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Inhibitory effects of propyl gallate on membrane lipids metabolism and its relation to increasing storability of harvested longan fruit

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ABSTRACT

Effects of propyl gallate on membrane lipids metabolism and its relation to storability of harvested longan fruits were studied. The results showed that the propyl gallate-treated longans maintained lower activities of pericarp phospholipase D (PLD), lipase and lipoxygenase (LOX) than those in control fruits. Such treatments could maintain higher levels of pericarp unsaturated fatty acids (USFAs), higher pericarp indices of unsaturated fatty acids (IUFA), and higher pericarp ratio of unsaturated fatty acids to saturated fatty acids (U/S) than those in control fruits. Furthermore, propyl gallate also delayed color changes of pericarp in the harvested longans. Therefore, the postharvest treatments of longan fruits with propyl gallate for increasing storability of longan fruits might be explained by a decrease in activities of PLD, lipase and LOX, and an the increased unsaturation of fatty acids, which could delay membrane lipids metabolism and maintain cell membrane characteristics.

1. Introduction

Longan (*Dimocarpus longan* Lour.) fruit is consumed globally and has a high commercial value. China is the primary producer of longan fruit (Apai, 2010; Jiang & Li, 2001; Jiang, Zhang, Joyce, & Ketsa, 2002; Lin, Chen, & Lin, 2010; Lin et al., 2014; Su et al., 2005). However, longan fruit has a short shelf-life with aril breakdown and pericarp browning, which can be attributed to the fruit maturing in summer with high temperatures and high humidity (Lin, Lin, Chen, Chen, & Lin, 2013; Lin, Hu et al., 2013; Lin, Lin, Chen et al., 2016). Pericarp browning is the major factor limiting for storage and marketing of harvested longan fruit (Duan et al., 2007; Duan, Zhang et al., 2011; Holcroft, Lin, & Ketsa, 2005; Lin et al., 2015).

Recently, more attention has been given to changes in cell membrane properties in this respect (Rui et al., 2010; Saquet, Streif, & Bangerth, 2003). Cell membrane degradation is highly correlated with membrane lipids metabolism (Lin et al., 2016), and the process includes the hydrolysis of membrane phospholipids to free fatty acid, peroxidation of fatty acid in cell membrane, and generation of hydroperoxide or other reactive oxygen species (ROS) (Liu et al., 2011). Excessive ROS generation also damages the cell membrane, which promotes browning (Lin et al., 2016). Previously, it has been reported that internal browning of loquats involved the loss of membrane integrity, increased in activities of phospholipase D (PLD) and lipoxygenase (LOX), higher levels of palmitic and stearic acids, belong to saturated fatty acids (SFAs), lower levels of inoleic and linolenic acids, belong to unsaturated fatty acids (USFAs), and a lower USFAs to SFAs (U:S) ratio. However, the heat-treatment of loquat fruit was associated with less internal browning, lower activities of PLD and LOX, and reduced SFAs content as well as higher concentrations of USFAs and a higher U:S ratio (Rui et al., 2010). Moreover, Lin et al. (2014) suggested that hydrogen peroxide, as an exogenous reactive oxygen, could promote the browning development of longan pericarp by reducing endogenous scavenging capacity. In addition, hydrogen peroxide could enhance LOX activity, reduce the levels of USFAs, U:S and IUFA (Lin et al., 2016). In contrast, propyl gallate has been reported to be associated with increased endogenous antioxidant activities and increased ROS scavenging capacity. These functions reduce the impact of ROS production and peroxidation of fatty acid in cell membranes and, accordingly, inhibited pericarp browning retaining the commercial value of the crop (Lin, Lin et al., 2013; Lin et al., 2015).

Currently, no studies have been published on the effect of propyl gallate on membrane lipids metabolism in longan fruit in relation to retardation of pericarp browning and maintenance of fruit

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commercial value. Therefore, to advance knowledge of this mechanism, this study investigated changes in pericarp color, activities of PLD, lipase and LOX, and fatty acid composition in cell membrane of harvested longan fruit.

2. Materials and methods

2.1. Plant material and treatments

Mature longan (*Dimocarpus longan* Lour. cv. Fuyan) fruit were harvested and treated as described in our previous studies (Lin, Hu et al., 2013; Lin et al., 2015).

2.2. Pericarp color measurement

The method described by Zhang et al. (2015) was used to measure chromaticity L^*, a^*, b^* values of longan pericarp color.

2.3. Assay of PLD, lipase and LOX activities

The methods of Liu et al. (2011) and Lin et al. (2016) were used to determine PLD, lipase and LOX activities. Protein content was determined according to the method of Bradford (1976).

2.4. Determination of membrane fatty acid composition

The method described by Lin et al. (2016) was used for extraction and determination of lipid as well as the analysis of composition and relative content of membrane fatty acids (FAs) by gas chromatograph (Model 7890A, Agilent Technologies Co. Ltd., USA). IUFA and U/S were calculated according to Lin et al. (2016)

2.5. Statistical analyses

All experiments were repeated in triplicate. Each value in figures are presented as the mean ± standard error (n = 3). Analytic variance was tested by SPSS version 17.0.

3. Results and discussion

3.1. Propyl gallate - delayed changes in chromaticity values

The loss of pericarp color, characterized by increasing pericarp browning, is the key factor accounting for reduced apparent quality and commercial value of longans (Chen et al., 2015). The objective measurement of color using chromaticity L^*, a^* and b^* system was used to represent the change in apparent color. L^* represents lightness, and positive a^* and b^* indicate red and yellow, respectively (Venkatachalam & Meenune, 2012; Zhang et al., 2015). Previously, fruit color has been measured at 13, 14, 15 and 16 weeks after anthesis and the result showed increased browning, as evidenced by lower values for L^* and b^* (Venkatachalam & Meenune, 2012). The loss of red color in litchi fruit coincided with decreased L^*, a^* and b^* (Zhang et al., 2015). Apple polyphenols could postpone the loss of red color and pericarp browning by maintaining higher values of L^*, a^* and b^* (Zhang et al., 2015).

In the present study, L^*, a^* and b^* in control fruit gradually decreased during storage (Fig. 1), indicating the gradually declined lightness of longans. The results were accordance with our previous works, in which pericarp browning index increased and commercial value declined during storage (Lin, Lin et al., 2013; Lin et al., 2015). Pericarp browning index was inversely associated with L^*, a^*, b^* values (correlation coefficient $r = -0.9809$, -0.9879, -0.9813, respectively, $p < 0.05$), while commercial value was strongly positive correlated with chromaticity L^*, a^*, b^* values ($r = 0.9906$, 0.9460, 0.9686, respectively, $p < 0.05$).

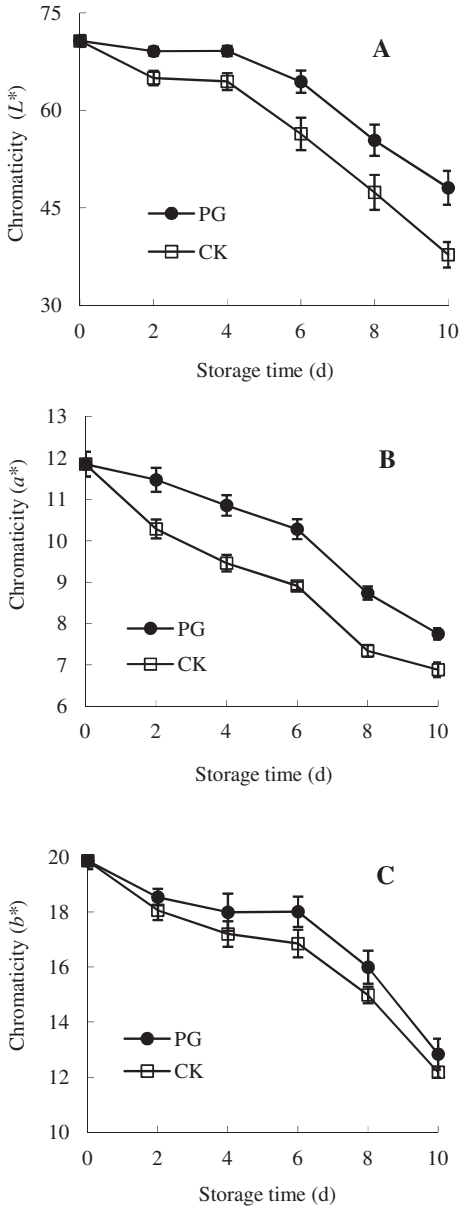

Fig. 1. Changes in chromaticity values of L^* (A), a^* (B) and b^* (C) in pericarp of harvested longan fruit.

Values for L^*, a^* and b^* reduced slowly in the propyl gallate-treated fruits. They were significantly ($p < 0.05$) higher than corresponding values in control fruits. These results are consistent with suppressed of pericarp browning and higher commercial value of longans treated by the propyl gallate (Lin et al., 2013). These results above demonstrated that propyl gallate exerted a strong effect on the lightness of apparent color suggestion inhibition of pericarp browning, and, thus, a higher rate of commercially acceptable fruit. Inhibition of browning through the application of propyl gallate on cold-stored banana fruits has also been reported (Jiang, Chen, Lin, & Chen, 1991).

3.2. Propyl gallate – inhibited changes in activities of PLD, lipase and LOX

Browning occurrence or decreased storability are the basic characteristics of senescence in harvested fruits such as peaches (Jin, Zhu, Wang, Shan, & Zheng, 2014), loquats (Cao, Yang, Cai, &