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Original Article

Prevention of enzymatic browning of postharvest longan fruit by N-acetyl-L-cysteine and 4-hexylresorcinol

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Abstract

The effects of N-acetyl-L-cysteine and 4-hexylresorcinol on browning inhibition of postharvest longan fruits cv. Daw were studied. The fruits were dipped for 5 min 5, 25, and 45 mM N-acetyl-L-cysteine and 0.01, 0.03 and 0.05% 4-hexylresorcinol, stored at 15±2°C and 85 %RH for 6 days. The results showed that N-acetyl-L-cysteine prevented pericarb browning of the fruits better than 4-hexylresorcinol, which resulted in better color values but did not significantly differ ($p>0.05$) among the concentrations used. Besides, the longan fruits treated with N-acetyl-L-cysteine tended to decrease disease incidence and lowered weight loss 2 compared with those treated with 4-hexylresorcinol. Neither browning inhibitor had an effect on the fall off fruits.

Keywords: longan; N-acetyl-L- cysteine; 4-hexylresorcinol

1. Introduction

Longan (*Dimocarpus longan* Lour.) is one of the most economically important fruits in the north of Thailand. In 2005, 134,433 tons of fresh longan were exported. Rapid pericarp browning during storage is the main problem resulting restriction on the export of longan to long distance markets. (Sardsud *et al.*, 1994) For many years, the recommended method to control postharvest decay and prevent pericarp browning in longan has been sulfur dioxide (SO_2) treatment. Recently, importing countries such as China and Singapore have restricted the import of langan product and other fruits and reduced the maximum permitted residual level of SO_2. Longan consumers are becoming cautious regarding SO_2 residues, due to allergenic symptoms. There is a need to develop effective methods to replace SO_2 treatment, with something less harmful to humans and the environment (Whangchai *et al*., 2006).

N-acetyl-L-cysteine is an amino acid containing sulfhydryl group and can prevent browning reaction by a couple reaction. One reaction is that the chemical will react with quinine and gives a stable and colorless compound. The other way is that it acts as a competitive inhibitor which alters the reaction between substrates and polyphenol oxidase (PPO) enzyme which limited the browning reaction (Nicolas, 1994; Sapers, 1993). It is usually applied into juices e.g. pear and apple juices and it was reported that 0.568 and 1.70 mM of N-acetyl-L-cysteine inhibited browning reaction in pear and apple and were effectively as same as using of 2.27 and 1.136 mM sodium bisulfite (Molnar and Friedman, 1990), and in fresh-cut produces e.g. apple and potatoes by using of 25 mM N-acetyl-L-cysteine and dipping time of 1-2 min, was effective in browning inhibition as same as using of 25 mM sodium bisulfite (Buta *et al*., 1999 ; Molnar and Friedman, 1990).

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4-hexylresorcinol (4HR) is a GRAS (Generally Recognized As Safe) resorcinol derivative that has been described as a potent inhibitor of shrimp blackspot due to PPO activity, and has been successfully used for browning control of fresh-cut apples, potatoes and avocados (Jimenez and Gracia-Carmona, 1997; Monsalve-Gonzalez *et al*., 1995). The combination of HR with N-acetyl-L-cysteine, isoascorbic acid and calcium propionate prevented browning in Red Delicious apple slices for up to 5 weeks at 5°C (Buta *et al*., 1999).

The treatment of fresh longan using sulfur dioxide is very effective in browning prevention on the pericarp of the fruits. Due to the restriction of the import countries, sulfur dioxide is less use due to allergic to humans. There is a need to find some alternative chemicals which are effective and can be used instead of sulfur dioxide. The objective of this study was to investigate the browning inhibition of longan fruits using N-acetyl-L-cysteine and 4-hexylresorcinol to provide better appearance and safety of the consumers.

2. Materials and Methods

2.1 Plant material

Longan fruit (*Dimocarpus longan* Lour.) cv. Daw, was obtained from an orchard in Phitsanulok province, Thailand. The fruits were harvested in the evening and packed in a 20 kg plastic basket laid with the leaves and transported to the laboratory. The fruits were then separated into bunches with selected homogenous size and number. The fruit bunches without defects and spoilage were used in the experiment.

2.2 Effect of N-acetyl-L-cysteine and 4-hexylresorcinol on browning inhibition of longan fruit

The experimental design in this study was a CRD using 3 concentrations of each chemicals (5, 25 and 45 mM of N-acetyl-L-cysteine and 0.01, 0.03 and 0.05% of 4-hexylresorcinol). The longan bunches dipped in distilled water were used as control. The bunches were dipped for 5 min in different solutions which added 0.02% tween 20 and left dry at room temperature (28± 2°C). The treated fruits were stored at 15±2°C, 85% RH. The fruit pericarbs were measured for the color values using colorimeter Minolta CR 300 (Japan). The fruits with disease incidence, weight loss and fall off fruits were monitored every 2 days of storage.

2.3 Statistical Analysis

The statistical analysis was carried out using a statistical program and Duncan's New Multiple Range Test was used to determine significant differences among the treatments.

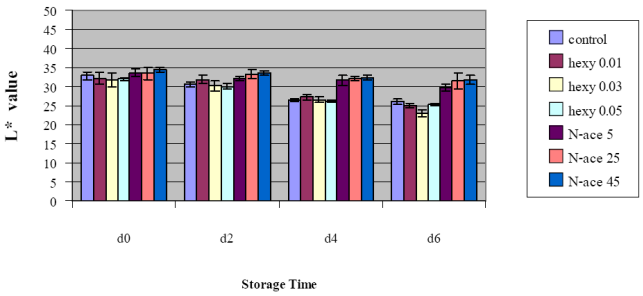

Figure 1. Effect of various concentrations of N-acetyl-L-cysteine and 4-hexylresorcinol on L* values of postharvest longan stored at 15±2°C, 85 %RH. Vertical bars represent standard errors.

3. Results and Discussion

3.1 Effect of N-acetyl-L-cysteine and 4-hexylresorcinol on browning inhibition of longan fruit

The L* values (lightness) of the fruit pericarb treated with various concentrations of N-acetyl-L-cysteine and 4-hexylresorcinol solutions compared with the control are shown in Figure 1. The values tended to decrease along the storage time. After 6 day storage, the L* values ranged between 22.89-31.76 and the fruits treated with different concentrations of N-acetyl-L-cysteine, tended to inhibit browning on fruit pericarb better than those treated with 4-hexylresorcinol and the control ($p<0.05$). The L* values of the fruits treated with different concentrations of N-acetyl-L-cysteine, were not significantly different ($p>0.05$). It was reported that cysteine could inhibit PPO enzyme which is the main cause of browning in many fruits because of its reduc-ing property. It interacts and forms complex with O-quinines so that the browning could not occur (Dorantes-Alveraz and Chiralt, 2000 ; Yue-Ming, 1998). 4-hexylresorcinol is used as an antibrowning agent, especially in fresh-cut or minimally processed fruits and vegetables. It also reacts with PPO and then inhibits browning reaction but has no bleaching property (McEvily *et al*., 1992). In this experiment, the results showed that different concentrations of 4-hexylresorcinol could not inhibit browning on the fruit pericarb.

When considering the relation between the L* values of N-acetyl-L-cysteine and 4-hexylresorcinol treated longans at various concentrations, it was found that the correlation coefficients (r) were between -0.975 to -0.988 and -0.952 to -0.987, respectively. This means that the chemical concentrations used in this experiment, influenced the changes of the L* values, therefore the chemicals used in this research, could significantly inhibit browning reaction on the longan pericarb ($p<0.05$) (data not shown).

Figure 2 shows the a* values (redness) of longan fruit pericarb treated with N-acetyl-L-cysteine and 4-hexylresorcinol solutions. The a* values tended to increase along storage time and on Day 6 the a* values ranged between

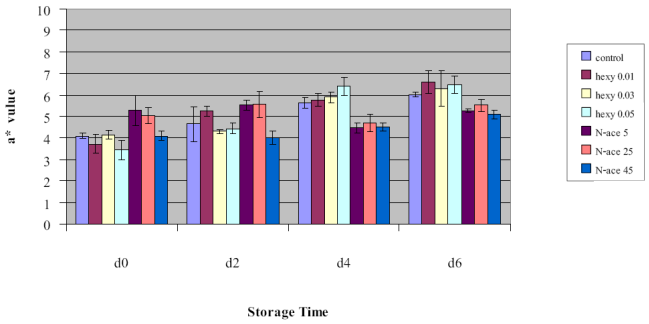

Figure 2. Effect of various concentrations of N-acetyl-L-cysteine and 4-hexylresorcinol on a* values of postharvest longan stored at 15±2°C, 85 %RH. Vertical bars represent standard errors.

5.10-6.59. Longans treated with 3 different concentrations of 4-hexylresorcinol were not different from each other and also the control. However, those treated with 3 different concentrations of N-acetyl-L-cysteine tended to inhibit browning on the pericarb where the a* values on Day 4 and Day 6 were lower than those treated with 4-hexylresorcinol and the control.

The b* values (yellowness) of longan fruit pericarb treated with N-acetyl-L-cysteine and 4-hexylresorcinol are shown in Figure 3. The b* values of longans treated with both chemicals tended to decrease along storage time. On Day 6, the b* values ranged between 8.87-14.89 and it was found that different concentrations of N-acetyl-L-cysteine tended to provide higher b* values than those treated with 4-hexylresorcinol and the control ($p<0.05$). It is shown that N-acetyl-L-cysteine could inhibit browning on the fruit pericarb but there was not significantly different ($p>0.05$) among the three concentrations used.

When considering the relation between the b* values of N-acetyl-L-cysteine and 4-hexylresorcinol treated longans at various concentrations, it was found that the correlation coefficients (r) were between -0.872 to -0.962 and -0.959 to -0.965, respectively. Hence, the chemical concentrations used in this experiment, provided good browning inhibition on the pericarb (data not shown).

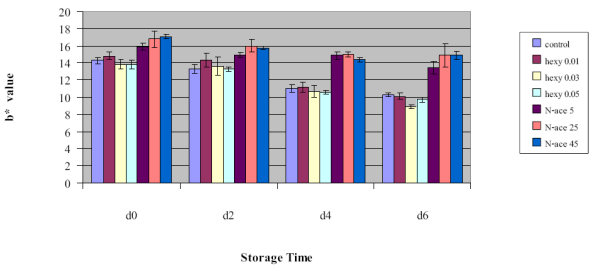

Figure 3. Effect of various concentrations of N-acetyl-L-cysteine and 4-hexylresorcinol on b* values of postharvest longan stored at 15±2°C, 85 %RH . Vertical bars represent standard errors.

The c* values (intensity) of longan fruit pericarb treated with N-acetyl-L-cysteine and 4-hexylresorcinol are shown in Figure 4. The c* values tended to decrease along the storage and on Day 6 they ranged between 10.91-15.72. The use of different concentrations of N-acetyl-L-cysteine provided higher c* values than those treated with 4-hexyl-resorcinol and the control ($p<0.05$). However, the use of 3 different concentrations of N-acetyl-L-cysteine did not significantly different result in c* values ($p>0.05$).

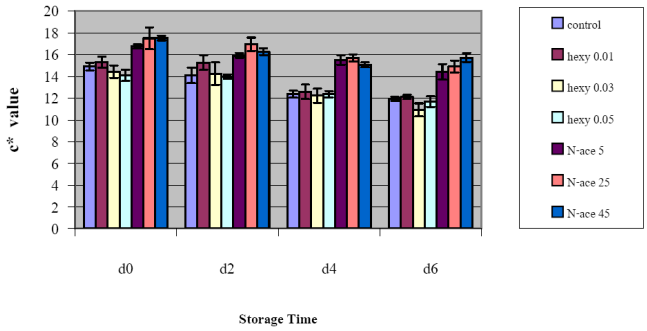

Figure 4. Effect of various concentrations of N-acetyl-L-cysteine and 4-hexylresorcinol on c* values of postharvest longan stored at 15±2°C, 85 %RH. Vertical bars represent standard errors.

Figure 5 shows the h* values of longan fruit peri-carb treated with N-acetyl-L-cysteine and 4-hexylresorcinol. The h* values tended to decrease along storage time. On Day 6, the h* values ranged between 54.99-71.01. Different concentrations of N-acetyl-L-cysteine resulted in significantly higher h* values ($p<0.05$) than those treated with 4-hexyl-resorcinol and the control, especially on Day 4 and Day 6. The use of different concentrations of N-acetyl-L-cysteine showed that there was not different in the h* values between longans treated with both chemicals and the control.

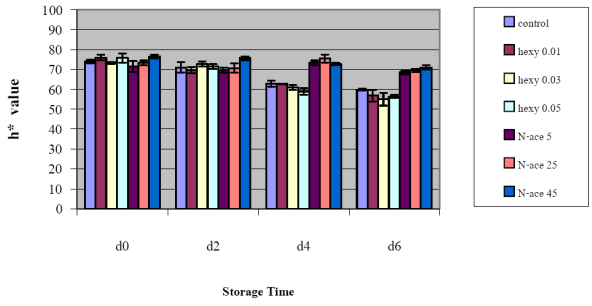

Figure 5. Effect of various concentrations of N-acetyl-L-cysteine and 4-hexylresorcinol on h* values of postharvest longan stored at 15±2°C, 85 %RH. Vertical bars represent standard errors.

The effect of N-acetyl-L-cysteine and 4-hexylresorcinol on the disease incidence was investigated and the results are shown in Figure 6. The disease incidence of the treated longans increased with increasing storage time. It was

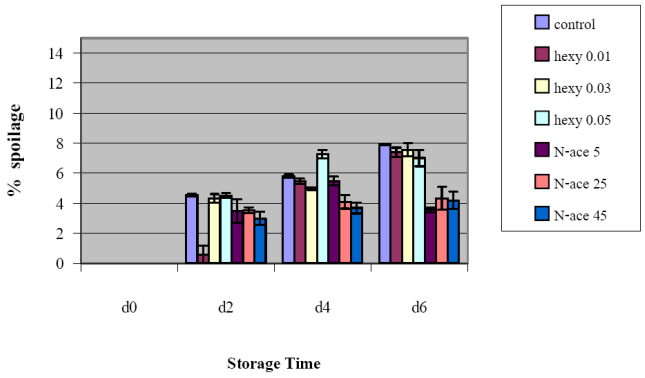

Figure 6. Effect of various concentrations of N-acetyl-L-cysteine and 4-hexylresorcinol on % spoilage of postharvest longan stored at 15±2°C, 85 %RH. Vertical bars represent standard errors.

reported that the cause disease incidence were *Acinetobacter* sp. (Lu *et al*., 1992) and also *Rhizopus* sp., *Alternaria* sp., *Pestalotiopsis* sp., *Penicillium* sp., and *Botryodiplodia* sp., (Jiang, 1997; Lu *et al*., 1992), which contaminate on the fruit pericarb. When comparing the disease incidence of longans treated with both browning inhibitors, it was shown that the fruits treated with N-acetyl-L-cysteine resulted in less disease incidence than those treated with 4-hexylresorcinol and the control. However, the 3 differentconcentrations of N-acetyl-L-cysteine gave no significantly difference in disease incidence.

Figure 7 shows the weight loss of longans treated with N-acetyl-L-cysteine and 4-hexylresorcinol. The weight loss of the fruits tended to increase along the storage. The longans treated with N-acetyl-L-cysteine had less weight loss than those treated with 4-hexylresorcinol and the control, which resulted in less browning on the pericarb. When compared between the 3 different concentrations of N-acetyl-L-cysteine used greater. The weight loss was not different. The more weight loss of the fruits caused wilt and freshness reduction and then resulted in browning on the pericarb. The browning reaction on the fruit pericarb is

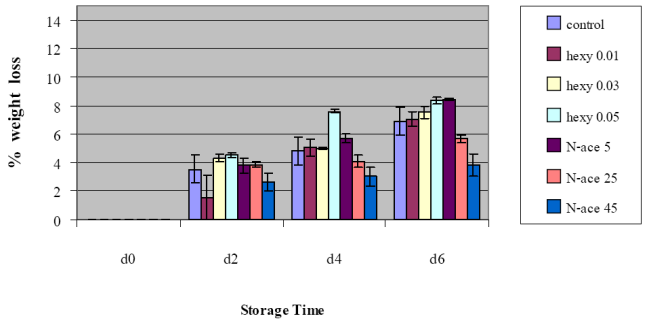

Figure 7. Effect of various concentrations of N-acetyl-L-cysteine and 4-hexylresorcinol on % weight loss of postharvest longan stored at 15±2°C, 85 %RH. Vertical bars represent standard errors.

caused by oxidation of phenolic compounds by PPO (Tian *et al.,* 2002; Jiang, 1999a; Liu, 1999) and also from the loss of moisture on the fruit pericarb hence the enzyme is activated (Su and Yang, 1996; Lu *et al.,* 1992).

The fall off fruits from the bunches of longans treated with N-acetyl-L-cysteine and 4-hexylresorcinol is shown in Figure 8 They tended to increase along the storage. The fall-off fruits which were treated with various concentrations of N-acetyl-L-cysteine, 4-hexylresorcinol and the control, were not different when stored for 6 days at 15±2°C and it could be assumed that the browning inhibitors used had no effect on the strengthen of the joint of the fruit bunches.

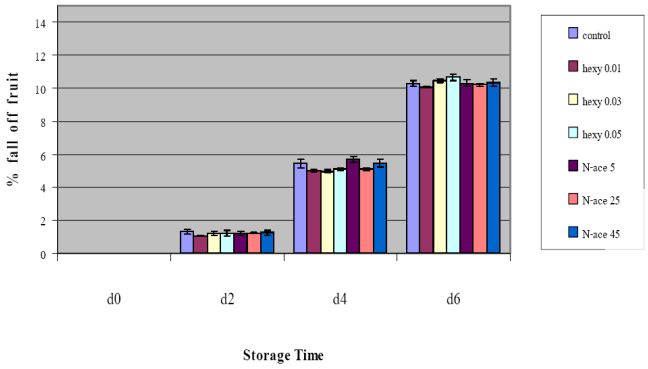

Figure 8. Effect of various concentrations of N-acetyl-L-cysteine and 4-hexylresorcinol on % fall off fruit of postharvest longan stored at 15±2°C, 85 %RH. Vertical bars represent standard errors.

4. Conclusion

Fresh longan production of the world markets are in competition and mostly depend on the quality e.g. fruit pericarb color, size, shelf life and also the safety of the fruits. The use of N-acetyl-L-cysteine and 4-hexylresorcinol, which are defined as GRAS could be used to reduce browning on the pericarb instead of sulfur dioxide fumigation of the fruits. From this experiment it is shown that N-acetyl-L-cysteine provided better browning inhibition than those treated with 4-hexylresorcinol when stored at 15±2°C for 6 days. However, there was no difference in the color values among the concentrations used when treated with N-acetyl-L-cysteine. Besides, N-acetyl-L-cysteine tended to decrease disease incidence of fruits and lower weight loss when compared with 4-hexylresorcinol and the control and better browning inhibitor used in this experiments had an effect on the number of fall-off fruits.

Acknowledgements

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References

Buta, J. G. M., H. E. Spaulding, D. W. and Wang, C. Y. 1999. Extending storage life of fresh-cut apples using natural products and their derivatives. Journal of Agricultural and Food Chemistry. 47(1) : 1-6.

Dorantes-Alvarez, L. and Chiralt, A. 2000. Color of Minimally Processed Fruits and Vegetables as Affected by some Chemical and Biochemical Changes. pp. 111-126. *In* "Minimally Processed Fruits and Vegetables". Fundamental Aspects and Applications. Alzamora, S. M. , Tapia, M. S. and Lopez-Malo, A. (eds.). Aspen Publishers, Inc. Maryland.

Jiang, Y. M. 1997. The use of microbial metabolites against post-harvest diseases of longan fruit. International Journal of Food Science and Technology. 32, 535-538.

Jiang, Y. M. 1999. Purification and some properties of polyphenol oxidase of longan fruit. Food Chemistry. 66: 75-79.

Jimenez, M. and Garcia-Carmona, F. 1997. 4-Substituted resorcinols (sulfite alternatives) as slow-binding inhibitors of tyrosinase chatecholase activity. Journal of Agriculture and Food Chemistry. 45(6) : 2061-2065.

Liu, J. M. 1999. Studies on abstraction and stability of yellow pigment and colour-retenting and fresh-keeping of longan fruit. Journal of Fruit Science. 16: 30-37.

Lu, R. X., Zhan, X. J., Zhuang, R. F., Huang, W. N., Cai, L. X. and Huang, Z. M. 1992. Studies on storage of longan fruits. Journal of Subtropical Plant Research Communications. 21: 9-17.

McEvily, A. J., Inengar, R. and Otwell, W. S. 1992. Inhibition of enzymatic browning in foods and beverages. Critical Reviews in Food Science and Nutrition 32 : 253-273.

Molnar, I. and Friedman, M. 1990. Inhibition of browning by Sulfur Amino Acid. 3. Apple and Potatoes. Journal of Agriculture and Food Chemistry. 38: 1652-1656.

Monsalve-Gonzalez, A., Barbosa-Canovas, G. V., McEvily, A. J. and Iyengar, R. 1995. Inhibition of enzymatic browning in apple products by 4-hexylresorcinol. Food Technology. 110-118.

Nicolas, J. J. 1994. Enzymatic browning reactions in apple and apple products. Critical Reviews in Food Science and Nutrition. 34 (2) : 109-157.

Sapers, G.M. 1993. Browning of foods : control by sulfites an antioxidants, and other means. Food Technology. 47 (1) : 75-84.

Sardsud, U., Sardsud, V., Sittigul, C. and Chaiwangsri, T. 1994. Effect of plant extracts on the in vitro and in vivo development of fruit pathogens. *In* Jonhson, G. I. Highley, (Eds.) Development of Post-harvest Handling Technology for Tropical Tree Fruit. ACIAR, Canberra, Australia.

Whangchai, K., Saengnil, K. and Uthaibuta, J. 2006. Effect of ozone in combination with some organic acids on the control of postharvest decay and pericarp browning of longan fruit. Crop Protection. 25 : 821-825.

Yue-Ming, J. 1999. Purification and some properties of polyphenol oxidase of longan fruit. Food Chemistry. 66 : 75-79.

Su, Y. R. and Yang, B. D. 1996. Experiments on storage of post-harvest longan fruit ambient temperature. Fujian Fruit 24: 14-17.

Tian, S. P., Xu, Y., Jiang, A. L. and Gong, Q. Q. 2002. Physiological and quality response of longan fruit to high O_2 or high CO_2 atmospheres in storage. Postharvest Biology and Technology. 24: 335-340.