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อิทธิพลของฮอร์โมน NAA และ MeJA ต่อสีและคุณภาพของสับปะรดพันธุ์ปัตตาเวียระหว่างการเก็บรักษา
Influence of NAA and MeJA on Color and Quality in Pineapple Fruit cv. Pattavia during Storage

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Abstract

This research aimed to study the effect of auxin (1-naphthaleneacetic acid; NAA) and methyl jasmonate (MeJA) towards color development (peel and pulp) and changes in the quality of pineapple fruit cv. Pattavia during storage. The pineapple fruits were immersed in distilled water (control), and in 1,000 µM of NAA or MeJA solution for 30 min. After treatment, the fruits were placed in baskets and stored at 25±2 °C for 12 days. The results elucidated that immersing in NAA helped to delay ripening by delaying chlorophyll degradation in the peel (maintained greenness), slowing down the respiration rate, and the accumulation of carotenoids in the peel and pulp. For MeJA treatment, it stimulated the accumulation of carotenoids in pineapple pulp. The quality changes included TSS/TA ratio, ascorbic acid contents, and total phenolic contents, they were non-significant differences in all treatments. In contrast, immersion in NAA or MeJA solution was able to delay the increase in malondialdehyde content in the early period of storage. This observation indicates that auxin (NAA) can delay the fruit ripening which it is beneficial to exporting pineapple. MeJA has the effect of stimulating the accumulation of carotenoids in the pulp (more yellow) which is beneficial to the canned pineapple industry that needs yellow pulp.

Keywords: 1-napthaleneacitic acid, carotenoids, chlorophyll, methyl jasmonate, pineapple

บทคัดย่อ

ในงานวิจัยนี้ศึกษาผลของฮอร์โมนออกซิน (1-naphthaleneacetic acid; NAA) และเมทิลจัสโมเนท (methyl jasmonate; MeJA) ต่อการพัฒนาสี (เปลือกและเนื้อ) และการเปลี่ยนแปลงด้านคุณภาพของสับปะรดพันธุ์ปัตตาเวียระหว่างการเก็บรักษา โดยจุ่มผลสับปะรดในน้ำกลั่น (ชุดควบคุม) และในสารละลาย NAA หรือ MeJA ที่ความเข้มข้น 1,000 ไมโครโมลาร์ เป็นเวลา 30 นาที หลังจากนั้นบรรจุสับปะรดใส่ตะกร้าและเก็บรักษาที่ 25±2 °C เป็นเวลา 12 วัน ผลการทดลอง พบว่าการจุ่มในสารละลาย NAA ช่วยชะลอการสุกได้ โดยชะลอการสลายตัวของคลอโรฟิลล์ในเปลือก (คงความเขียว) ชะลออัตราการหายใจและการสะสมของปริมาณแคโรทีนอยด์ในเปลือกและเนื้อของสับปะรด ส่วนการจุ่มในสารละลาย MeJA มีผลกระตุ้นให้เกิดการสะสมแคโรทีนอยด์ในเนื้อสับปะรด สำหรับการเปลี่ยนแปลงด้านคุณภาพ ได้แก่ อัตราส่วน TSS/TA ปริมาณกรดแอสคอร์บิก และปริมาณฟีนอลิกทั้งหมด ไม่มีความแตกต่างในทุกชุดการทดลอง ในทางกลับกัน พบว่าการจุ่มในสารละลาย NAA หรือ MeJA สามารถชะลอการเพิ่มขึ้นของปริมาณมาลอนไดแอลดีไฮด์ในช่วงแรกของการเก็บรักษา ผลการทดลองนี้ชี้ให้เห็นว่า NAA สามารถชะลอการสุก ซึ่งเป็นประโยชน์ต่อการส่งออกสับปะรด ส่วน MeJA มีผลกระตุ้นการสะสมของแคโรทีนอยด์ในเนื้อ (เนื้อเหลืองขึ้น) ซึ่งเป็นประโยชน์ต่ออุตสาหกรรมสับปะรดกระป๋องที่ต้องการสับปะรดที่มีเนื้อสีเหลือง

คำสำคัญ: กรด 1-แนฟทาลีนแอซีติก คลอโรฟิลล์ แคโรทีนอยด์ เมทิลจัสโมเนท สับปะรด

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Introduction

Pineapple (*Ananas comosus* L.) is one of the most economically important tropical and subtropical crops in Thailand. Pineapples cv. Pattavia are widely planted and have a high economic value for domestic and export markets both fresh and processed products, especially canned fruit. One of the problems encountered during the export of pineapples is peel de-greening (yellowing) due to the ripening process, which shortens their storage life. This issue has a more pronounced impact on export markets. In contrast, for fresh fruit consumption and the fruit processing industry, consumers and entrepreneurs prefer yellow-colored pineapple peel and pulp which indicates sweetness. Previous studies have demonstrated that plant hormones are involved in plant physiology and developments, such as fruit growth and development, seed germination and plant pigments. Auxin (i.e., IAA and NAA) and MeJA are plant hormones that regulate various plant physiological processes. The application of IAA and NAA to strawberries resulted in a delay in the ripening process, which was accompanied by delayed the anthocyanin accumulation, chlorophyll loss and fruit softening (Given *et al*., 1988; Ji *et al*., 2012; Symons *et al*., 2012). In term of MeJA, it has been shown to induce fruit ripening, accumulation of pigments, phenolic compounds, antioxidants and sugars (Turner *et al*., 2002; Reyes-Diaz *et al*., 2016). Furthermore, MeJA has been demonstrated to reduce chilling injury symptoms by inducing plant resistance against pathogens and enhancing the secondary metabolites in several fruits during stored at a low temperature (Reyes-Díaz *et al*., 2016). Thus, this research aimed to study the effect of auxin (1-naphthaleneacetic acid; NAA) and methyl jasmonate (MeJA) on color development (peel and pulp) and quality changes in pineapple fruit cv. Pattavia during storage. The research outcome will be beneficial for increasing the price of pineapple for the domestic market and processing industry.

Materials and Methods

1. Plant materials and treatments

Pineapples cv. Pattavia at the commercial stage (145-165 days after induced flowering) were harvested from Siam Food Products Public Co., Ltd. Fruit of uniform shape, size, and color were selected and washed with tap water. Afterward, the fruits were dipped into a 200 ppm sodium hypochlorite solution for 5 min to control postharvest decay, and then air dried at 25 °C for 2 hr. The fruits were separated into 3 groups and immersed in water (control), 1,000 µM NAA, and 1,000 µM MeJA for 30 min. Afterward, the fruits were air-dried, placed in the baskets, and stored at 25±2 °C, 80-85 %RH for 12 days. Five fruits from each treatment were randomly sampled, and quality was evaluated on day 0, 3, 6, 9, and 12 of storage. The fruit were sampled separately for the peel and pulp, and then directly frozen in liquid nitrogen and stored at -20°C until used.

2. Determination

Changes in the color of fruit from each treatment were measured by colorimeter and reported as ΔE (in peel) and b* value (in pulp). Total soluble solids (TSS), titratable acidity (TA), carotenoids, total phenolic content, ascorbic acid, and malondialdehyde content were measured in the pineapple pulp. The chlorophyll contents were measured in the pineapple peel. The results are subjected to an analysis of variance (ANOVA) and the significant differences among means were determined by Tukey's Test ($P \leq 0.05$) using SAS software.

Results

To explore the effect of the hormones NAA and MeJA towards color development (peel and pulp) and changes in the quality of pineapple fruit cv. Pattavia during storage, we found that the color of the pineapple peel changed from green to yellow during storage, starting from the stem end. As shown in Figure

1, the results elucidated that the NAA treatment could maintain greenness in the peel, whereas the MeJA treatment induced yellowness in both the peel and pulp. For pineapple peel, the results demonstrated that the ΔE values in the fruit treated with NAA were significantly lower than those observed in the other treatments throughout storage (Figure 2A). For pineapple pulp, the fruit treated with MeJA exhibited the highest b* value (indicating more yellowness) compared with other treatments on the 6th and 9th days after storage (Figure 2B). Changes in the color were related to chlorophyll and carotenoid contents in both peel and pulp. The NAA treatment significantly maintained the decrease of chlorophyll contents in the peel compared to other treatments on the 6th, 9th, and 12th days after storage (Figure 2C). In the pulp of pineapple, the MeJA treatment showed high carotenoid contents than the control fruits and NAA-treated fruits after storage 3 days (Figure 2D). Regarding fruit quality, including TSS/TA ratio, ascorbic acid contents, and total phenolic contents, there were no significant differences in all treatments (Figure 3A, B, and C). In contrast, immersion in NAA or MeJA significantly delayed the increase in malondialdehyde content on the 3rd and 6th days after storage (Figure 3D). The respiration rate increased throughout the experiment period. NAA-treated fruits showed significantly lower respiration rates than control fruits and MeJA-treated fruits on the 6th and 9th days of storage (Figure 3E).

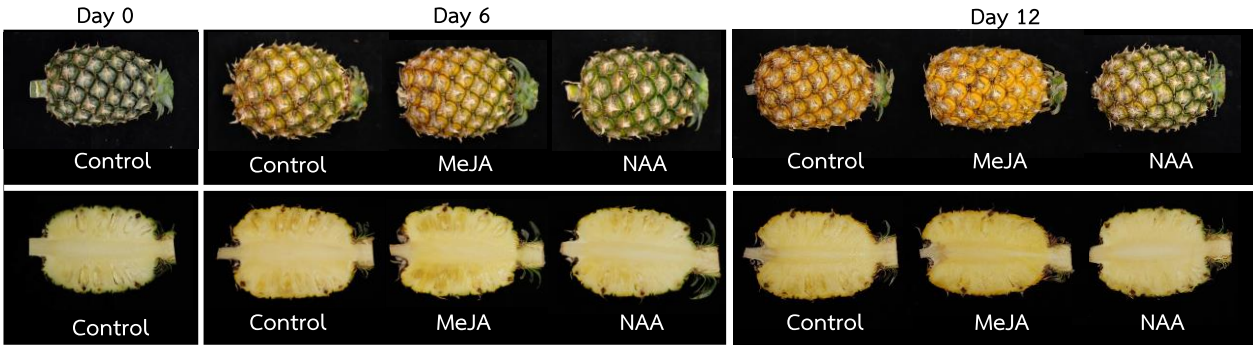

Figure 1 Comparison of the appearance of peel and pulp between MeJA- and NAA-treated fruits and non-treated fruits (control) during storage at 25 °C.

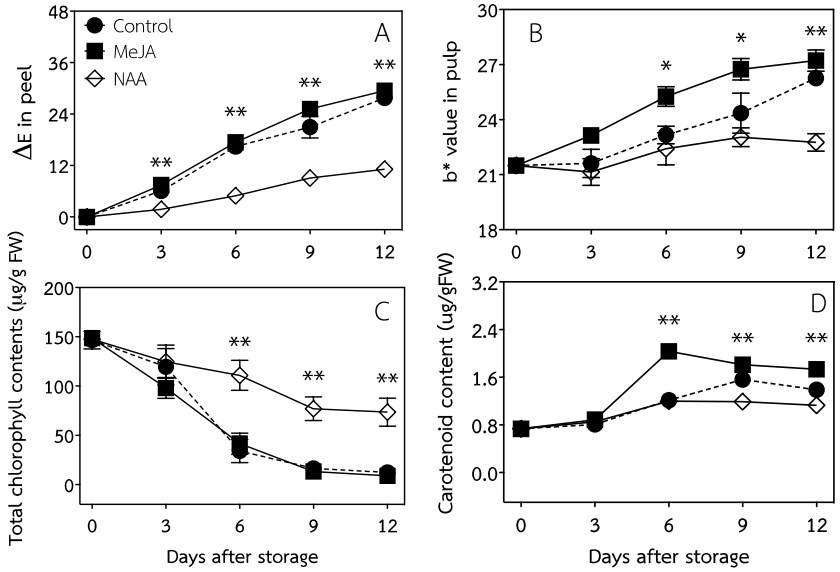

Figure 2 Delta E (A) and total chlorophyll contents (C) in pineapple peel, and b* value (B) and carotenoid contents (D) in pineapple pulp after treatment with water (control), MeJA, and NAA during storage at 25 °C. The Tukey's test was applied to analyze the difference between each treatment at *p < 0.05 and **p < 0.01 levels, error bar represents the average with SE for five replicate samples.

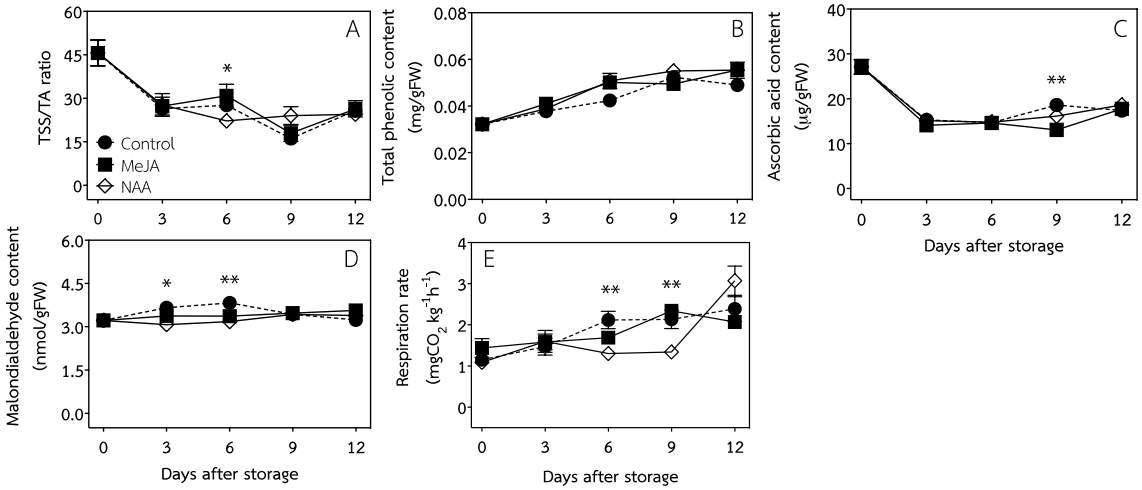

Figure 3 TSS/TA ratio (A), total phenolic acid content (B), ascorbic acid content (C), malondialdehyde content (D) in pineapple pulp, and respiration rate (E) in pineapple after treatment with water (control), MeJA, and NAA during storage at 25 °C. The Tukey's test was applied to analyze the difference between each treatment at $*p < 0.05$ and $**p < 0.01$ levels, error bar represents the average with SE for five replicate samples.

Discussion

Plant hormones are naturally organic compounds that play an important role in the physiological processes of plants. MeJA is generally known as a regulator involved in various plant growth and metabolic activities, including root elongation, fruit stress responses, ripening, and carotenoid biosynthesis. Auxin application suppresses the expression of many ripening-associated genes related to pigmentation, stress response, cell wall metabolism, and the synthesis of flavors and aroma compounds (Manning, 1994, 1998; Harpster *et al*., 1998; Aharoni *et al*., 2002). In the present study, the application of MeJA resulted in enhanced fruit ripening, as indicated by high **Δ**E and b* values (yellowness) in the peel and pulp. MeJA treatment also induced chlorophyll degradation in the peel and promoted carotenoid accumulation in the pulp. Similarly, postharvest application of MeJA induces changes in color by degrading chlorophyll content and enhancing carotene accumulation in mandarin fruit during storage (Gomez *et al*., 2017; Baswal *et al*., 2021). The expression of MYC2 (transcript factor) was up-regulated by MeJA treatment, resulting in promoting the expression of genes regulated to the carotenoid biosynthesis, such as PSY, LCYb, BCH, and CCD4b (Yue *et al*., 2023). In addition, MeJA was effective at enhancing the stability of cell membranes by inducing antioxidant enzyme activities, thereby decreasing oxidative levels in lemons (Siboza and Bertling, 2013). On the other hand, the application of NAA can suppress the color development of the peel and pulp of pineapple by suppressing chlorophyll degradation in the peel and carotenoid accumulation in the pulp. Moreover, the membrane degradation was prevented by NAA and MeJA treatments. which also resulted in the maintenance of the MDA level during the initial period of storage. In a previous study, Chen *et al*. (2016) demonstrated that exogenous IAA delayed the ripening process of harvested strawberries by suppressing genes related to pectin depolymerization, cell wall degradation, sucrose biosynthesis, and anthocyanin biosynthesis. Similarly, applied NAA to strawberries resulted in a delay in anthocyanin accumulation, chlorophyll loss, and fruit softening (Given *et al*. 1988; Ji *et al*. 2012; Symons *et al*. 2012). Moreover, auxin (NAA) may inhibit fruit respiration rate and reduce fruit vitality by down-regulating the expressions of genes associated with the TCA cycle and oxidative phosphorylation during tomato fruit ripening (Li *et al*., 2016). This study elucidates that NAA can delay the pineapple ripening, whereas MeJA can stimulate the pineapple ripening.

Conclusions

This study indicates that NAA can delay fruit ripening, which is beneficial for exporting pineapple. MeJA can stimulate ripening, which is advantageous for the canned pineapple industry that requires yellow pulp.

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