Influence of the use of acids and films in post-harvest lychee conservation[1]

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ABSTRACT

Lychee (*Litchi chinensis* Sonn.) has a high commercial value; however, it has a short shelf-life because of its rapid pericarp browning. The objective of this study was to evaluate the shelf-life of 'Bengal' lychee fruits stored after treatment with hydrochloric acid and citric acid, associated with cassava starch and plastic packaging. Uniformly red pericarp fruits were submitted to treatments: 1-(immersion in citric acid 100 mM for 5 minutes + cassava starch 30 g L^{-1} for 5 minutes), 2-(immersion in hydrochloric acid 1 M for 2 minutes + starch cassava 30 g L^{-1} for 5 minutes), 3-(immersion in citric acid 100 mM for 5 minutes + polyvinyl chloride film (PVC, 14 µm thick)) and 4-(immersion in hydrochloric acid 1 M for 2 minutes + PVC film). During 20 days, the fruits were evaluated for mass loss, pericarp color, pH, soluble solids and titratable acidity, vitamin C of the pulp and pericarp and activities of polyphenol oxidase and peroxidase of the pericarp. The treatment with hydrochloric acid associated with PVC was the most effective in maintaining the red color of the pericarp for a period of 20 days and best preservation of the fruit. The cassava starch associated with citric acid, and hydrochloric acid did not reduce the mass loss and did not prevent the browning of lychee fruit pericarp.

Key words: *Litchi chinensis* Sonn., modified atmosphere, quality.

RESUMO

Influência da utilização de ácidos e filmes na conservação pós-colheita de lichia

A lichia (*Litchi chinensis* Sonn.) possui alto valor comercial no mercado, entretanto, apresenta vida útil pós-colheita curta, por causa do rápido escurecimento do pericarpo. O objetivo deste trabalho foi avaliar a vida útil pós-colheita de lichias 'Bengal', armazenadas após tratamento com ácido clorídrico e ácido cítrico, associados a fécula de mandioca e embalagem plástica. Frutos com pericarpos uniformemente vermelhos foram submetidos aos tratamentos: 1-(imersão em ácido cítrico 100 mM por 5 minutos + fécula de mandioca 30 g/L por 5 minutos); 2-(imersão em ácido clorídrico 1 M por 2 minutos + fécula de mandioca 30 g/L por 5 minutos); 3-(imersão em ácido cítrico 100 mM por 5 minutos + filme de policloreto de vinila (PVC ,14 µm de espessura)); e 4-(imersão em ácido clorídrico 1 M por 2 minutos + filme de PVC). Durante 20 dias, os frutos foram avaliados quanto à perda de massa fresca, cor do pericarpo, pH, teor de sólidos solúveis e acidez titulável da polpa, vitamina C do pericarpo e da polpa e atividades de polifenoloxidase e peroxidase do pericarpo. O tratamento com ácido clorídrico associado ao PVC foi o mais efetivo na manutenção da cor vermelha e o que melhor conservou as características de qualidade dos frutos. A fécula de mandioca associada ao ácido cítrico e ácido clorídrico não reduziu a perda de massa e não impediu o escurecimento do pericarpo de lichia.

Palavras-chave: *Litchi chinensis* Sonn., atmosfera modificada, qualidade.

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INTRODUCTION

Lychee (*Litchi chinensis* Sonn.) is cultivated in tropical and subtropical areas, and its fruit has a high commercial value in the international market (Jiang *et al*., 2004). Lychee has a bright-red pericarp involving a translucent pulp of great nutritional value (Solomon *et al*., 2006). However, it has a short shelf life due to the rapid pericarp browning, which can occur in less than 72 hours after harvest (del Aguila *et al*. 2009).

Pericarp browning has been attributed to desiccation by heat stress, senescence, chilling injuries, pests and diseases. Skin browning commonly results from the degradation of the anthocyanin pigments by oxidases (polyphenol oxidase (PPO), peroxidase (POD) and ascorbic acid oxidase) (Mizobutsi *et al*., 2010).

The darkening process is triggered when phenolic substrates present in the vacuoles come into contact with the oxidative enzyme that catalyses polyphenol oxidation (PPOs) in the cytoplasm associated with plastid membrane structures. Browning occurs when phenolic substrates, PPOs and oxygen are in optimum conditions of pH, temperature and water activity (Reuck *et al*., 2011).

Water loss during fruit storage disrupts cellular solute compartmentalization allowing the contact between enzymes and their substrates, promoting undesirable reactions that damage the fruit appearance and, therefore, their commercialization (Lima *et al*., 2010).

Thus, new attempts to delay or reduce enzymatic oxidation, prevent oxygen-fruit contact and reduce fruit mass losses are important to reduce browning and maintain market quality of litchee under increased storage periods.

Fumigation with sulfur dioxide has been primarily used to prevent lychee pericarp browning (Ducamp-Collin *et al*., 2008), but fumigation leaves undesirable residues, alters the fruit taste and may result in health risks to consumer and workers in the packing houses (Hojo *et al*., 2011).

Acids have been used as an alternative in the prevention of pericarp browning of lychee, especially the hydrochloric acid (Jiang *et al*. 2004). Other alternatives include the use of ascorbic acid, citric acid, chitosan, lecithin, waxes and plastic packaging (Silva *et al*. 2,010; Sivakumar & Korsten, 2006).

This study evaluated the association of acids, cassava starch and PVC films in the reduction of pericarp browning and quality maintenance of 'Bengal' lychees fruits.

MATERIAL AND METHODS

'Bengal' lychees fruits were harvested with completely red pericarp, in the morning in December 2007. The plants were from the Experimental Orchard, Universidade Federal de Viçosa, Viçosa, Brazil (21º 07' S, 42° 57' W, 651 m a.s.l.).

Fruits with uniformly red pericarp were selected and immersed in the fungicide prochloraz at concentration of 49.5 g/100 L of water for five minutes and dried at room temperature.

The fruits were then submitted to the following treatments: a) (immersion in citric acid 100 mM for 5 minutes+ cassava starch 30 g L^{-1} for 5 minutes), b) (immersion in hydrochloric acid 1 M for 2 minutes + cassava starch 30 g L^{-1} for 5 minutes) c) (immersion in citric acid 100 mM for 5 minutes + polyvinyl chloride film (PVC 14µm thick) d) (immersion in hydrochloric acid 1 M for 2 minutes + PVC film) and e) (immersion in distilled water). The fruits from all treatments, including the control, were packed in polystyrene trays (220 mm x 140 mm x 40 mm), in cold storage at 5.0 ± 1.2 °C and 90 ± 5% RH.

The fruits were evaluated every four days over a period of 20 days for mass loss, pericarp coloration attributes, pH, soluble solids and titratable acidity, vitamin C in the skin and pulp and pericarp activities of polyphenol oxidase (PPO) and peroxidase (POD).

Gravimetric determination was used to find mass loss and results were expressed as a percentage of fresh mass loss.

The pericarp color was determined by reflectometry, using a Minolta reflectometer (Color Reader CR-10). Two readings were taken per fruit in diametrically opposite positions. The coordinates were L* (light), ranging from 0 (black) to 100 (white), and a*, ranging from green (-60) to red (+60) (McGuire, 1992).

The pulp pH was determined by readings from tissue samples in digital pHmeter after grinding in a blender.

PPO and POD activity on pericarp were determined by methods adapted from Maia *et al*. (2011). The enzyme extract was obtained using 1g of pericarp added with 5 ml of 0.2 M phosphate buffer (pH 6.0), cooled in an ice bath and triturated in a polytron grinder at 20,500 rpm for 40 s. The suspension was centrifuged at 10,000 g for 21 minutes at 4 °C. The activity was determined by seven absorbance readings at 30-seconds intervals in a spectrophotometer λ = 425 nm (PPO) and λ = 470 nm (POD). The results were expressed in enzyme units per gram of sample based on the extract amount that induced an increase in absorbance of 0.01 units per minute.

A factorial design (2x2) +1 was used to conduct the experiment, where two acids were combined with two films and a control unit consisting of six fruits. The experiment was arranged in a completely randomized design with three replications. Data were submitted to analysis of variance and regression using the software SAEG 9.1 - System for Genetic Analysis and Statistics. Regression analysis as a function of time was performed for all variables, regardless of the significance of the interaction of the factor with time. Descriptive analysis was used for the data of PPO and POD enzyme activity.

RESULTS AND DISCUSSION

The associations of PVC film with hydrochloric acid and PVC film with citric acid were the treatments that most successfully reduced the loss of fresh fruit matter. At the end of the experimental period these treatments showed fresh matter losses of only 2.68 and 2 98%, respectively (Figure 1A). In contrast, the combination of hydrochloric acid with cassava starch and the association of citric acid with cassava starch resulted in high percentages of fresh fruit loss, reaching up to 18.56 and 18.38% on day 20 of storage (Figure 1A). Somboonkaew & Terry (2010) also report that the application of plastic films on lychee fruits reduces mass loss. However, Campos *et al*., 2011, showed that the coating with cassava starch associated with chitosan was effective in reducing mass loss in strawberries. Chen *et al* (2001) stated that a mass loss of 18% is sufficient to cause total browning of lychee pericarp and, contrarily, Lima *et al*. (2010), consider that a loss of 3 to 5% can promote the same effect.

Regarding to light, it was found that the treatments of PVC film associated with hydrochloric acid and the combination of PVC and citric acid (Figure 1B) resulted in a smaller reduction of the L* values at the end of the experimental period. Fruit color, measured by the parameter a* had smaller alterations in the treatment with the combination of film and hydrochloric acid (Figure 1C) in the last storage days. The parameters L* and a* are critical to the successful commercialization of the fruit because the smaller the values of a*, the smaller the intensity of the red colour in the fruit pericarp, while L* represents light/brightness of the pericarp. According to Solomon *et al*. (2012), an undesirable change in the color of lychee, shown by the rapid reduction in light (L*) indicates pericarp browning and loss of intense-red color, and its consequent loss of commercial value.

A decrease in the soluble solids content was observed during all the storage period and in all treatments (Figure 2B). This suggests that there is a reserve consumption due to the metabolic activity of the fruit (Silva *et al*., 2010). Lima *et al*. (2011) observed similar behavior, although Hojo *et al*. (2011) found increased values in soluble solids in ‘Bengal’ lychee after hydrothermal treatment and hydrochloric acid.

An increase in pH was observed in fruits of all treatments. However, the starch and hydrochloric acid treatments promoted the highest increments of pH (Figure 2A).

There was a reduction in the acidity levels of fruits from all treatments. The treatments with starch and

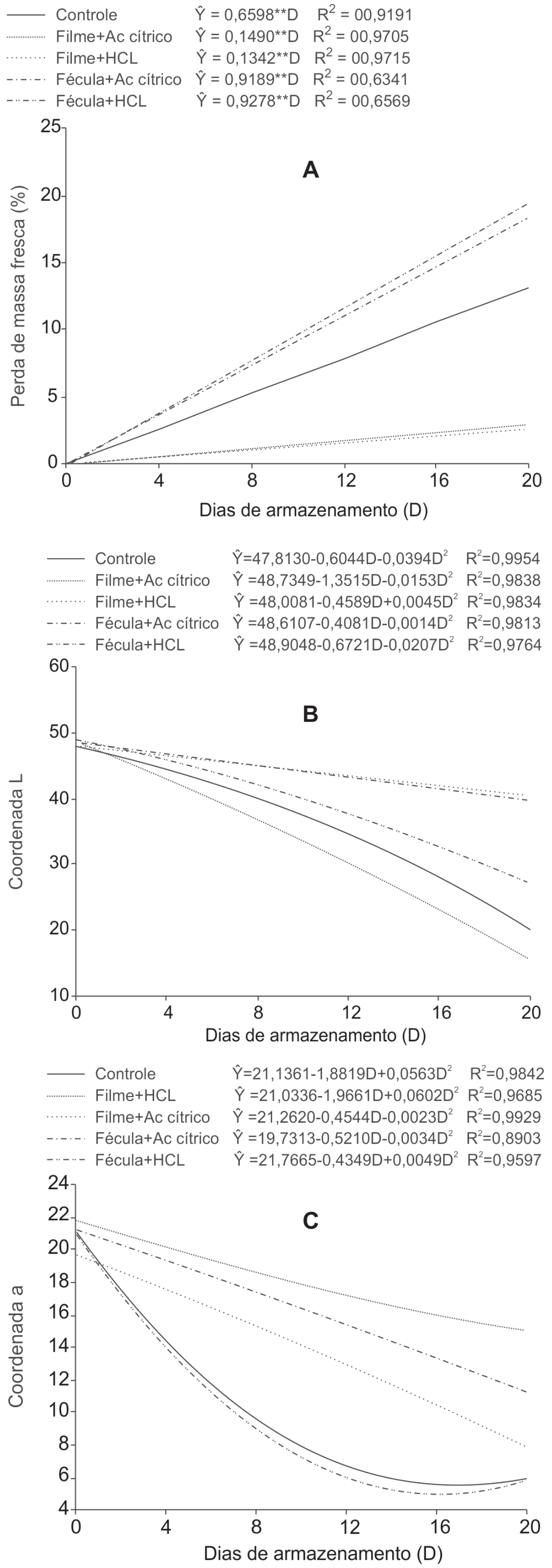

Figure 1. Fresh mass loss (%) (A); coordinate L* (B); and coordinate a* (C) of ‘Bengal’ lychee fruitS stored at 5 ± 1.2 °C and 90 ± 5% RH for 20 days.

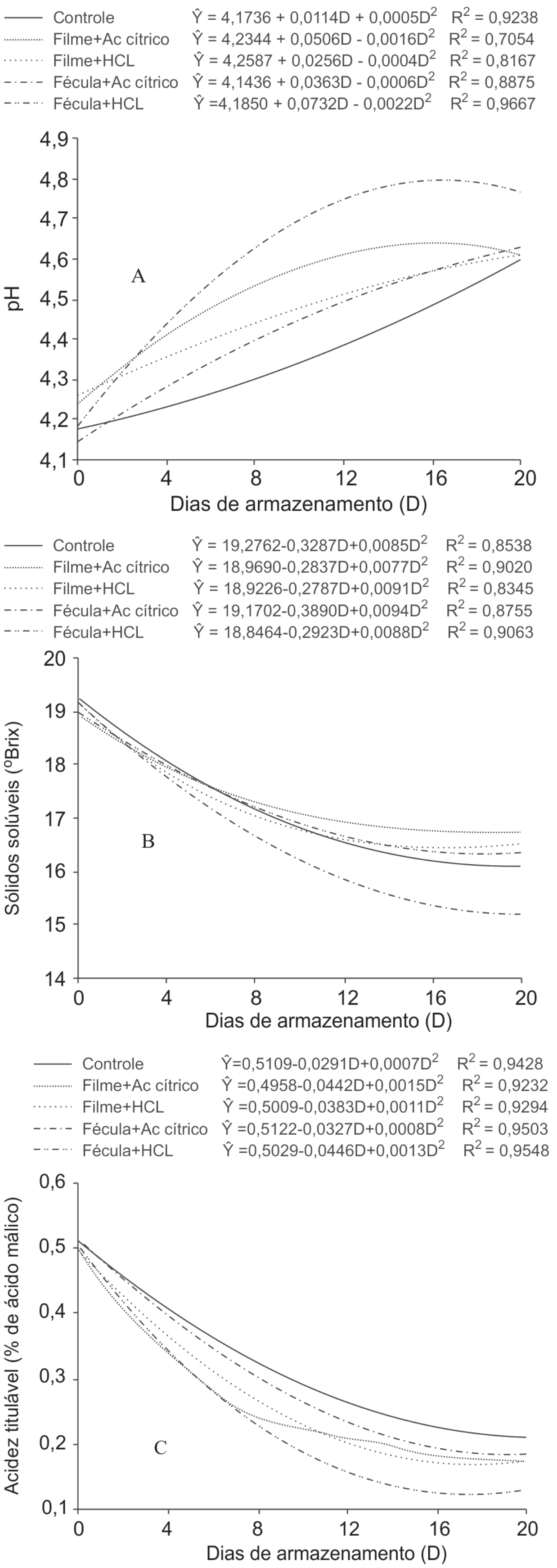

Figure 2. pH (A), soluble solids (° Brix) (B) and titratable acidity (% malic acid) (C) of 'Bengal' lychee fruit pulp stored at 5 ± 1.2 °C and 90 ± 5 % RH for 20 days.

hydrochloric acid showed the smallest reductions in the levels of acidity (Figure 2C). This reduction may indicate that organic acids are used as respiratory substrates and as carbon skeletons in the synthesis of new compounds (Reuck *et al*. May 2011). Hojo *et al*. (2011) also observed a reduction in the acidity of lychee after hydrothermal treatment and hydrochloric acid.

Reductions in the vitamin C content of fruit pericarp were observed in all treatments (Figure 3A). In this case, smaller reductions in vitamin C were found in the fruits treated with hydrochloric acid associated with cassava

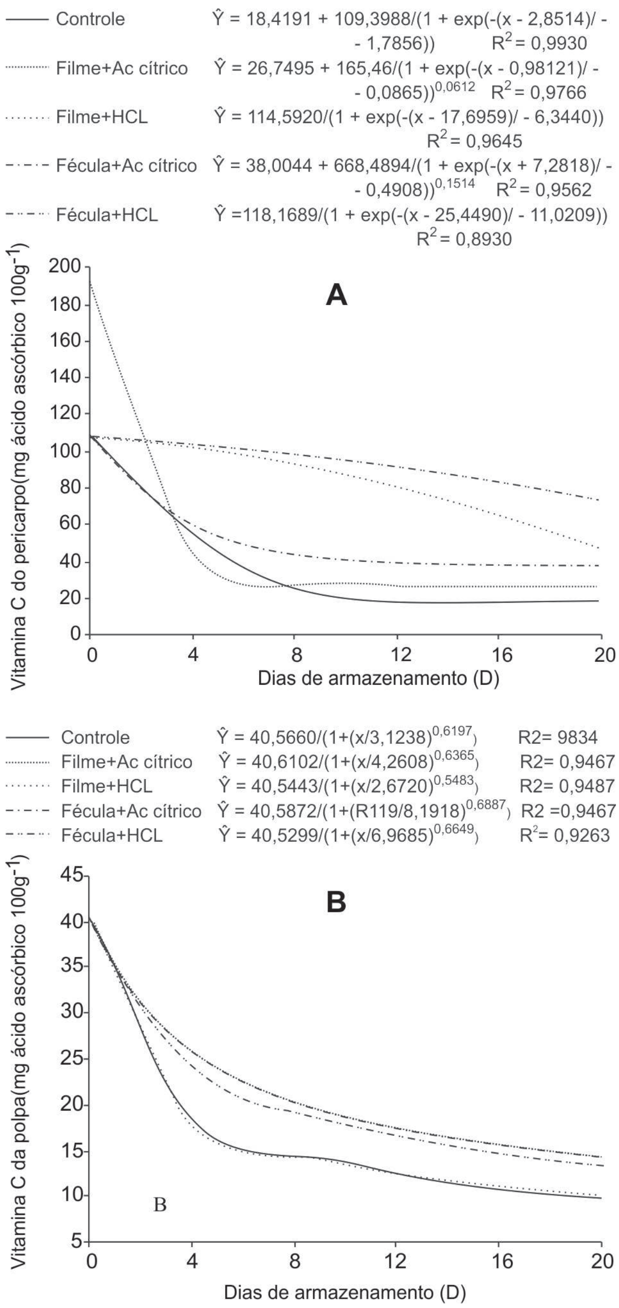

Figura 3. **Figure 3.** Vitamin C (ascorbic acid 100 mg g^{-1}) of pericarp (A) and pulp (B) of 'Bengal' lychee stored at 5 ± 1.2 °C and 90 ± 5% RH for 20 days.

starch and PVC. C. Silva *et al*. (2010) reported similar behavior in ‘Bengal’ lychee treated with 30 mM ascorbic acid, as the ascorbic acid is not highly effective in color retention of lychee due to their reversible inhibitory effect on the enzyme.

Smaller reductions in the levels of ascorbic acid were observed in the pulp packaged in PVC associated with acids (Figure 3B). Hojo *et al*. (2011) found lower levels of ascorbic acid in lychee pulp treated with 1% hydrochloric acid for six minutes.

On the fourth storage day, the polyphenol oxidase activity increased in fruits of all treatments (Figure 4A), but the combination of hydrochloric acid and PVC film promoted lower enzymatic activity. The same was observed for the peroxidase activity in all treatments and the combination of hydrochloric acid and PVC film also promoted a lower increase in the enzymatic activity (Figure 4B). Silva *et al*. (2010) also observed that the enzymes were in peak activity on the fourth storage day in lychee treated with different doses of ascorbic acid. An initial increase followed by a subsequent decrease in the activity of POD was observed by Zheng & Tian (2006) in Huaizhi lychee treated with oxalic acid and stored at 25ºC and 80% RH for six days. Hojo *et al*. (2011) also found an increase in PPO activity in lychee between the days 3 and 4 of storage. Zhang *et al*. (2004) reported high peroxidase activity for lychee cv. Huaizhi on day 4 of storage at 28 ºC. Lima *et al*. (2011) observed an increase of PPO activity on day 10 of storage for lychees treated with ethylene and 1-methylcyclopropene.

Based on all the studied characteristics, it was found that the ‘Bengal’ lychee treated with hydrochloric acid and packaged with PVC film kept the red color of the pericarp similar to the harvest day, maintaining its quality characteristics throughout the experimental period in refrigerated conditions. Therefore, lychee fruits that underwent this treatment were still suitable for consumption, even after 20 days of storage.

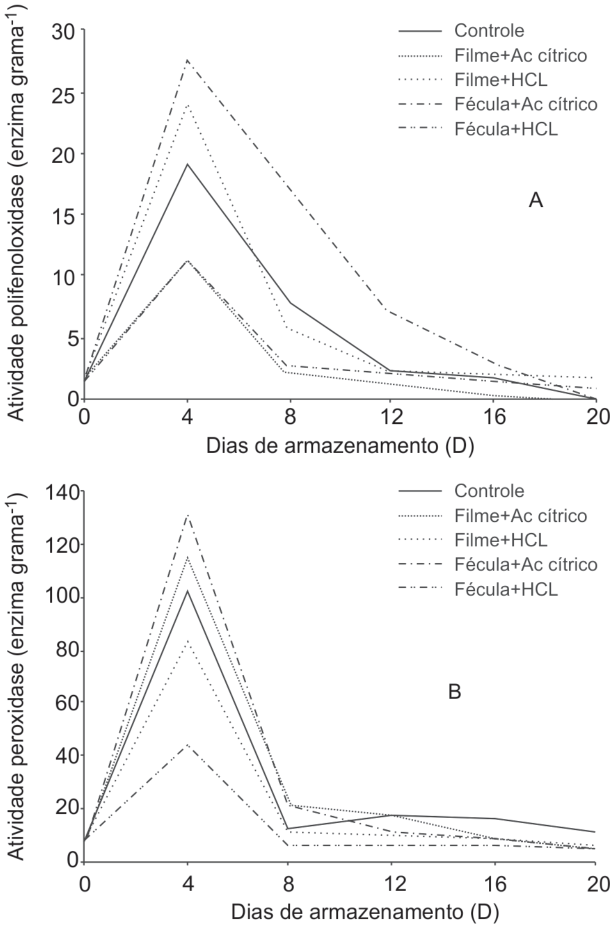

Figure 4. Polyphenol oxidase activity (A) and peroxidase (B) from ‘Bengal’ lychee pericarp stored at 5 ± 1.2 ° C and 90 ± 5% RH for 20 days.

CONCLUSIONS

The treatment with hydrochloric acid associated with PVC was able to maintain the red pericarp color during 20 days and was also the treatment that most preserved the fruit quality characteristics.

The cassava starch associated with the citric acid, and hydrochloric acid did not reduce mass loss and was unable to prevent lychee pericarp browning.

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