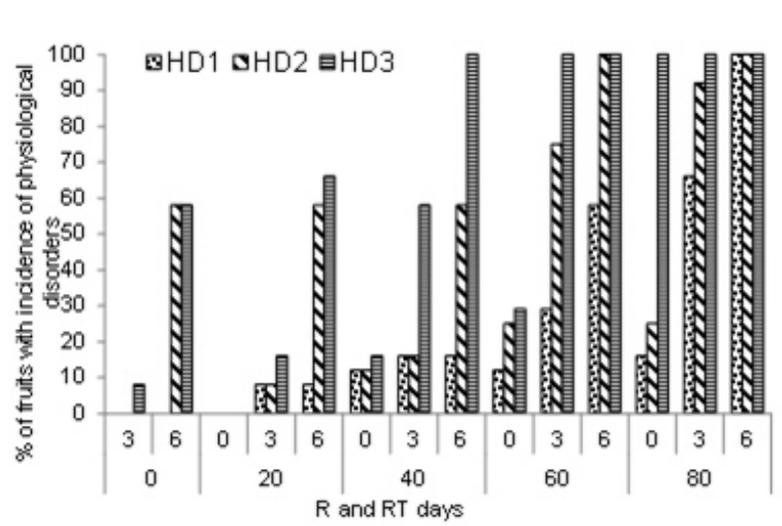
The fruit from HD2 and HD3 showed values of acceptability higher than those of the fruit from HD1 after three days in room temperature without being subjected to refrigerated storage, being 81.53, 79.12 and 67.82, respectively (Table 1). The lowest acceptability attributable to the fruit from HD1 occurred due to high flesh firmness and lack of flavor, which was ratified by higher firmness values and low soluble solids content (Figures 2A and 3A). It was evident that the fruit from HD1 were immature, with high starch and low sugar content, not meeting the requirements of the tasters and having therefore the need to be submitted to conditioning treatment to induce ripening.

The tasters assigned values of 81.92% and

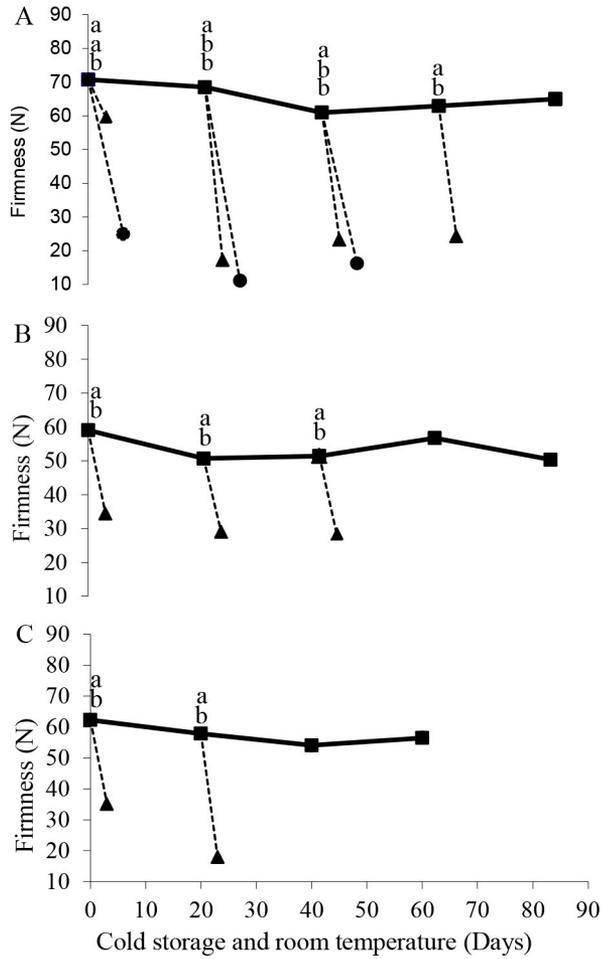
80.18% to the fruit from HD1 after being stored at low temperatures for 20 and 60 days, followed by three days in a simulated environment, respectively (Table 1). According to the reports of the tasters, the highest values are due to juiciness and flavor, but after 60 days, there were reports that the fruit were overripe. Although only 8% of the pears from HD1 were observed with physiological disorder after 20 days of cooling followed by 6 days in the environment, high loss of quality of most fruit for sensory evaluation was found, which made it unfeasible to present these pears to the tasters. The fruit from HD2, after 40 days of cold storage followed by three days at room temperature, had an

index of 82.24% acceptability, and it was reported that the fruit had good texture and were tasty, but some samples tasted bad due the advanced stage of maturation.

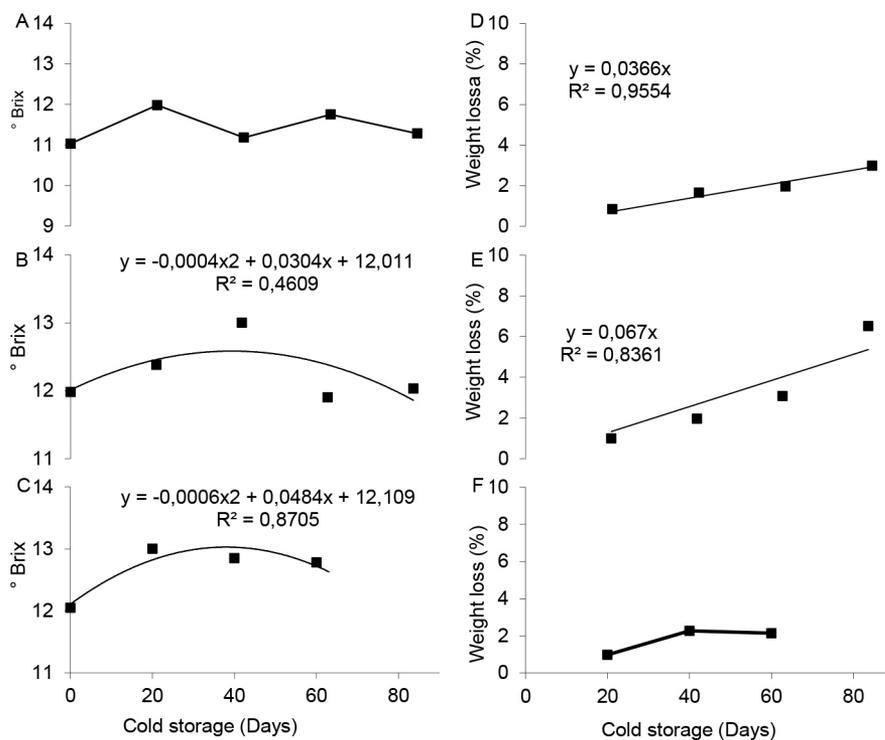
The tasters rated the fruit from HD3 after 20 days of cold storage negatively, which received the lowest acceptability rate (58.93%). This assessment was due to the fact that the fruit were overripe and unpalatable. Benitez et al. (2005) reported that the fruit harvested late or ripening on the plant do not express the typical juiciness of the European pears, presenting a meaty pulp.



**FIGURE 1** – Incidence of physiological disorder in ‘Bartlett’ pears harvested on three dates (HD1=01/25/2010, HD2=02/01/2010 and HD3=02/08/2010) and kept for up to 80 days cooling (R) at  $0 \pm 1^\circ\text{C}$  and  $90 \pm 5\%$  RH and followed by zero, three and six days at room temperature (RT) ( $20 \pm 1^\circ\text{C}$ ). Bento Golçalves, 2010.



**FIGURE 2** – ‘Bartlett’ pears flesh firmness harvested on three dates (HD1=01/25/2010 (A), HD2=02/01/2010 (B) and HD3=02/08/2010 (C)), and kept for up to 80 days at  $0 \pm 1^\circ\text{C}$  and  $90 \pm 5\%$  RH followed by zero (■), three (▲) and six days (●) at room temperature ( $20 \pm 1^\circ\text{C}$ ). Same letters vertically indicate that the averages of environment simulated each time on cold environment do not differ ( $p > 0.05$ ). Bento Golçalves, 2010.



**FIGURE 3** – Soluble solids content pears harvested on three dates (HD1=01/25/2010 (A), HD2 = 02/01/2010 (B) and HD3 = 02/08/2010 (C) and weight loss of ‘Bartlett’ on three dates (HD1=01/25/2010 (D), HD2 = 02/01/2010 (E) and HD3 = 02/08/2010 (F) kept for up to 80 days at  $0 \pm 1^\circ\text{C}$  and  $90 \pm 5\%$  RH. Bento Golçalves, 2010.

**TABLE 1** – Contents of acceptability (%) of ‘Bartlett’ pears harvested on three dates (HD1=01/25, HD2=02/01 and HD3=02/08) and kept for up to 80 days in a refrigerator (R) at  $0 \pm 1^\circ\text{C}$  and  $90 \pm 5\%$  RH and up to six days at room temperature (RT) at  $20 \pm 1^\circ\text{C}$ . Bento Golçalves, 2010.

	R	RT	HD1	HD2	HD3
	0	3	67.82	81.53	79.12
	0	6	72.16	*	*
	20	0	74.70	76.70	58.93
	20	3	81.92	75.13	75.23
	20	6	*	*	*
	40	0	69.21	59.74	68.68
	40	3	69.44	82.24	*
	40	6	71.73	*	*
	60	0	66.63	68.19	70.50
	60	3	80.18	*	*
	80	0	68.21	63.81	*

\* Fruit not subject to the acceptability test because the fruit of 4 replications have shown at least 50% incidence of physiological disorders.

## CONCLUSION

'Bartlett' pears harvested with flesh firmness 70.75 N can be stored in a cold room at  $0 \pm 1^\circ\text{C}$  for up to 40 days and commercialized, preferably, within three days, when they show the firmness recommended for consumption. The extent of both the refrigeration period and the trading period may result in higher incidence of physiological disorders and loss of sensory quality.

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