MAINTAINING POSTHARVEST QUALITY OF JACKFRUIT DURING COLD STORAGE

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ABSTRACT

Two types of selected fungicides; Tilt (AI: Propiconazole) and Octave (AI: Prochloraz) at different concentration (0, 250, 500 and 1000 ppm) and two types of non-chemicals; distilled white vinegar and baking soda (sodium bicarbonate) at different concentration (2%, 3%, 4% and 5%) were evaluated for their potential to control the mycelial growth of Lasidiplodia theobromae using agar diffusion method. Initial results showed that propiconazole, prochloraz and distilled white vinegar significantly ($p<0.05$) retard the growth of L. theobromae except for baking soda ($p>0.05$). Selected fungicide propiconazole was assessed in vivo experiments using jackfruits (Artocarpus heterophyllus L. var J33) by keeping at 12 °C with 85-90% relative humidity using different types of packaging materials for two weeks. Mature fruits were harvested at 90-95 days after bagging and each fruit was packed in according to A: Corrugated fibre box (CFB) only, B: CFB+ low-density polyethene (LDPE), C: CFB+ LDPE+ paper, D: CFB+ perforated LPDE and E: CFB+ perforated LPDE+ paper. Fruits from all treatments could ripen normally at room temperature after 3-4 days upon removal. Fruits packed within sealed LDPE bag failed to ripen normally and exhibited symptoms of carbon dioxide injury during storage. The results showed that fruits packed in perforated LDPE had lower scores of disease incidence, better appearance, delayed losses of ascorbic acid (AA) content, titratable acidity (TTA) and soluble solids content (SSC). In conclusion, fruits packed with perforated LDPE are better in prolonging the storage life of jackfruit up to two weeks of storage.

Key words: carbon dioxide injury, disease incidence, ethylene, postharvest quality

INTRODUCTION

Jackfruit (*Artocarpus heterophyllus*), is a non-seasonal tropical composite fruit which belongs to the family Moraceae. It is also known as the largest tree-borne fruit that is widely cultivated in equatorial countries such as India, South-East Asia and South America (Saxena, Bawa and Raju, 2011). Both the immature and ripe fruits are an important source of dietary fibre, vitamins and functional properties (Baliga et al., 2011). In Malaysia, there are several jackfruit varieties registered under Department of Agricultural like J29, J31, (NS1), J32 (Mantin), J33 (Tekam Yellow) and J35 (Mastura) (Noor Baiti and Mohammad Zaki, 2018). Among the varieties, Tekam Yellow is the most preferred by consumers due to sweetness and crunchy texture. Depending on growers' experience, the recommended harvest maturity after bagging for J33 jackfruit is 90-95 days for the export market and 100 days for minimally processing. At 90-95 days, the fruit considered to be physiologically matured (mature green) and firm to withstand postharvest handling. However, jackfruit has relatively poor short storage life due to its susceptibility to fruit rot. *Lasiodiplodia theobromae* is one major fungal pathogen that causes postharvest decay on many important horticultural fruits such as citrus, avocados, mangos, papayas, bananas and guavas (Zhang, 2014). In the early stage, the fungal colonization of *L. theobromae* remains latent (quiescent) and does not cause any fruit decay but infections tend to manifest after harvest especially under conditions of high temperatures and relative humidity (Zhang, 2014). In jackfruit, *L. theobromae* tend to develop rapidly after the onset of ripening process during cold storage or at ambient temperature. Due to this, refrigeration is usually used to store jackfruit for its beneficial effect on extending storage life both by maintaining fruit quality and by reducing disease incidence (Singh and Sharma, 2018). Under optimum conditions, the whole jackfruit harvested at 90-95 days could be stored for at least 2 weeks at 12 ±1 °C with 85-90% relative humidity. Therefore, the first objective of the present studies is to select potential fungicide

that is safe to use for jackfruit to control postharvest decay caused by *L. theobromae*. The second objective is to evaluate different types of packaging on maintaining the postharvest qualities of jackfruit during storage.

MATERIALS AND METHODS

In vitro screening methods using fungicides and non-chemicals against *L. theobromae*

Two types of selected fungicides; Tilt (AI: Propiconazole) and Octave (AI: Prochloraz) at different concentration (0, 250, 500 and 1000 ppm) and two types of non-chemicals; distilled white vinegar and baking soda (sodium bicarbonate) at different concentration (2%, 3%, 4% and 5%) were evaluated for their potential to control the mycelial growth *of L. theobromae* using agar diffusion method. Antifungal activity of fungicides was evaluated by measuring the zone of no growth (cm). In control treatments, sterilized water was used instead of fungicides. The data were subjected to analyses of variance for CRBD and to determine the effect of treatments in each period. Differences within the means will be compared using Duncan Multiple Range Test (DMRT).

Fruits

Mature jackfruits weighing from 12 – 14 kg were harvested at 90-95 days after bagging from a local grower at Lancang, Pahang, Malaysia. The fruits were then washed and treated with 250 ppm propiconazole for 2 min dip and left to dry for 1 hour before packing. Each fruit was packed in according to A: without packaging (control), B: sealed low-density polyethene (LPPE) bag (0.004 mm in thickness), C: 5% perorated LDPE bag and D: PVC film (0.008mm in thickness). After applying the packaging treatment, each fruit was placed in a double corrugated fibreboard (CFB) and stored at 12 °C with 80–95% relative humidity (RH) for three weeks. Fruits were removed and then allowed to ripen at ambient temperature (25 ± 2 °C; 70–75% RH).

Analysis of quality attributes

At 2nd week of storage, all fruits were subjected to physicochemical analysis at subsequent transfer to ambient temperature (25°C) for 3 days. Parameters measured included colour, disease incidence, gases in the package (CO_2, O_2 and ethylene) and biochemical (pH, titratable acidity, soluble solids content, vitamin C, SSC: TTA ratio and acetaldehyde, ethanol, ethyl acetate).

Statistical analysis

The experiment was conducted using a completely randomized design (CRD) with three replications. All data were subjected to analysis of variance (ANOVA) and means separated using Duncan Multiple Range Test (DMRT) by using SAS 9.4 (SAS Institute Inc., USA).

RESULTS AND DISCUSSION

The PIRG (percentage inhibition of radial growth) values ranged from 0 to 100%, with propiconazole and distilled white vinegar being significantly most effective on inhibiting the fungal growth (PIRG 100%) (Table 1) which completely overgrew the colony of *L. theobromae* within seven days of incubation. Prochloraz at 250ppm, 500ppm and 1000ppm also significantly inhibit the fungal growth of *L. theobromae* at 94.04%, 93.15% and 90.99% respectively. Baking soda did not show any inhibition effect. However, white vinegar when assessed in vivo experiments using jackfruits caused the peel to turn brown compare to other fungicides. A preliminary study to test the effective dipping time and concentration of propiconazole were carried out (results not shown), indicated that the dipping time for propiconazole is effective at 2 min at 250ppm.

Fruits packed within LDPE bags (Treatment B and C) without perforation had significantly higher CO_2 and lower O_2 within the package (Table 2) compared to control (Treatment A) and fruits bagged in perforated LDPE (Treatment D and E). Fruits packed in LPDE bags (B and C) failed to ripen at ambient temperature upon removal from the cold room. The skin of jackfruits turned brown most likely as a result of carbon dioxide injury. Fruits affected from CO_2 injury developed brown patches of hypoxia (due to low oxygen) on the fruit surface. Long term hypoxia then tends to lead to respiratory accumulation of alcohol and the onset of fruit rot. Ethanol and acetaldehyde content was found to be significantly higher ($p<0.05$) in fruits bagged in LDPE (Fig. 1) compared to control (Treatment A) and perforated LDPE (Treatment D and E). Plant responses to severe stress of low O_2 and/or very high CO_2 concentrations include induction of fermentation pathways, accumulation of succinate and/or alanine, and decreases in intracellular pH and ATP levels (Ke at al., 1995). Accumulation of acetaldehyde and ethanol is a major metabolic response of plant tissue to anoxia or severe hypoxia (Zhang and Watkins, 2005). Other than that, hypoxia delayed fruit ripening and senescence as it decreases ethylene production and tissue sensitivity to ethylene (Kader et al, 1989). Jackfruits held in sealed LDPE bag failed to ripen normally compared to other treatments.

Freshly harvested jackfruits after 90 days of bagging were characterized with their bright green skin. As storage week progressed, fruits wrapped in both perforated LDPE (D and E) and control show similar colour development in term of lightness, L*, a* and b* after two weeks of storage in the cold room (Fig. 2). Compared to the initial skin colour of freshly harvested fruits, the fruits of A, D and E showed no significant changes ($p>0.05$) in a* value indicating the skin colour remained green during two weeks of storage (Fig. 2). Whereas for fruits of B and C treatment, had significantly higher a* value and significant lower L* and b* value indicating the fruits become duller and browner in appearance, likely due to CO_2 injury (Fig. 2).

Control fruit and fruit bagged in perforated LDPE (D and E) had significantly higher soluble solids content and ascorbic acid content ($p<0.05$) than fruits bagged in LDPE (B and C) (Fig. 3). This is due to the rapid sugar breakdown caused by fermentation

as reduced activity of cellular respiration in hypoxia fruits (Boersig et al., 1988). Other than that, due to fermentation, fruits of B and C had a significantly lower pH ($p<0.05$) value compared to other treatment (Fig. 3). In terms of disease incidence, fruits bagged in perforated LDPE had significantly lower disease incidence ($p<0.05$) compared to other treatments (Fig. 3) after two weeks of cold storage.

CONCLUSION

Combination dipping treatment of propiconazole at 250 ppm for 5 min and packing with perforated LDPE improve postharvest quality of jackfruit for 2 weeks at optimum storage temperature (12°C). However, further study using GRAS (generally recognized as safe) antifungal as an alternative non-chemical need to be carried out.

Table 1: Percentage inhibition of mycelia growth of *Lasiodiplodia theobromae* after 7 days incubation of treated with different concentration of selected fungicides.

TREATMENT		ANTAGONISM (PIRG %)
T1	Control	0c
T2	Tilt (AI: Propiconazole) 250 ppm	100a
T3	Tilt (AI: Propiconazole) 500 ppm	100a
T4	Tilt (AI: Propiconazole) 1000 ppm	100a
T5	Octave (AI: Prochloraz manganese chloride) 250 ppm	94.036b
T6	Octave (AI: Prochloraz manganese chloride) 500 ppm	93.15b
T7	Octave (AI: Prochloraz manganese chloride) 1000 ppm	90.994b
T8	White vinegar 2%	100a
T9	White vinegar 3%	100a
T10	White vinegar 4%	100a
T11	White vinegar 5%	100a
T12	Baking soda (sodium bicarbonate) 2%	0c
T13	Baking soda (sodium bicarbonate) 3%	0c
T14	Baking soda (sodium bicarbonate) 4%	0c
T15	Baking soda (sodium bicarbonate) 5%	0c
Pr > F		< 0.0001
Significant		Yes

Means not followed by the same letter are significantly different (p=0.05)
*PIRG – percentage inhibition of radial growth

Table 3: Effects of different packaging on carbon dioxide, oxygen and ethylene production of jackfruit during storage

Treatment	Carbon dioxide (%)	Oxygen (%)	Ethylene (ppm)
A	3.00b	16.66a	8.72a
B	29.73a	1.91c	2.48b
C	35.23a	4.02b	1.41b
D	1.472b	16.97a	2.73b
E	2.019b	16.09a	3.95b
	**	**	**
Storage days			
D2	11.04b	12.47a	2.97
D5	11.77b	10.93b	3.81
D7	12.19b	12.28a	5.21
D9	18.46a	9.77c	4.43
D12	17.97a	10.19b	2.86
F-sig	*	*	**ns**
Treatment x Storage days	*	**	**ns**

Means within a column with the same letters are not significantly different at $p<0.05$ according to DMRT (A: Corrugated fibre box (CFB) only, B: CFB+ low-density polyethene (LDPE), C: CFB+ LDPE+ paper, D: CFB+ perforated LPDE and E: CFB+ perforated LPDE+ paper)

Figure 1: Effects of different packaging on the concentration of ethanol, acetaldehyde and ethyl acetate of jackfruit after removal from storage at 2 weeks. A: Corrugated fiber box (CFB) only, B: CFB+ low density polyethylene (LDPE), C: CFB+ LDPE+ paper, D: CFB+ perforated LPDE and E: CFB+ perforated LPDE+ paper.

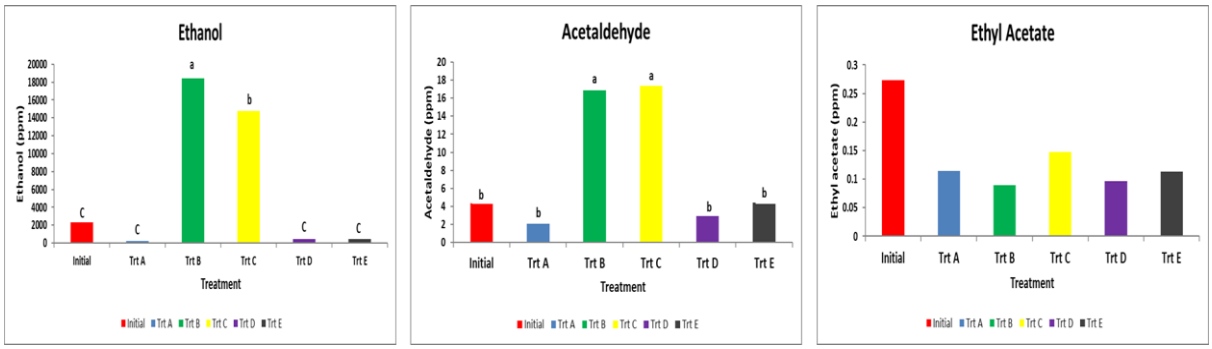


Figure 2: Effects of different packaging on the concentration of colour development (lightness L*, a* and b* values) of jackfruit after removal from storage at 2 weeks. A: Corrugated fiber box (CFB) only, B: CFB+ low density polyethylene (LDPE), C: CFB+ LDPE+ paper, D: CFB+ perforated LPDE and E: CFB+ perforated LPDE+ paper.

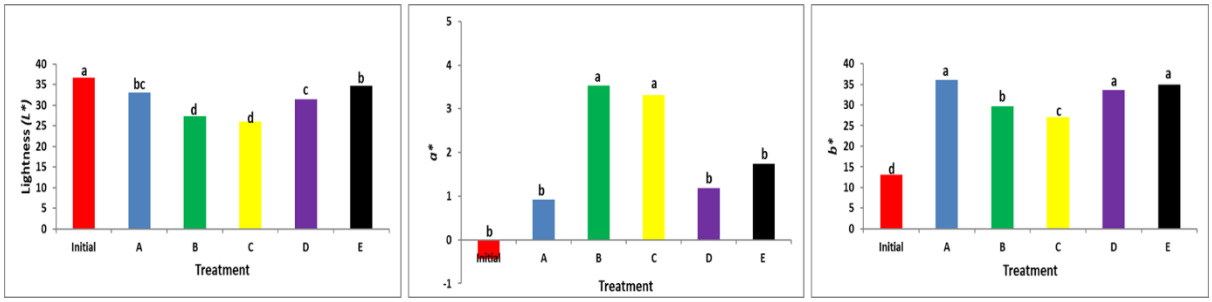
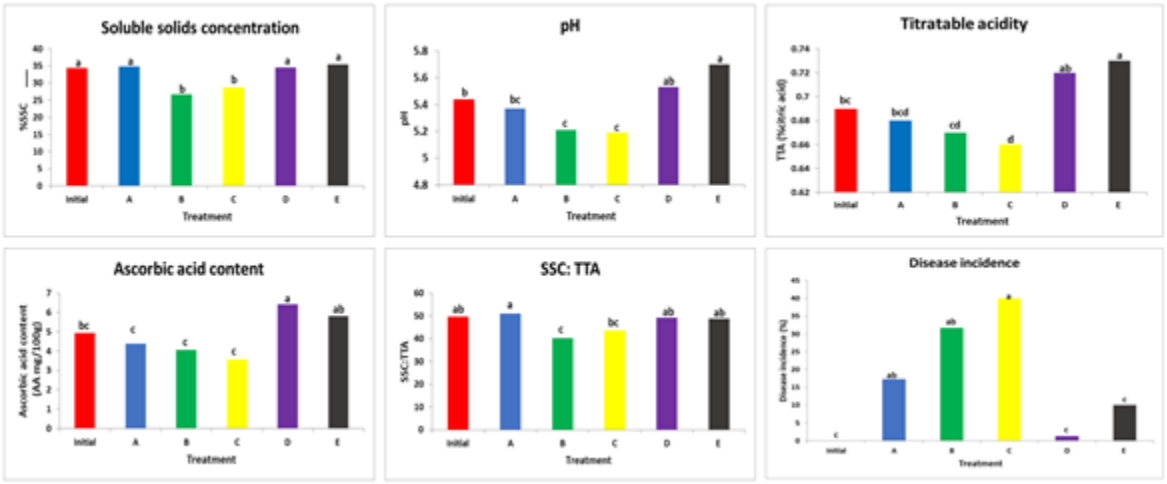


Figure 3: Effects of different packaging on the postharvest qualities of jackfruit after removal from storage at 2 weeks. A: Corrugated fiber box (CFB) only, B: CFB+ low density polyethylene (LDPE), C: CFB+ LDPE+ paper, D: CFB+ perforated LPDE and E: CFB+ perforated LPDE+ paper.



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