การชะลอการเปลี่ยนแปลงทางสรีรวิทยาและคุณภาพของผลมังคุด (*Garcinia mangostana* L.) โดยบรรจุภัณฑ์และ 1-MCP

Delaying the Physiological and Quality Changes of Mangosteen Fruit (*Garcinia mangostana* L.) by Packaging and 1-MCP

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บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาการเปลี่ยนแปลงทางสรีรวิทยาและคุณภาพของผลมังคุด (*Garcinia mangostana* L.) ที่บรรจุในถุงพลาสติกชนิดต่างๆ และเก็บรักษาที่ 13°C ความชื้นสัมพัทธ์ 95% นาน 30 วัน โดยนำผลมังคุดที่สุกแก่ทางการค้า (ระยะที่ 2-3) มาล้างด้วยน้ำประปาและจุ่มในสารกำจัดเชื้อราโปรคลอราซความเข้มข้น 500 มล./ล. ก่อนบรรจุในถุงชนิดต่างๆ ดังนี้ ถุงที่ดูดซับเอทิลีน (ES) ถุงพอลิเอทิลีนเจาะรู (PPE) ถุงพอลิเอทิลีนเจาะรูความหนาแน่นต่ำ (LDPE) และ ถุง LDPE ที่ใส่ซองบรรจุ 1-MCP ชนิดผง ผลมังคุดที่ไม่ได้บรรจุถุงทำหน้าที่เป็นชุดควบคุม ผลการทดลองพบว่า การบรรจุผลมังคุดในถุง LDPE + ซอง 1-MCP มีประสิทธิภาพดีที่สุดในการชะลอการเปลี่ยนแปลงสีเปลือกและกลีบเลี้ยง ความแน่นเนื้อ อัตราการหายใจ การผลิตเอทิลีน และพบการเกิดโรคผลเน่าน้อยกว่าผลมังคุดในชุดควบคุม นอกจากนี้ พบว่าปริมาณก๊าซคาร์บอนไดออกไซด์ภายในถุงเพิ่มสูงขึ้น ขณะที่ปริมาณออกซิเจนภายในถุงลดลงในระหว่างการเก็บรักษา ผลการทดลองนี้แสดงให้เห็นว่า การใช้ถุง LDPE ที่ใส่ซองบรรจุ 1-MCP ชนิดผง ร่วมด้วย สามารถรักษาคุณภาพของผลมังคุด โดยมีผลชะลอกระบวนการสุกและการพัฒนาของโรคในผลมังคุดระหว่างการเก็บรักษาที่อุณหภูมิต่ำได้

คำสำคัญ: คุณภาพ, บรรจุภัณฑ์, ระยะสุกแก่, 1-MCP

Abstract

The objective of this research was to investigate the physiological and quality changes of mangosteen fruit (*Garcinia mangostana* L.) packed in different types of bags and stored at 13°C and 95% relative humidity for 30 days. The fruits harvested at commercial maturity stages (stage 2-3) were washed with tap water and disinfected in 500 ml/l Prochloraz (fungicide) before being packed in various bag types: ethylene scavenger (ES) bag, perforated polyethylene (PPE) bag, low-density polyethylene (LDPE) bag, and LDPE bag with -MCP sachet. Non-packaged fruits served as a control. The results indicated that packaging mangosteen fruits of both maturity stages in LDPE bag + 1-MCP sachet showed the best effect in retarding of pericarp and calyx color changes, pericarp firmness, respiration rate, ethylene production, and fruit rot development in comparison with the non-packaged control. Furthermore, it was found that the carbon dioxide concentration inside the bag increased whereas oxygen concentration declined during storage. The results suggest that using LDPE bag with 1-MCP sachet could maintain the quality of mangosteen fruit by delaying the ripening process and also disease development during storage at low temperature.

Keywords: quality, packaging, maturity, 1- MCP sachet

Introduction

Mangosteen, one of the most common tropical fruits, is a climacteric fruit (Paull and Ketsa, 2004). The fruit is rapidly ripen and senescence throughout the physiological process including color, flavor, harden of pericarp,

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and pathogen infection (Piriyavinit *et al*., 2011; Khewkhom *et al*., 2011). At room temperature, it has a short shelf life of about 4-5 days as the pericarp becomes hard and the calyx dehydrates. Modified atmosphere packaging (MAP) has been developed to delay deterioration by providing a protective air surrounding the produce. MAP is used with various kinds of produce, where internal gas inside the package depends on the type of produce, packaging materials and storage temperature (Cliffe-Byrnes and O'Beirne, 2005). MAP bag has been reported to extend the storage life and maintain the quality of mangosteen for 16 days at 12°C (Pranamornkith *et al*., 2003). Recently, successful commercial application of 1-methylcyclopropene (1-MCP) has been shown to inhibit ethylene production (Watkins, 2006) and prolong the shelf life of mangosteen by delaying hardening of fruit pericarp, color changes and calyx wilting (Piriyavinit *et al*., 2011). However, the combined effects of MAP and 1-MCP on mangosteen fruit during cold storage have not yet been reported. Thus, the objective of this research was to investigate the effectiveness of MAP and/or 1-MCP sachet treatment in delaying physiological changes and maintaining the quality of mangosteen fruit during storage at low temperature.

Materials and Methods

Mangosteen fruits at the commercial maturity stages (stages 2 and 3) with two different colors were harvested from Chanthaburi province, Thailand. They were selected for uniformity of color, size and freedom from disease infection. The fruits at each maturity stage were then washed with tap water and disinfected with a fungicide (500 ml/l Prochloraz). They were packaged in various types of bags: ethylene scavenger (ES) bag, perforated polyethylene (PPE) bag, low-density polyethylene (LDPE) bag, and LDPE bag + 1-MCP sachet (EthylBloc^{TM}). The size of bag was 20 x 25 cm. Non-packaged fruits served as a control. All samples were stored at 13°C and 90-95% relative humidity for 30 days. Fruit quality and disease development were evaluated every 5 days with four replicates of 6 fruits in each replicate. The color of pericarp and calyx was measured using Minolta Colorimeter (Model RC 300) and reported as the hue angle (h^{o}). Weight loss and pericarp firmness were determined with a balance and a texture analyzer, respectively. Ethylene production and respiration rate were measured with a GC-8A (Shimadzu, Japan). Disease development was observed and expressed as the disease index (DI) using the formula: $DI = \sum(df)/ND$, where d = the degree of rot severity assessed on the fruit, f = respective quantity of fruit, N = the total number of fruits examined and D = the highest degree of disease severity occurring on the scale. The experiment was arranged as completely ramdomized design (CRD) and the treatment means were compared using analysis Duncan's new multiple range test (DMRT) at $p \leq 0.05$.

Results

The change in hue angle mangosteen pericarp after packaging with various types of bags and storage at 13°C is shown in Figure 1A. From days 5 to 30, it was found that packaging in LDPE bag and LDPE bag + 1-MCP sachet significantly maintained the hue angle in comparison with the other treatments. Figure 1B shows the change in the hue angle of mangosteen calyx which tended to decrease and there were significant differences among treatments during storage for 10 days. From days 15 to 30, it was found that packaging in LDPE bag + 1-MCP sachet significantly maintained the hue angle compared with the other treatments. However, ES bag was not able to delay color development.

The pericarp firmness of mangosteen decreased significantly, while the weight loss increased during the postharvest period. After 5 days of storage, the firmness decreased sharply in all the treatments. From days 15 to 30, the firmness of fruits packaged in LDPE bag and LDPE bag + 1-MCP sachet were significantly higher than those of the other treatments (Figure 1C). The weight loss of fruits in various kinds of bags was significantly lower than that of the control. Packaging in LDPE + 1-MCP sachet resulted in the lowest weight loss during the storage period (Figure 1D).

The ethylene production of mangosteen increased and the peak of ethylene production was observed on day 5 of storage in all treatments. The highest ethylene peak (22.0 µl C_2H_4/kg.h) was observed in the control and the lowest value (12.03 µl C_2H_4/kg.h) was found in LDPE bags + 1-MCP. However, they were not significantly different from the values for the other treatments. The ethylene production then decreased sharply in all the treatments on day 10, and the ethylene peak of the control (10.26 µl C_2H_4/kg.h) was observed on day 20. It was significantly higher than the values for the other treatments (Figure 1E). The respiration rate of the control peaked on day 20 (236.67 mg CO_2 /kg.h), and was significantly higher than the peaks for the other treatments (Figure 1F). All packaging treatments resulted in respiration suppression.

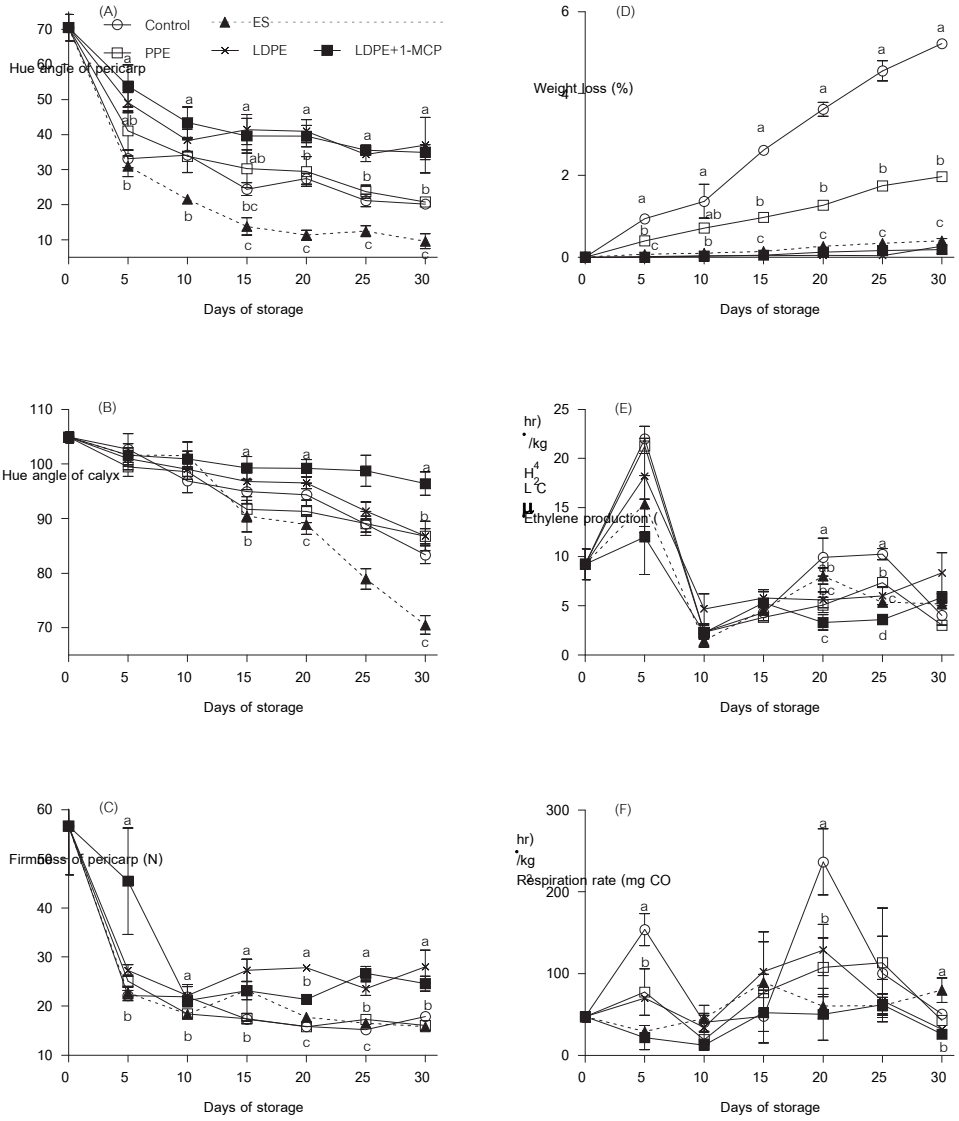

Figure 1 Hue angle of pericarp (A) and calyx (B), pericarp firmness (C), weight loss (D), ethylene production (E) and respiration rate (F) of mangosteen fruits packaged in various types of bags: ethylene scavenger (ES) bag, perforated polyethylene (PPE) bag, low-density polyethylene (LDPE) bag, and LDPE bag + 1-MCP sachet before storage at 13°C, 90-95% RH. Non-packaged fruits were served as a control.

Additionally, no disease incidence (DI) was observed up to day 20 in all the treated fruits and the control fruits except for those in ES packaging (0.02). The DI of the control appeared on day 30 (0.04), but it was not significantly different from those of the other treatments. The maximum DI was found in the fruit packaged in ES bag (0.61), whereas the minimum DI was observed in LDPE bag +1-MCP (0.02) (data no shown).

Discussion

A particular feature of mangosteen ripening and senescence is the decrease in pericarp firmness, color development and sugar content, which is regulated by ethylene production, and it has been found in grapes (El-Kereamy *et al*., 2003) and banana (Pongprasert and Srilaong, 2014). The pattern of ethylene production of mangosteen fruit in this study was similar to that reported by other researches (Palapol *et al*., 2009). MAP application successfully extends the postharvest shelf life of whole and fresh-cut produce by maintaining higher humidity levels, reducing their respiration rate and weight loss and retarding color changes of commodities (Waghmare *et al*., 2013). Moreover, the appropriate CO_2 and O_2 permeability of the packaging film is affected by the fruit respiration rate and microbiological development (Irtwange, 2006). 1-MCP extends the storage and shelf life of mangosteen and banana fruit (Piriyavinit *et al*., 2011; Pongprasert and Srilaong, 2014) and delays fruit senescence. In this study, LDPE + 1-MCP had the strongest effect on decreasing weight loss, delaying skin color changes and retaining fresh green color of the calyx. Hue angle and pericarp firmness decreased rapidly during fruit color development, these changes being the general phenomena of the ripening process. The lowest disease index was found in LDPE bag + 1-MCP, which was probably caused by the most effective MAP and 1-MCP treatment. It maintained the fruit quality and delayed the senescence process of mangosteen.

Summary

The application of LDPE bag + 1-MCP sachet had the greatest effect on the delayed senescence process including decreased weight loss, delayed skin color changes, retained fresh green color of the calyx and suppressed pathogenic infection in mangosteen fruits harvest at both commercial maturation stages (stage 2 and 3) during storage at low temperature.

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