Postharvest Use of Hexanal Vapor and Heat Treatment on Longan Fruit Decay and Consumer Acceptance

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Abstract

The effects of postharvest treatment with hexanal vapor for 2 h at 900 $\mu L \cdot L^{-1}$ at 5, 30, or 40 ^{o}C on longan fruit decay and consumer acceptance were studied during fruit storage at ambient temperature for 8 d and at 5 ^{o}C for 30 d after treatment. Hexanal vapor treatment at 5 and 30 ^{o}C reduced % fruit decay through 8 days and reduced severity through 5 days at ambient temperature storage. Hexanal treatment at 40 ^{o}C was not effective at reducing decay.. For fruit stored at 5 ^{o}C for 30 d, fruit showed symptoms of decay within 5 d, and decay increased through 30 d. Fruit exposed to hexanal at 40 ^{o}C showed the highest % decay and severity by 5 and 10 d, respectively. Hexanal treatment at 5 and 30 ^{o}C reduced decay incidence and severity through 30 d.. Consumer acceptance scores for quality of the fruit indicated that hexanal treatment reduced visual acceptability of the outer and inner peel and aril, and adversely affected aril aroma, flavor, and overall quality. Though hexanal vapor treatment at 5 and 30 ^{o}C effectively suppressed decay after harvest, the adverse effects on consumer acceptability must be overcome for the treatment to be commercially viable.

Keywords: postharvest; natural volatile; longan; *Lasiodiplodia theobromae*; consumer acceptance

1. Introduction

Longan (*Dimocarpus longan* Lour.) fruit have a short shelf life [1]. The primary factors reducing longan storage life and marketability are pericarp browning and microbial decay, with *Lasiodiplodia theobromae* causing the most severe decay [2-3] Treatment with SO_2 is commonly used for preventing longan fruit decay and browning [4]. However, it leaves sulfite residues [5] that may have adverse effects on some consumers [6-7]. As concerns of food safety increase, SO_2 treatment may face greater regulation or outright bans.

Natural volatile compounds with fungistatic or fungicidal properties could be an alternative to SO_2 treatment. The plant

volatile compound hexanal has shown antimicrobial activity against spoilage microorganisms *in vitro* and with cold-stored fruit [8-13]. Hexanal treatment of longan fruit pathogens was fungicidal when tested against spore germination and mycelia *in vitro* and on fruit stored for 3 d at ambient temperature [14]. Hexanal is commercially available, and has been approved as a food additive by the U.S. Food and Drug Administration, and has an ORL-MAM LD50 of 3700 mg · kg^{-1} [15] Thus, hexanal is a candidate for replacing SO_2 treatment of longan.

Heat treatment after harvest has shown potential for inhibiting ripening, reducing decay, and extending cold storage life [16-18]. The vapor pressure of hexanal is a function of temperature, and its antifungal effect is enhanced as temperature increases [19]. Thus, a hexanal plus heat treatment could have additive or synergistic effects on longan decay reduction. However, the combination of hexanal with heat treatment for postharvest disease control has not been reported for any fruit species.

One objective of this study was to determine the interaction of hexanal vapor with treatment temperature on longan fruit decay. In addition, given the potential for use of hexanal as a postharvest treatment, consumer acceptance of hexanal-treated fruit was also assessed.

2. Materials and methods

2.1 Isolation and culture of *Lasiodiplodia theobromae*

The most virulent strain of *Lasiodiplodia theobromae* (Pat.) Griffon & Maubl. strain LP20 from a pathogenicity test of the fungus, isolated from diseased longan fruit, was obtained from the Department of Biology, Faculty of Science, Chiang Mai University, Thailand. It was cultured on potato dextrose agar (PDA) (Sigma, St. Louis, MO, USA).

2.2 Longan fruit

Longan fruit (cv. Daw) were purchased from a commercial orchard in Chiang Mai province, and were transported to the laboratory within 2 h after harvest. Fruit were selected for uniformity in size, and were prepared by cutting the stem to a 0.5 cm length. *L. theobromae*-inoculated fruit were prepared by placing 5 mm diameter mycelial discs, taken from the periphery of two-day old active cultures, on the pericarp of the stem-end of longan fruit, Then, incubating the fruit in a closed plastic box with a moist tissue for 6 h at ambient temperature. The mycelial disc was removed from the fruit before further use.

2.3 Influence of hexanal vapor treatment temperature on longan fruit decay

Fruit were exposed to hexanal vapor by placing ten non-inoculated or ten inoculated fruit on wire mesh in an 850 mL glass bottle with a sterilized filter paper. A volume of hexanal was quickly added to the filter paper, and the bottle was sealed with a locking lid for a designated period of time. A vapor treatment of hexanal at 900 µL L^{-1} for 2 h was deemed the best treatment for reducing fruit decay with minimal impact on fruit quality [14]. For controls, a volume of sterilized distilled water was added, equal to that of hexanal. These treatments were applied at 3 temperatures, 5, 30, and 40 ^{o}C. Bottles were placed in chambers set at each temperature during treatment. There were 4 replicate bottles of 10 fruit each per treatment temperature.

After treatment, fruit were transferred to a foam tray. The trays were placed at ambient temperature for 8 d or in 5 ^{o}C storage for up to 30 d. The appearance of fungi on the fruit, severity of decay, and phytotoxic symptoms were recorded by rating fruit at 1, 5, and 8 d during ambient temperature storage, and at 5 d intervals during 5 ^{o}C storage. The number of fruit with decay was recorded on each date and the % incidence was calculated. The

severity of fungal development on the surface was scored from 0 to 4 with 0 = no visual evidence of fungi, 1 = less than 10%, 2 = 10-30%, 3 = 31-70%, and 4 = more than 70% of the surface affected with fungus. Mean scores of fungal development was calculated as: mean score

$$= \frac{\Sigma(\text{number of fruit with each score X score})}{\text{Total observed fruit.}}$$

2.4 Evaluation of fruit quality acceptance

Non-inoculated longan fruit receiving hexanal treatment at ambient temperature were selected for evaluation of quality acceptance at 4, 7, 11, 15, 17, 21, and 24 d of cold storage. The visual appearance of the outer peel (pericarp), inner peel (pericarp), and aril, and the aroma, flavor and overall quality acceptance of the aril were evaluated by scoring each. Five well-trained evaluators scored each part of each fruit as: 1= mostly dislike, 2 = moderately dislike, 3= neither like nor dislike, 4 = moderately like, or 5= mostly like. Panelists were given one fruit per treatment on each sampling date.

2.5 Statistical analysis

The experiments were arranged in a completely randomized design. All statistical analyses were performed by analysis of variance (ANOVA) using Statistix version 8.0. Treatment means were compared by Fisher's Least Significant Difference (LSD) test at a significance level of $P \leq 0.05$.

3. Results and discussion

3.1 Influence of hexanal vapor treatment temperature on longan fruit decay

Inoculation of fruit with *L. theobromae* resulted in a significant level of fungal incidence within one day of ambient temperature storage, whereas non-inoculated fruit did not show decay until day 8 (Fig. 1). The low level of decay on non-inoculated fruit indicated a low level of natural fungal inoculation. Due to the low level of natural inoculation, neither hexanal or temperature affected % decay or severity (Fig. 2) through day 8 at ambient temperature. For inoculated fruit, hexanal vapor treatment at 5 and 30 ^{o}C reduced % fruit decay through 8 days, and reduced severity through 5 days. Hexanal treatment at 40 ^{o}C was not effective at reducing decay, though it has been effective with other species [17, 18]. Hexanal treatment at 5 and 30 ^{o}C reduced decay incidence and severity. This occurred on both non-inoculated and inoculated fruit. These symptoms on fruit not receiving hexanal treatment are due to natural postharvest senescence as well as cold or heat effects.

For fruit stored at 5 ^{o}C for 30 d, non-inoculated fruit showed few decay symptoms (Fig. 3A). In contrast, *L. theobromae*-inoculated fruit showed symptoms of decay within 5 d, and decay developed through 30 d (Fig. 3B). Fruit exposed to hexanal at 40 ^{o}C showed the highest % decay and severity at 5 and 10 d. By 15 d, fruit not treated with hexanal also exhibited significant decay. Hexanal treatment at 5 and 30 ^{o}C reduced decay incidence and severity through 30 d (Fig. 4).

3.2 Fruit quality acceptance

Consumer acceptance scores for quality of the fruit indicated that hexanal treatment reduced visual acceptability of the outer and inner peel and aril (Fig. 5A). For the aril, the edible part of the fruit, hexanal treatment also reduced acceptability of aroma, flavor, and overall quality (Fig. 5B).

4. Conclusion

Hexanal vapor applied at 5 and 30 ^{o}C was effective at suppressing % decay and severity of inoculated fruit through 30 days of cold storage to acceptable levels. Treatment at 40 ^{o}C was not effective,

appearing to increase the % decay. The 40 ^{o}C treatment alone was not effective. The same general treatment effects were evident for fruit stored at ambient temperature, but the effect of hexanal was not commercially acceptable. as % decay exceeded 60% within 24 h. However, even though hexanal controlled fruit decay and severity of cold-stored fruit, and it is a GRAS (generally recognized as safe) substance, the use of hexanal vapor on longan will need to be studied further before it is commercially viable due to the adverse consumer response to hexanal vapor on peel and aril appearance and aril aroma, flavor and quality.

5. Acknowledgements

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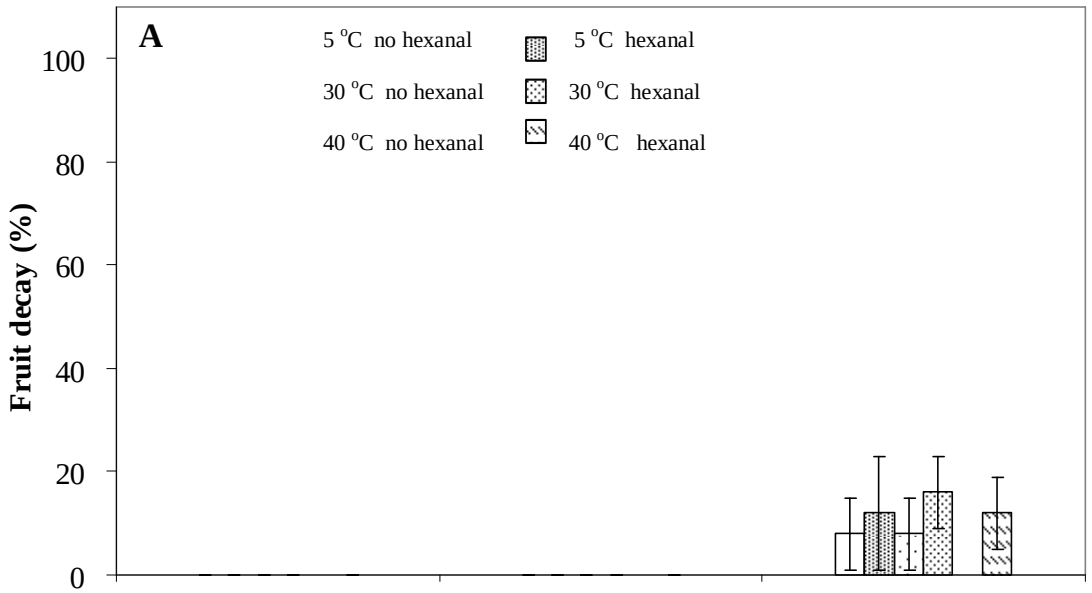


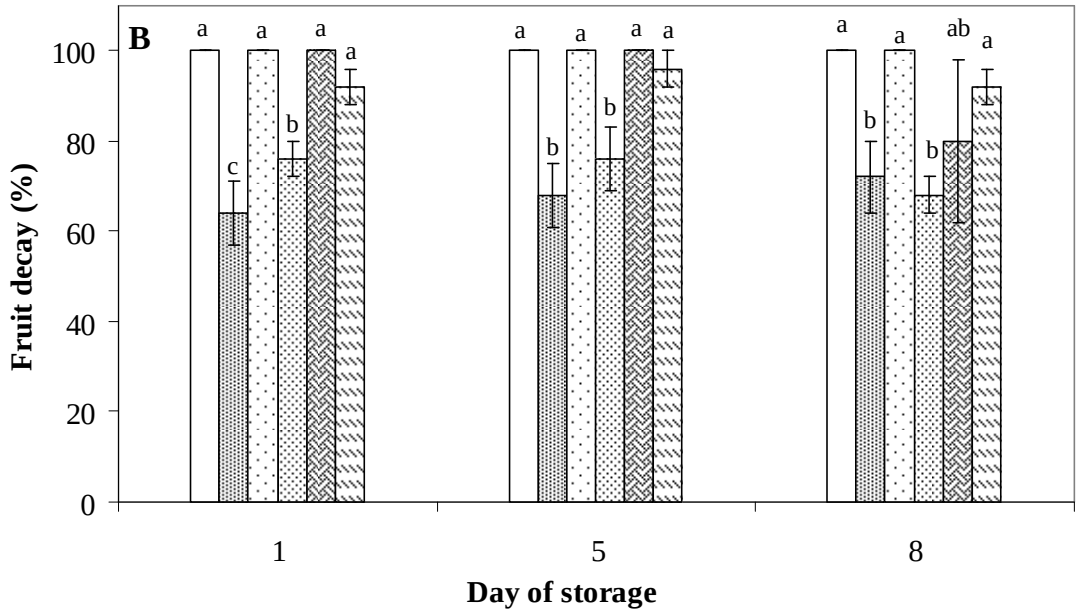
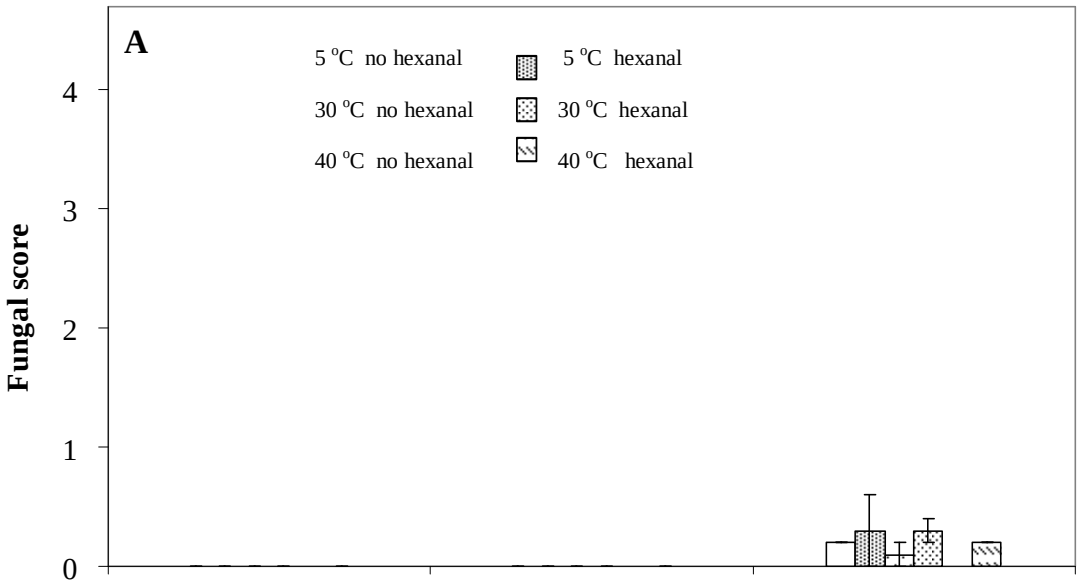


Fig. 1 Percentage of fruit decay of non-inoculated (A) and *L. theobromae* inoculated (B) longan fruit stored at ambient temperature after hexanal treatment at 900 µL L^{-1} for 2 h at 5 °C, ambient temperature and 40 °C. Treatment means were compared by Fisher's Least Significant Difference (LSD) test at a significance level of $P \leq 0.05$.



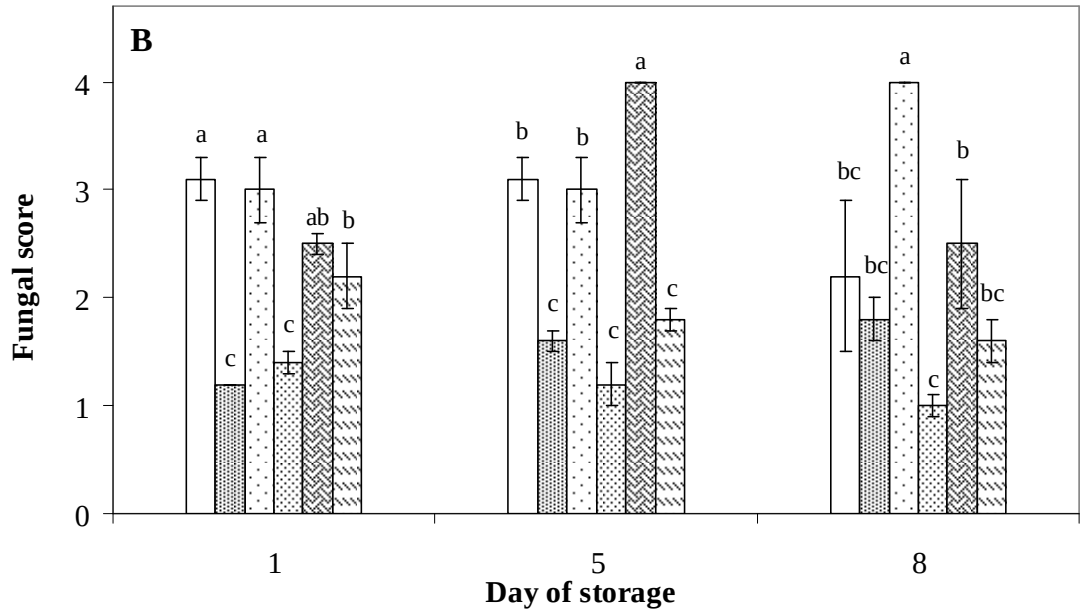
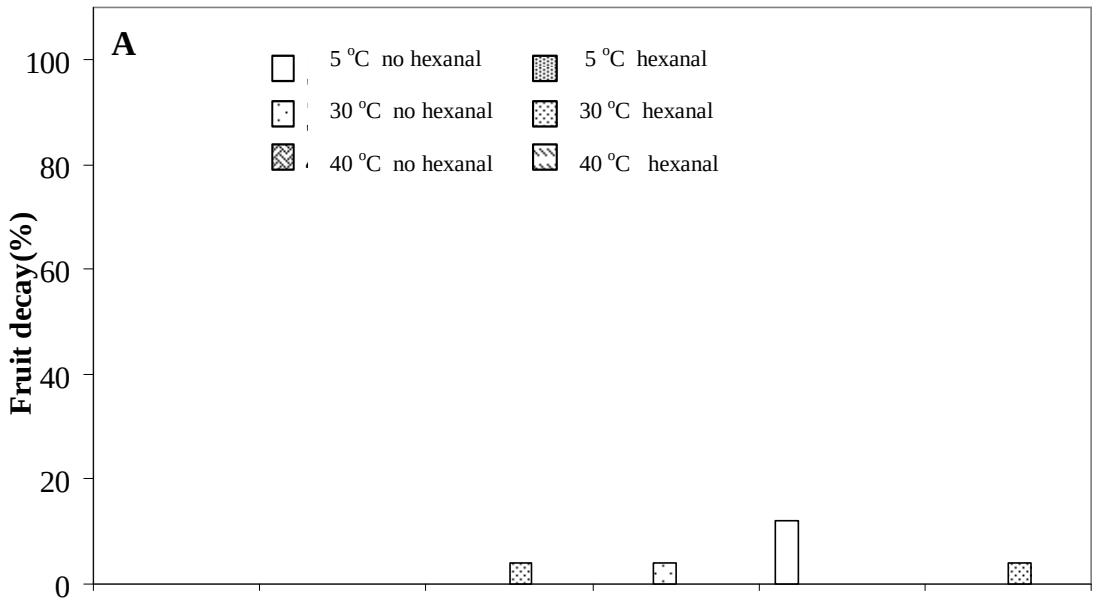


Fig. 2 Fungal incidence score of non-inoculated (A) and *L. theobromae*. inoculated (B) longan fruit stored at ambient temperature after hexanal treatment at 900 µL L^{-1} for 2 h at 5 ^{o}C, ambient temperature and 40 ^{o}C; 0 = no visual evidence of fungi, 1 = less than 10%, 2 = 10-30%, 3 = 31-70%, and 4 = more than 70% of the surface affected with fungus. Treatment means were compared by Fisher's Least Significant Difference (LSD) test at a significance level of $P \leq 0.05$.



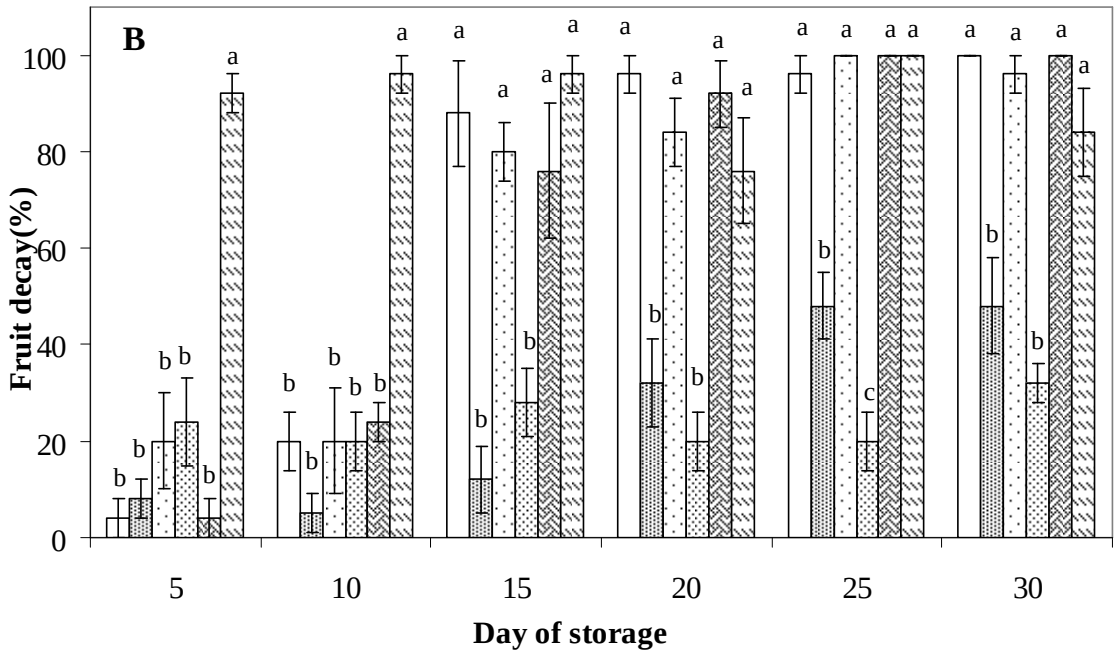
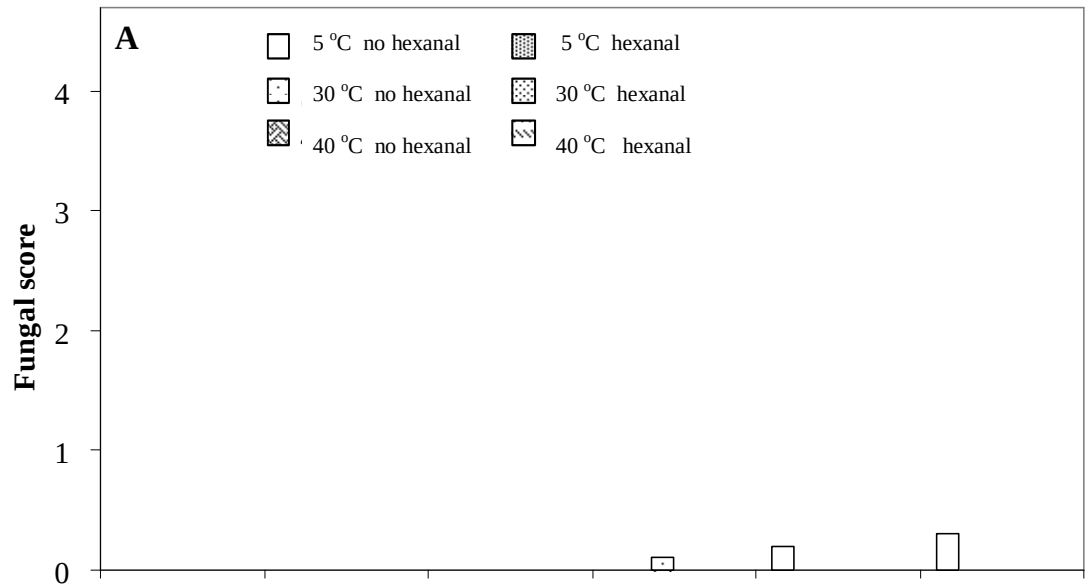


Fig. 3 Percentage of fruit decay of non-inoculated (A) and *L. theobromae* inoculated (B) longan fruit stored at 5°C after hexanal treatment at 900 µL L^{-1} for 2 h at 5 °C, ambient temperature and 40 °C. Treatment means were compared by Fisher's Least Significant Difference (LSD) test at a significance level of $P \leq 0.05$.



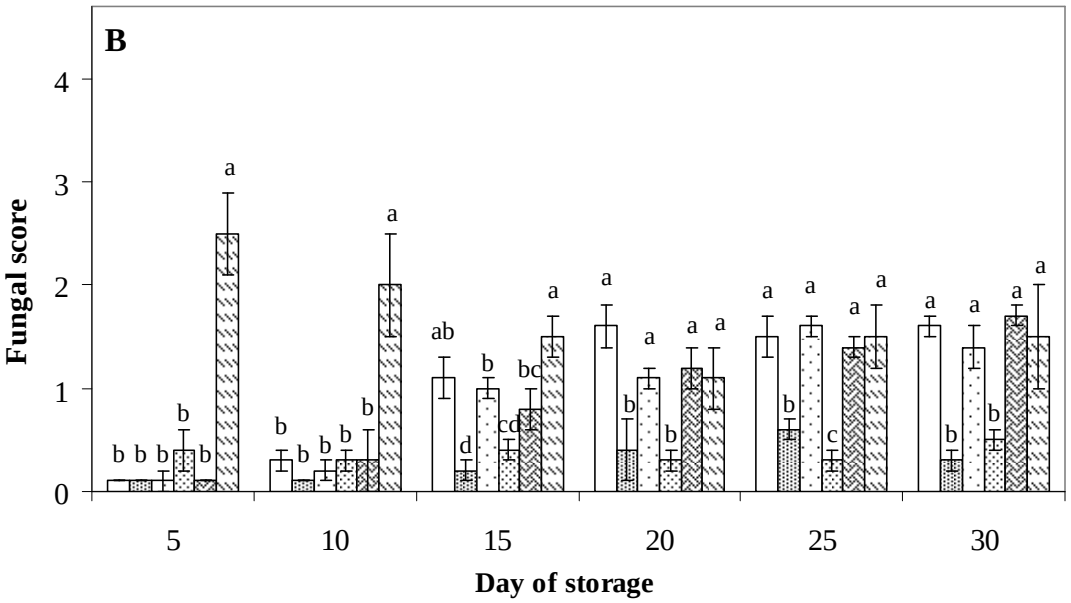
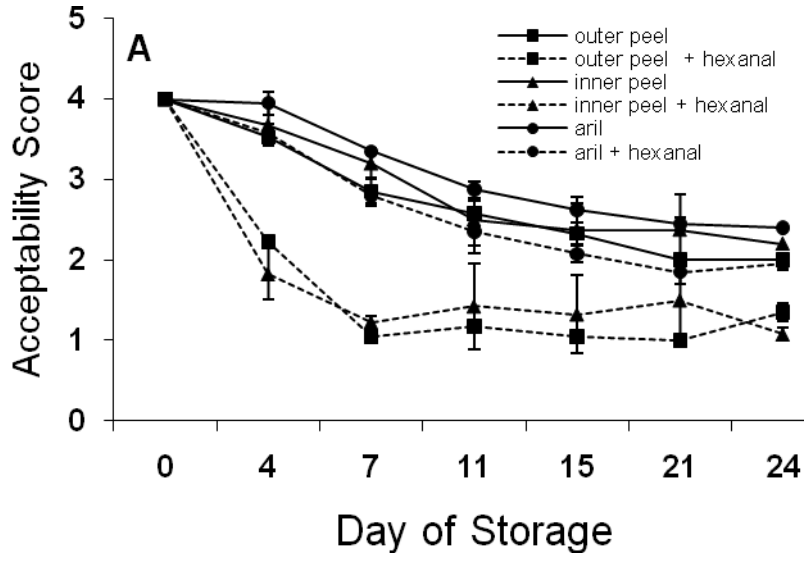


Fig. 4 Fungal incidence score of non-inoculated (A) and *L. theobromae* inoculated (B) longan fruit stored at 5 ^{o}C after hexanal treatment at 900 µL L^{-1} for 2 h at 5 ^{o}C, ambient temperature and 40 ^{o}C ; 0 = no visual evidence of fungi, 1 = less than 10%, 2 = 10-30%, 3 = 31-70%, and 4 = more than 70% of the surface affected with fungus. Treatment means were compared by Fisher's Least Significant Difference (LSD) test at a significance level of $P \leq 0.05$.



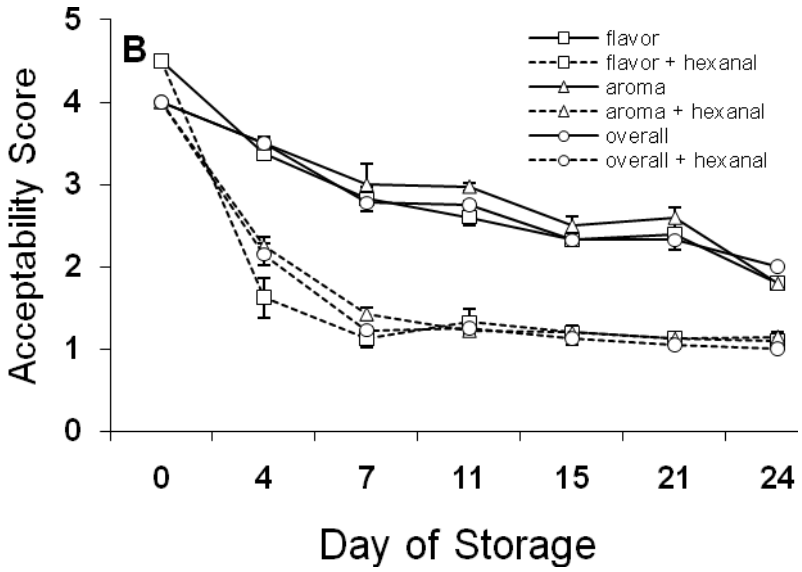


Fig 5. A) Visual acceptability of outer peel, inner peel, and aril. B) Aril aroma, flavor, and overall acceptability of longan fruit (cv. Daw) stored at 5 ^{o}C after hexanal treatment at 900 µL L^{-1} for 2 h at ambient temperature. Scores are: 1 = mostly dislike, 2 = moderately dislike, 3 = neither like nor dislike, 4 = moderately like, and 5 = mostly like. All hexanal treatment values were significantly different from control values on each date at $P \leq 0.05$.