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Research Article

The physiology of chilling injured longan fruit

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Abstract

It is known very well that longan fruit was easily deteriorated during storage at low temperature. Longan pulp, translucent aril, generally contains high amount of sugars while the longan peel, yellowish-brown pericarp, consists of high phenolic substances. In this study, longan fruits were kept at low temperature (4ºC) to investigate the changes of pulp and peel properties. It was found that longan peel was obviously malformation as a result of the increasing in an electrolyte leakage value, hardness and discoloration. The dry peel then reabsorbed water that caused swelling and disintegrating. The pulp color altered from translucent white to light yellow since the polyphenol oxidase activity dramatically increased. The pulp also contained more juice after longer storage. However, it is still difficult to identify the symptoms of chilling injury on longan pulp. One possibly involved factor is the electrolyte leakage value as it increased during storage.

Keywords: discoloration, polyphenol oxidase, electrolyte leakage, longan

Introduction

The longan (*Dimocarpus longana* Lour.) is belonged to the Sapindaceae family. It is recognized that Thailand is the world's largest longan producer (Batten, 1986). Most of longan growing area is located in the northern region of Thailand (10ºN) such as Chiang Mai and Lamphun provinces. From previous research, the alternate bearing of longan has been induced by potassium chlorate treatment (Charoensri et al., 2005). Currently, longan growing areas are spread around Thailand such as Chanthaburi, Sakaeo and Samut Sakhon provinces and five of popular longan cultivars (E-dor, Beow-keow, Chompoo, Haew and Phet Sakhon) are favorably planted on those regions. Nevertheless, only one variety: E-dor, was selected as a product champion to export from Thailand (Jaroenwanit et al., 2001). Even though longan is a non-climacteric fruit, it's shelf life is very short according to peel browning and hardness by enzymatic process (Paull and Chen, 1987; Khunpon et al., 2011). After harvest, fruit peel is rapidly discoloration, hardness at ambient temperature or softening or swelling during low temperature storage (Wara-Aswapati et al., 1988). In this case, sulfur dioxide fumigation is applied to prevent longan peel browning or swelling (Jiang et al., 2002). However, the residue of sulfur dioxide in longan peel and pulp are encountered problem for exporter (Hai et al. 2011). Therefore, the present research aimed to investigate the deterioration symptoms of longan peel and pulp during low temperature storage.

Materials and methods

Longan fruits cv. E-dor were harvested from a commercial orchard in Lamphun province and transported to Bangkok by car. After grading, longan fruits were separated into two groups and placed in plastic baskets (15x30cm) with plastic sheet (0.063mm thickness) liner.

The first group was stored at ambient temperature (27-31°C; RH 58%) while the other one was stored at 4°C (RH 79.5%). Later, longan fruits were randomly sampled for quality analysis every 3 days. This experiment was repeated 3 times.

Total phenol content was determined according to method of Singleton and Rossi (1965). Longan pulp (30 g) or peel (5 g) was ground with 80% ethanol and adjusted to the final volume (50 ml) with same solution. The ground solution was centrifuged at 15660 g for 20 min. The supernatant (1ml) was mixed with 10 ml of 10% Folin-Ciocalteu and 8 ml of 7.5% sodium bicarbonate. The flask containing solution was incubated in hot water bath (35°C) for 1 h and then cold water bath for 1 h. Subsequently the flask was shifted and left at room temperature. The reaction mixture was used to measure phenol content by the spectrophotometical method at 760 nm.

Polyphenol oxidase (PPO) extraction and determination were carried out following the method of Luh and Phithakpol (1972). Flesh or peel tissue (10 g) was ground with 95% cold acetone and filtered with Whatman No.2. The acetone powder (0.2 g) was then dissolved in 100 ml of citric acid phosphate buffer pH 6.2 and gently blended for 10 min. The blended solution was filtered with Whatman No.42 and the aliquot was used for measuring enzyme activity. Ten milliliters of enzyme solution was mixed with 5 ml of 0.1M catechol and the activity was measured by the spectrophotometical method at 420 nm. Protein content was determined according to Bradford (1976).

Electrolyte leakage was investigated according to the method of Fuchs et al. (1989). Longan, flesh or peel, disk was prepared with a cock borer (1 cm in diameter). Two grams of disks were placed into an Erlenmeyer flask as well as 30 ml of 0.4M mannitol and mixed on a shaker (100 rpm) for 3 hours at 25°C. The disk was then measured of the electrolyte conductivity by a TH 27 conductometer. Subsequently, it was transferred to a deep freeze (-80°C) for 15 min. After thawing, disk was incubated in a hot air oven (121°C) for 30 min and measured of electrolyte conductivity as mentioned above. Electrolyte leakage was finally calculated as percentage of electrolyte conductivity before and after tissue freezing.

Results and discussion

After harvest, longan peel was rapidly discolored and malfunctioned by unsuitable temperature and relative humidity conditions. High temperature enhanced discoloration of longan peel (Fig. 1). Longan peel surface showed discoloration after storage for 3 days at room temperature while inside of the peel (white layer) was not much changed. The fruit peel was completely hard after storage for 6 days at room temperature (data not shown). Interestingly, the peel showed swelling and disintegrating during storage at low temperature condition.

The result revealed that longan peel contained higher amounts of phenolic compounds than pulp (Fig. 2 and 3). This data was supported by Hsu and Chyn (1991) as they found that phenolic compounds in longan peel and seed were acetonylgeraniin A and B, and gallic acid which were further oxidized by PPO. Degree of discoloration in longan varied depending upon the activity of PPO and phenolic substances (Prapaipong and Rakariyatham, 1990). It is possible that the polymerization of tannic acid caused peel hardness and discoloration to bar the effective gas and water movement. Polyphenol oxidase activity in longan peel and pulp was related to the phenolic substances. The activity of PPO in peel sharply increased while the

phenol content decreased during storage (Fig. 2 and 4). However, both PPO activity and phenol content in pulp increased at first period of storage (Fig. 3 and 5). The pulp color altered from translucent white to light yellow after storage for 18 days. The PPO activity also indicated that the peel had more suffered to CI than the pulp because browning always needs oxygen in it reaction and most of oxygen passed through wounding or drying tissues.

Longan fruit is classified as a berry type, peel and pulp which definitely separate from each other. Fruit pulp (aril) is originated from the seed funiculus that may not supply water to fruit peel during loss of their weight. For chilling injury investigation, the electrolyte leakage of peel tissue decreased during the storage period (Fig. 6). This suggests that longan peel tissue was rapidly malfunctioned after harvest. Conversely, the pulp contained more juice after longer storage. This is still difficult to identify the symptoms of chilling injury on longan pulp tissue but one of the engaged factors could be the electrolyte leakage value as it increased during storage (Fig. 7). Our results led to the deduction that low temperature had high effect to induce chilling injury in the pulp than the peel tissue.

Hence, we can conclude that chilling injury on longan fruit is able to observe from the rapid rising of PPO activity in both peel and pulp whereas electrolyte leakage from both sources is incapable to indicate chilling injury since it changed a little. Moreover, wax coating could be more retardant on the degradation of peel than sodium metabisulfite treatment.

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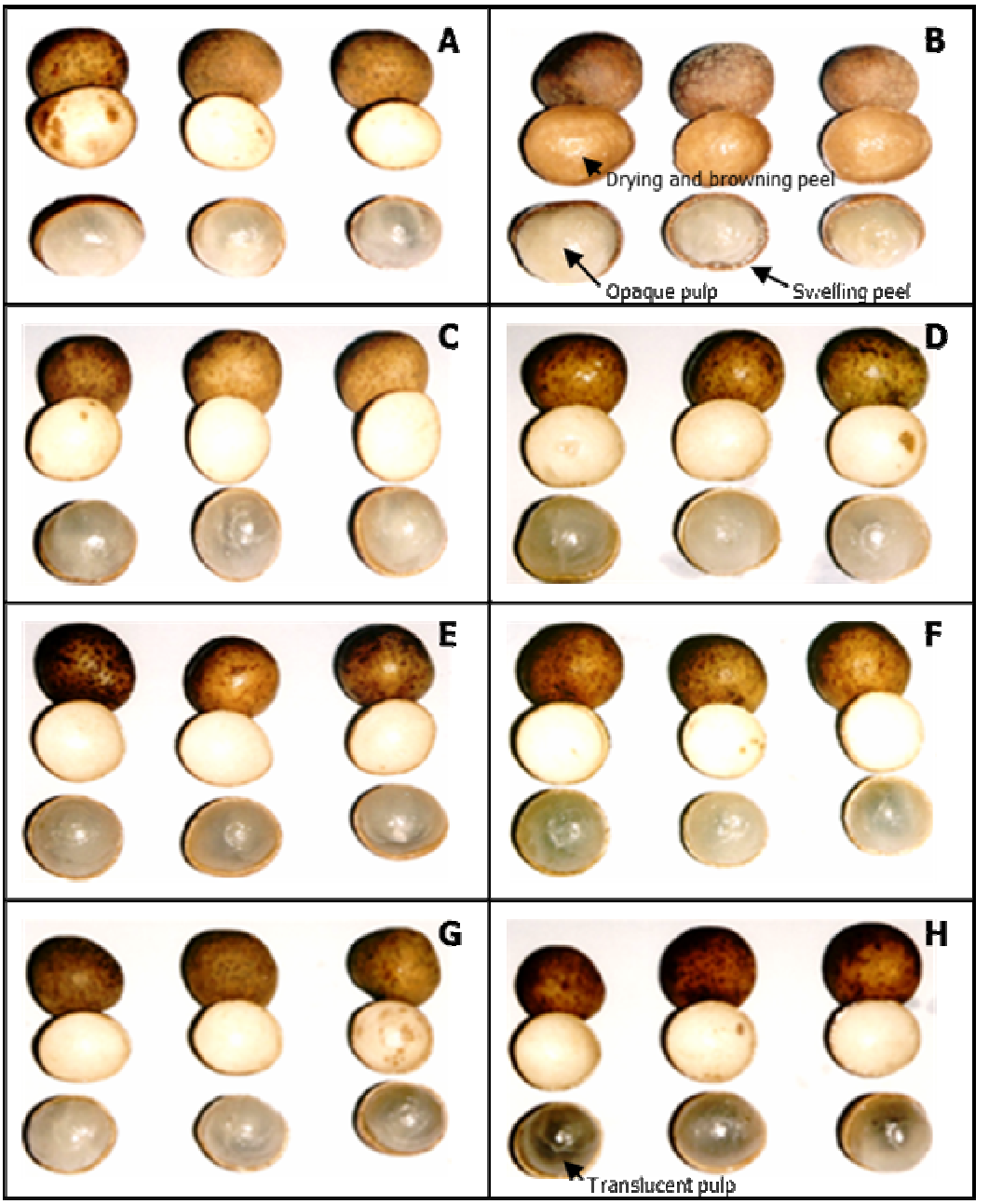

Figure 1. Longan fruit peel and pulp during storage: A and B = 3 and 6 days at ambient temperature (27-31^{O}C), respectively; C, D, E, F G and H = 3, 6, 9, 12, 15, 18 days at 4^{O}C, respectively.

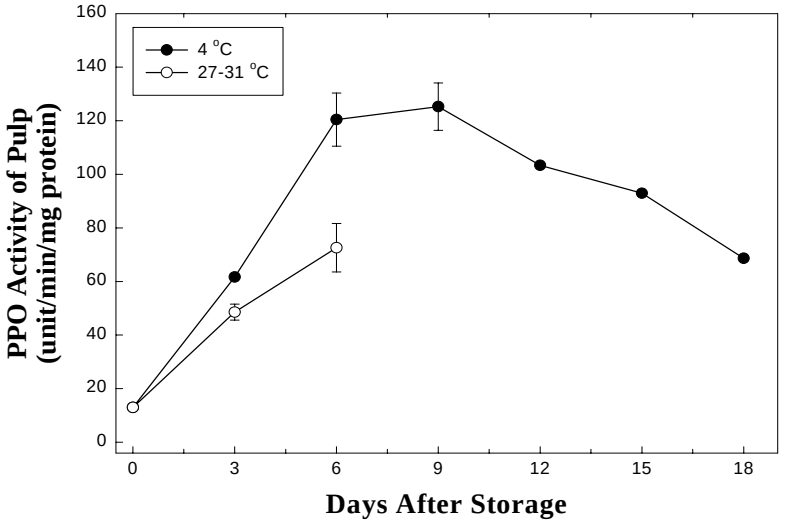

Figure 2. Phenol content changes in longan peel during storage at ambient temperature (27-31^{O}C) and 4^{O}C. This experiment was repeated 3 times. Means±SE of data from a replicate experiment are presented.

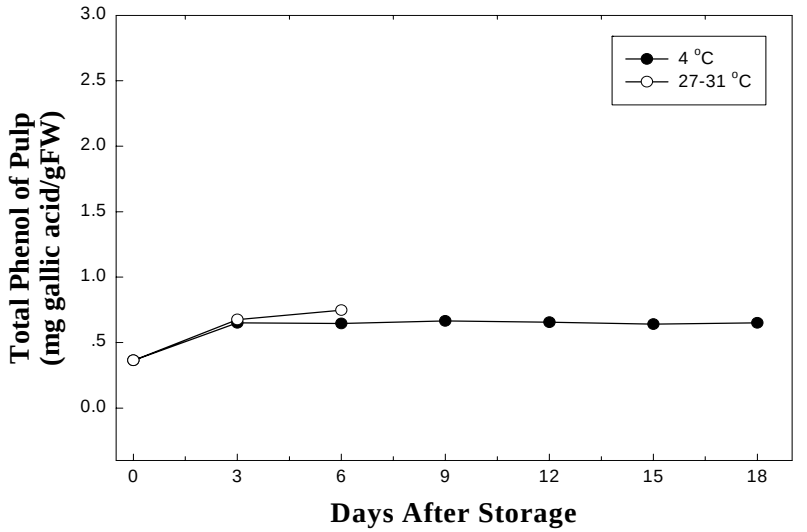

Figure 3. Phenol content changes in longan pulp during storage at ambient temperature (27-31^{O}C) and 4^{O}C. This experiment was repeated 3 times. Means±SE of data from a replicate experiment are presented.

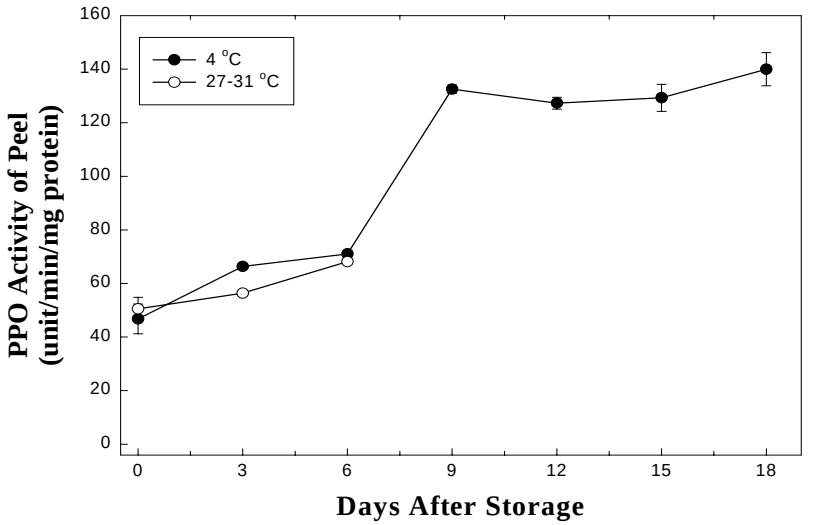

Figure 4. Polyphenol oxidase activity in longan peel during storage at ambient temperature (27-31^{O}C) and 4^{O}C. This experiment was repeated 3 times. Means±SE of data from a replicate experiment are presented.

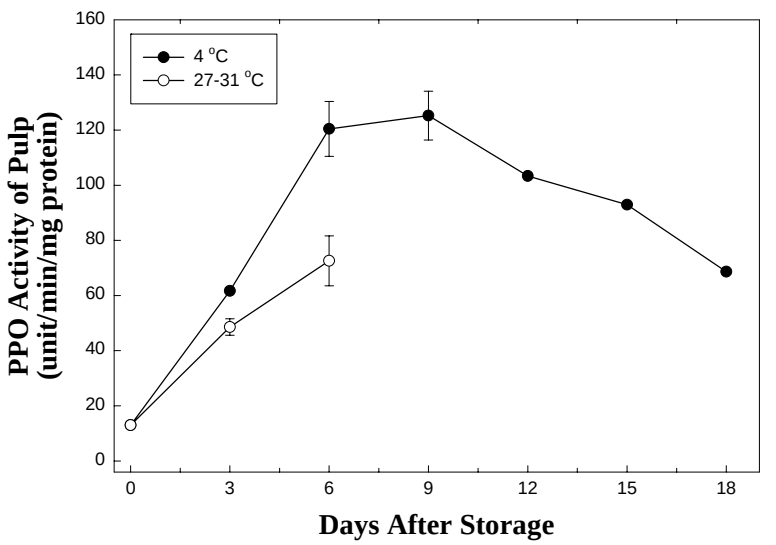

Figure 5. Polyphenol oxidase activity in longan pulp during storage at ambient temperature (27-31^{O}C) and 4^{O}C. This experiment was repeated 3 times. Means±SE of data from a replicate experiment are presented.

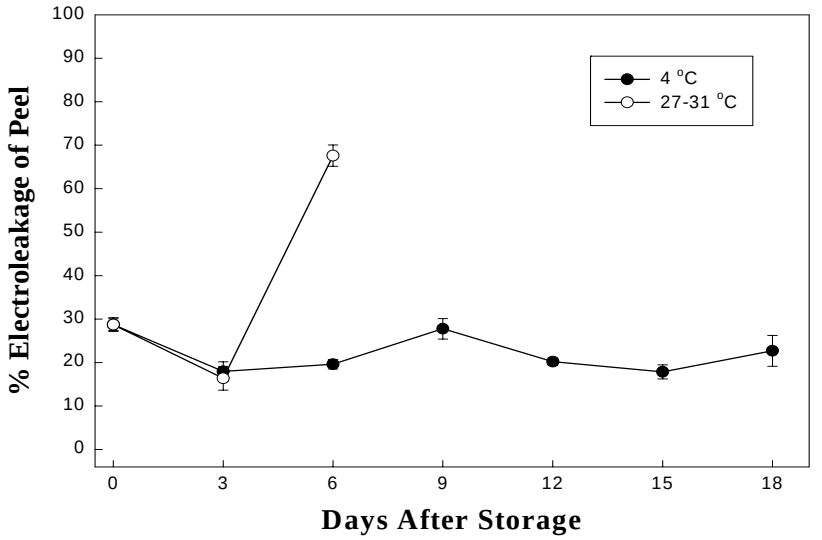

Figure 6. Electrolyte leakage percentage in longan peel during storage at ambient temperature (27-31^{O}C) and 4^{O}C. This experiment was repeated 3 times. Means±SE of data from a replicate experiment are presented.

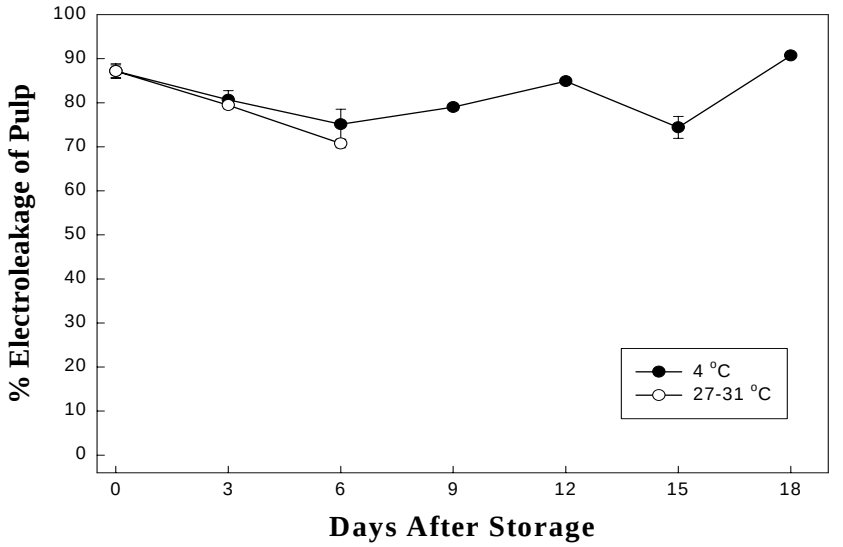

Figure 7. Electrolyte leakage percentage in longan pulp during storage at ambient temperature (27-31 ^{O}C) and 4 ^{O}C. This experiment was repeated 3 times. Means±SE of data from a replicate experiment are presented.