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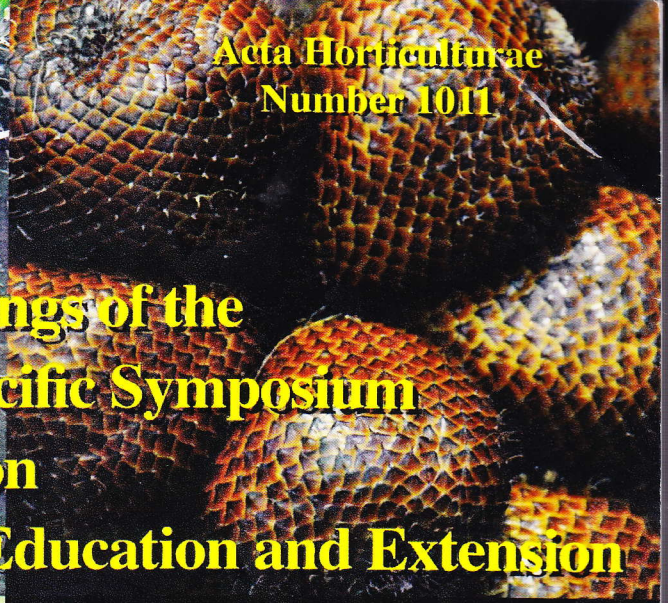

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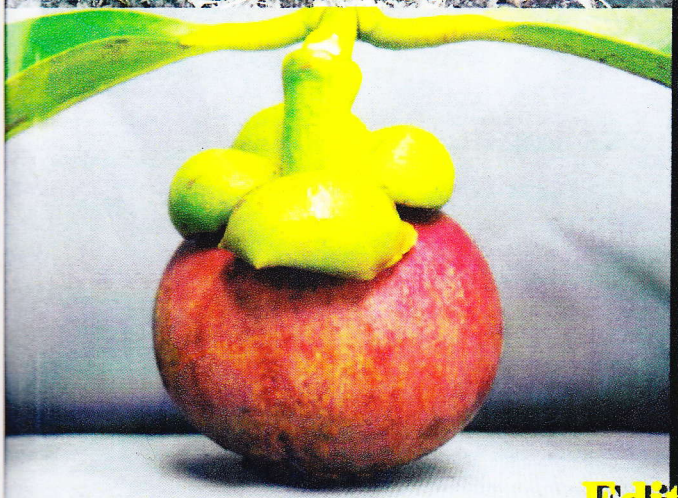

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1. Salak Pondoh plants and fruits (by courtesy of G. Szrednicki).
2. Salak Pondoh fruits (by courtesy of W. Maneerat).
3. Mangosteen maturity index 3 for export (by courtesy of H.K. Purwadaria).
4. Ready to eat mangosteen (by courtesy of H.K. Purwadaria).
5. Demonstration facility for multipurpose plant factory, Osaka Prefecture University, Japan (by courtesy of H. Murase).
6. Demonstration facility for high efficiency energy conservation plant factory, Osaka Prefecture University, Japan (by courtesy of H. Murase).

LIST OF CONTENTS

Ginger and Turmeric Extracts: Their Effects on *Thielaviopsis paradoxa* Infection of Salak Pondoh during Storage

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Keywords: red ginger, turmeric, wax, salak pondoh, *Thielaviopsis paradoxa*

Abstract

The objectives of this study were to: (1) investigate the effect of red ginger and turmeric rhizome extracts on growth of *Thielaviopsis paradoxa*; (2) find the most effective coating formula to maintain quality of salak pondoh during storage. In the first experiment, the concentrations of red ginger and turmeric rhizome extracts used were 20, 30 and 40%. The fungus was grown on potato dextrose agar (PDA) containing each concentration of the extracts. PDA not containing red ginger and turmeric extract served as control. In the second experiment, three treatments consisting of waxing 10%, red ginger rhizome extract, and the combination of wax 10% and red ginger extract were used to examine their effect on fungal infection of salak pondoh during storage. The fruit quality examined every 3 days of storage consisted of moisture content, weight loss, firmness, soluble solid content (SSC), respiration rate and organoleptic test. Results indicated that red ginger and turmeric rhizome extracts inhibited growth of *T. paradoxa* starting at 30% concentration. Percentage growth inhibition of the fungus caused by red ginger and turmeric rhizome extracts at this concentration were 100 and 34%, respectively. Red ginger extract at 30% concentration was more effective than the turmeric rhizome extract. Use of 10% wax in combination with 30% red ginger extract for coating salak pondoh fruit could maintain fruit quality at room temperature (28.0±1.5°C) and relative humidity 65-75% for 12 days, while controls could only maintain postharvest quality for up to 9 days.

INTRODUCTION

Apart from mangoesteen, mango, citrus, banana and durian, salak (snake fruit, *Salacca edulis* Reinw.) is an important fruit grown in Indonesia with an annual of production 815,227 tonnes (BPS, 2010).

As a perishable fruit, salak postharvest deterioration can be rapid because of mechanical, physical, physiological and microbiological factors. After harvest fruit are physiologically active, and continue to respire. *Thielaviopsis paradoxa* is the most important postharvest fungal pathogen of salak. Fungal infection can cause changes in aroma, taste and texture. Poor taste, soft texture and unattractive appearance will affect the market value of salak. Synthetic fungicides have been used to control postharvest diseases of many fruits, but excessive use of fungicides can result in development of pathogen resistance.

According to Winiarti et al. (2007) onion, turmeric and galangal (*Alpinia galanga*)

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have antimicrobial activities. Sunilson et al. (2009) reported that turmeric and ginger gav better control of microbes than galangal. Wax coating is a method used to extend fru shelf-life and to protect fresh products from microbial attack. Apart from that, waxing also needed especially if there is wound or scratch on the fruit surface. Waxing is usuall used in combination with synthetic chemicals to kill bacteria or fungi.

The objectives of this study were (1) to investigate the effect of red ginger an turmeric rhizome extracts on the growth of *T. paradoxa* and (2) to find the most effectiv coating formula to maintain quality of salak pondoh during storage.

MATERIALS AND METHODS

Red Ginger and Turmeric Rhizomes, Isolate of *T. paradoxa* and Salak Cultivar

Red ginger and turmeric rhizomes (7-8 months after planting) were obtained fror the Central Bangka Regency, Bangka Belitung Island Province. An isolate of *T. paradox* was obtained from SEAMEO BIOTROP fungal culture collection (Fig. 1). The Sala pondoh cultivar 'Super Hijau' was collected from Pusat Pelatihan Pertanian dan Pedesaa Swadaya (P4S) Antanan in Kecamatan Caringin, Bogor, West Java.

The Effect of Ginger and Turmeric Extracts on Growth of *T. paradoxa*

Thielaviopsis paradoxa was cultivated on Potato Dextrose Agar (PDA) at roon temperature (28±1.5°C) for 6 days. Each inoculum (4 mm in diam.) of the fungus wa placed on the center of petri plates (9 cm in diam.) each containing PDA and 20, 30 o 40% of ginger and turmeric extracts. As control, the fungus was grown on PDA no containing ginger and turmeric rhizome extract. Three replicates were used for eacl treatment, including the control. Petri plates were incubated at room temperature. Funga growth was observed by measuring colony diameter (in mm) after 24, 48, and 72 l incubation.

Effect of Wax Coating in Combination with Ginger Extract on *T. paradoxa* Infection of Salak during Storage

About 500 g of salak fruit of the same size and maturity were coated with differen treatments, i.e., (a) bees wax at 10% concentration, (b) ginger extract, and (c) wax 10% in combination with ginger extract. As control, salak was not coated with wax and ginge extract. Three replicates were used for each treatment, including the control. The fruit quality were examined every 3 days for 15 days of storage consists of moisture content, weight loss, firmness, soluble solid content (SSC), respiration rate and organoleptic test. They were determined using an oven method, gravimetric, rheometer, refractometer, closed system and panelist tests, respectively.

RESULTS AND DISCUSSION

The Effect of Ginger and Turmeric Extracts on Growth of *T. paradoxa*

Growth of *T. paradoxa* was affected by both type and concentration of extracts on which it grew being inhibited 92, 100 and 100%, by ginger extracts of 20, 30 and 40% concentration respectively (Fig. 2). Ginger extract at 30% concentration was the most effective concentration inhibiting *T. paradoxa* growth. According to Ficker et al. (2003) has shown that ginger, which contains gingerol, gingerdiol and zingerone can inhibit fungal growth. Padma et al. (2007) reported that ginger extracts inhibited proliferation of fungal cells and induced apoptosis.

Turmeric extracts at concentrations of 20, 30 and 40% inhibited fungal growth by 25, 34 and 36%, respectively (Fig. 3). According to Singh et al. (2002) artheric oil of turmeric containing 100 ppm cesquiterpen inhibited growth of *Colletotricum falcatum*, while the growth of *Aspergillus niger* and *Fusarium oxysporum* were inhibited at 200 ppm concentration.

The Effect of Wax Coating in Combination with Ginger Extract on Quality of Salak Pondoh Fruit

Quality of salak pondoh as affected by wax coating in combination with ginger extract after 9 days of storage is shown in Table 1. Moisture content and weight loss of salak pondoh fruit coated with 10% wax in combination with 30% ginger extract was significantly different after 9 days of storage. Fruit coated with 10% wax in combination with 30% ginger extract maintained moisture content of salak and this treatment inhibited deterioration of salak caused by *T. paradoxa*. This wax coating could slow transpiration, consequently free water content and respiration was maintained as well. Thus ginger extract probably inhibited spoilage of salak fruit as a result of suppressing metabolic activity such as transpiration and respiration, which in turn inhibited fungal growth. According to Kader (1992) weight (mass) loss in fruit is caused directly by transpiration and indirectly by respiration that converts sugar into CO_2 and H_2O. Fruit coatings using 10% wax in combination with 30% ginger extract suppressed weight loss, because wax and ginger extract coatings covered the lenticels of fruit, consequently transpiration and respiration rates were inhibited.

The fruit coating using 10% wax in combination with 30% ginger extract resulted in significant differences of fruit firmness after 3 days of storage. After 9 days of storage, control fruit were soft (0.53 kg f) and significantly less than fruit treated with wax (2.16 kgf), ginger extract (2.16 kg f), or 10% wax in combination with 30% ginger extract (2.23 kg f). Thus fruit treated with 10% wax in combination with 30% ginger extract can maintain its firmness. Ginger extract at 30% concentration inhibit growth of *T. paradoxa*, consequently decay of fruit was retarded. Ginger extract also maintained moisture content and reduced weight loss of fruit and thus fruit remained firmer than in controls. According to Seymour et al. (1993) fresh fruit softening is caused by loss of turgor pressure, change of starch to sugar and degradation of cell walls.

After 9 days of storage, SSC of fruit treated with 10% wax in combination with 30% ginger extract (17.2°Brix) was with the same as those treated with 10% wax (18.8°Brix), but lower than control fruit (19.9°Brix) and those treated with 30% ginger extract (19.2°Brix). The wax plus ginger combination inhibited the increase of SSC. Changes of SSC were a result of starch hydrolysis into glucose and fructose during storage (Amiarsi et al., 1996). Fungal growth can induce increased fruit respiration at room temperature (28.0±1.5°C). Fruit coated with 10% wax and 30% ginger extract suppressed fungal growth, consequently neither respiration nor SSC increased. Respiration rate of fruit treated with 10% wax in combination with 30% ginger extract (7.7 ml/kg h) was significantly less than control (12.8 ml/kg h) and 30% ginger extract (11.0 ml/kg h), but it was not from fruit treated with 10% wax (9.6 ml/kg h). Fruit treated with the combination of was and ginger extract inhibited respiration rate. In control, *T. paradoxa* growth was obvious after 3 days of storage. Infection increased with increase of storage duration, consequently damaging more cells in the fruit and hence increasing fruit respiration rate as suggested by Brecht (1995). Mitchell (1992) reported that wax coating will cover some of the pores in the fruit skin, consequently respiration rate was inhibited and the rate of water loss was suppressed.

Quality acceptance of salak fruit determined by the sensory panel tended to decrease during storage at room temperature and relative humidity 65-75%. It was in line with the decrease of acceptable colour, aroma and firmness (Fig. 4). After 9 days of storage, based on hedonic value of fruit treated with 10% wax in combination with 30% ginger extract (4.68) acceptability was significantly higher than control fruit (3.25), and those treated with 10% wax (4.20) or 30% ginger extract (4.39). Minimum acceptability of the fruit was 3.5. The change in salak colour to blackish brown and the existence of fungal growth indicated that the fruit quality was compromised seriously. The colour changes of salak fruit after 9 days of storage are presented in Figure 5.

CONCLUSIONS

Red ginger and turmeric rhizome extracts inhibited growth of *T. paradoxa* starting

at 30% in concentration. However, the red ginger extract was much more effective (100% fungus inhibition) than the turmeric extract (34% fungus inhibition). Using a combination of 10% wax and 30% ginger extract to coat salak pondoh fruit maintains quality of fruit at room temperature (28-29°C) and relative humidity 65-75% for up to 12 days, which is 3 days more than untreated control fruit.

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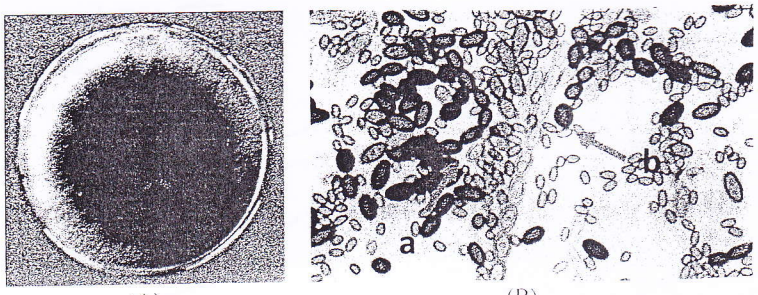
Tables

Table 1. Quality of salak fruit after 9 days of storage at room temperature.

Treatment	Moisture content (%)	Weight loss (%)	Firmness (kg f)	SSC (°Brix)	Respiration (ml/kg h)
Control	82.2±0.1 a	28.2±0.8 b	0.53±0.15 a	19.9±0.9 b	12.8±2.1 c
Wax 10%	84.6±1.0 b	25.1±1.7 a	2.16±0.19 b	18.8±0.9 ab	9.6±1.1 ab
Ginger 30 %	85.1±1.6 b	25.7±1.1 a	2.16±0.44 b	19.2±1.3 b	11.0±1.9 b
Wax 10%+ Ginger 30%	85.7±0.2 b	24.0±1.0 a	2.23 ±0.22 b	17.2 ±0.7 ab	7.7±1.0 a

Means followed by the same letter in the same column are not significantly different according to Duncan's multiple range test at the 5% level.

Figures



(A) (B)

Fig. 1. (A) Colony of *Thielaviopsis paradoxa* on potato dextrose agar after 3 days of incubation at 28±1.5°C, (B) photo micrograph. *T. paradoxa* (200×); (a) chlamydospore, (b) endoconidium.

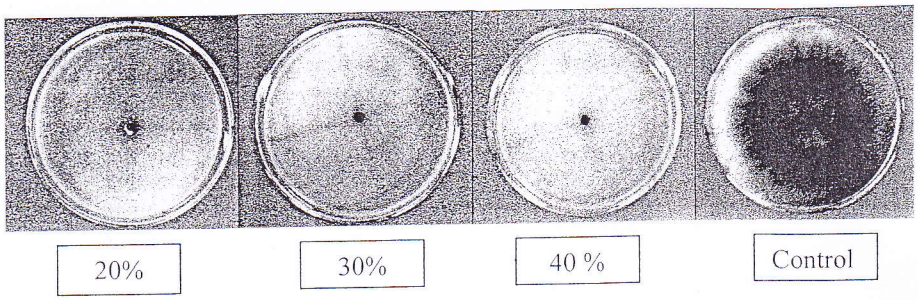


Fig. 2. Growth of *T. paradoxa* on potato dextrose agar containing various concentrations of ginger extract and control.

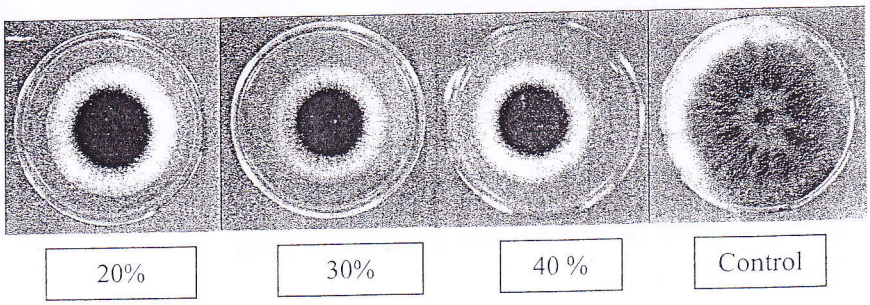


Fig. 3. Growth of *T. paradoxa* on potato dextrose agar containing various concentrations of turmeric extract and control.

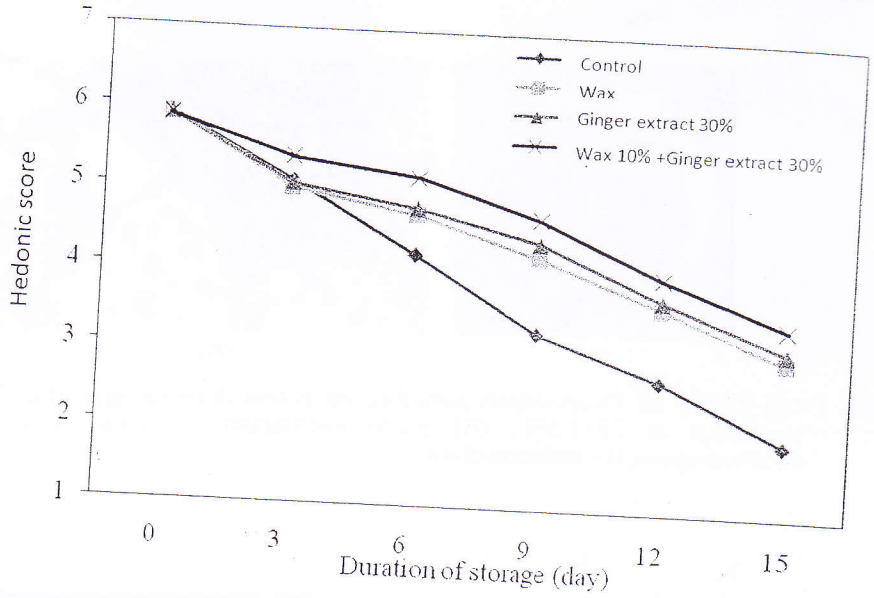


Fig. 4. The change in acceptability to the whole acceptance of fruit during storage.

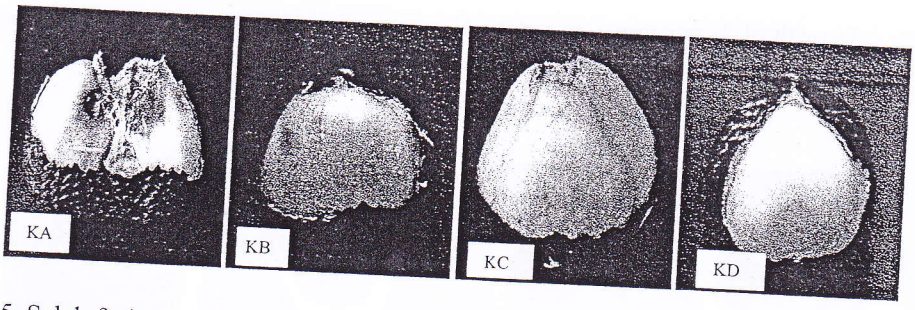


Fig. 5. Salak fruit stored at room temperature (28.0±1.5°C) and relative humidity 65-75% after 9 days of storage (KA= control, KB= wax 10%, KC= ginger extract 30%, KD= wax 10% in combination with ginger extract 30%).