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THE EFFECTS OF ETHYLENE GAS TREATMENT AND MATURITY STAGES ON POSTHARVEST QUALITY CHARACTERISTICS OF VAPOUR HEAT TREATED 'PAIOLA' PAPAYA (Carica papaya. L)

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BY

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A project report submitted to the Faculty of Agriculture, Universiti Putra Malaysia, in fulfillment of the requirements of PRT 4999 (Final Year Project) for the award of the degree of Bachelor of Horticultural Science

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CERTIFICATION

This project report entitled **The Effects of Ethylene Gas Treatment and Maturity Stages on Postharvest Quality Characteristics of Vapour Heat Treated 'Paiola' papaya *(Carica papaya*. L*)*** is prepared by Lee Kok Wei and submitted to the Faculty of Agriculture in fulfillment of the requirement of PRT 4999 (Final Year Project) for the award of the degree of Bachelor of Horticultural Science.

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ABSTRACT

The objective to conduct this experiment was to determine the effects of exogenous ethylene gas and maturity stages on postharvest quality characteristics of vapor heat treated 'Paiola' papaya (*Carica papaya*). Papaya fruits were obtained from a farm in Lanchang, Pahang. The fruits were harvested at maturity stage 2 and treated with fungicide (0.1% Octave®) for 3 to 5 minutes. Then, the fruits were transported to the Department of Agriculture, Serdang for vapor heat treatment (VHT). The papaya fruits were treated with 46.5 ºC fruit-core temperature for 20 minutes. After VHT, the fruits were treated with 100 µL/L ethylene gas at 20 ˚C for 24 hours. Non-ethylene treated (control) fruits were also kept at 20 ˚C for 24 hours. After 24 hours, all the papaya fruits were removed from the ripening rooms and stored at ambient temperature (25 ˚C). Measurements for quality characteristics, firmness, soluble solids concentration (SSC), titratable acidity (TA), ascorbic acid content, pH, peel and pulp colour, of fruits was made when the fruits reached maturity stage 4, 5, and 6. Results showed that the exogenous ethylene applied after heat treatment had no affect on firmness, SSC, TA, ascorbic acid, pH, peel and pulp colour, after VHT. There were no interaction effects of postharvest quality characteristics between ethylene and maturity stages on VHT Paiola papaya. However, there were significant effects of maturity stages on fruit firmness, ascorbic acid content, peel and pulp colour of VHT Paiola papaya. The exogenous ethylene treatment was not necessary apply instantly on Paiola papaya after VHT since there were no signification effects on postharvest quality characteristics. The ethylene treatment may apply on VHT Paiola papaya after being exported to Japan when the

endogenous ethylene production and respiration rate were recovered. Furthermore, the major problem of VHT Paiola papaya was the fruits did not achieve a desirable firmness even at MS 6. It could be prevented by reducing the period of Paiola papaya in VHT chamber.

ABSTRAK

Objektif kajian ini adalah untuk meneliti kesan gas etilena eksogen and tahap kematang ke atas ciri-ciri kualiti pasca tuai betik 'Paiola' (*Carica papaya*) yang dirawat dengan wap panas. Buah betik Paiola diperoleh dari ladang Lanchang, Pahang. Betik Paiola dituai pada tahap kematangan 2 dan dirawat dengan racun kulat (Octave 0.1% ®) selama 3 hingga 5 minit sebelum diangkut ke Jabatan Pertanian, Serdang untuk rawatan wap panas (VHT). Isi betik Paiola dipanaskan hingga suhu 46.5 ºC selama 20 minit . Selepas VHT betik dirawat dengan 100 µL / L gas etilena pada suhu 20 ˚C selama 24 jam di dalam bilik simpanan sejuk. Buah betik yang tidak dirawat (kawalan) oleh gas etilena juga disimpan dalam bilik sejuk lain pada suhu 20 °C selama 24 jam. Selepas 24 jam, semua buah betik telah dikeluarkan dari bilik simpanan sejuk masing-masing dan disimpan ke dalam bilik makmal pada suhu bilik (25 ˚C). Analisis kualiti, kekerasan, kepekatan pepejal terlarut, asid tertitrat, kandungan asid askorbik, pH, warna kulit dan isi buah betik dilakukan apabila buah betik mencapai tahap kematangan 4, 5, dan 6. Keputusan kajian ini menujukkan bahawa gas etilena yang digunakan selepas VHT tidak menberi kesan kepada kekerasan, kepekatan pepejal terlarut, asid tertitrat, kandungan asid askorbik, pH, warna kulit dan isi. Tiada kesan interaksi dalam ciri-ciri kualiti pasca tuai antara rawatan gas etilena dan tahap kematangan bagi betik Paiola VHT. Namun, terdapat perbezaan yang ketara dalam kekerasan, kandungan asid askorbik, warna kulit dan isi buah betik pada tahap kematangan yang berbeza bagi betik Paiola VHT. Dengan itu, rawatan etilena eksogen tidak diperlukan serta merta bagi betik Paiola selepas VHT kerana tiada kesan ketara dalam ciri ciri kualiti pasca tuai. Rawatan

gas etilena boleh dilakukan kepada betik Paiola VHT selepas tiba di Jepun, apabila penghasilan aktiviti metabolik (etilena dalaman dan kadar respirasi) telah memulih. Dalam kajian ini didapati bahawa masalah utama bagi betik Paiola VHT adalah kelembutan isinya tidak mencapai tahap keinginan pengguna walaupun telah mencapai tahap kematangan 6. Ini mungkin dapat dielakkan jikalau tempoh VHT bagi betik Paiola dalam kebuk wap panas dikurangkan.

CHAPTER 1

INTRODUCTION

Papaya (*Carica papaya*. L) is a fruit of the plant which is a member from Caricaceae family and of tropical species. It is a fast growing, non seasonal and early bearing plant.

In Malaysia and South Africa, *Carica papaya* matures and starts to produce after 6 to 9 months of planting, but it needs a longer time in cooler countries. Papaya was believed to originate from tropical America, perhaps from Southern Mexico and the neighbouring Central America. It landed on Malacca about 1550 (Morton and Miami, 1987). Papaya was continued distributed from Malacca to Asia and the South Pacific region.

The development of the papaya industry started in 1972, when the Solo papaya was brought into Malaysia by Dr R.A. Hamilto from the University of Hawaii. He introduced the Sunrise Solo for testing at the Malaysia Agriculture Research and Development Institute (MARDI) station in Serdang Selangor. Its production was low in Malaysia due to the environmental factor, so MARDI released the papaya 'Eksotika' in 1987. This variety can produce 60 tonne fruits/ha/year. The fruit size of the Eksotika papaya is considered to be medium (400-800 g) and is suitable for a small family. The next popular papaya in Malaysia is called Sekaki or Hong Kong. It was released in 1991, and it is a cross-pollinated cultivated variety. It has similar characteristics with Eksotika,

but it produces 70 tonne fruits/ha/year and the fruit size are approximatly 1.5-2 kg (Chan and Tee, 1975).

In 2004, outbreak of the Bacterial Dieback *(Erwinia*) caused the export volume of papaya in Malaysia to decrease from 71,500 metric tonnes (2003) to 58,149 metric tonnes in 2008. The total amount of loss was RM 51.5 million in 2008 (Maktar *et al.,* 2008). In December 2006, the Malaysia Agrifood Corporation Berhad (MAFC) started to rejuvenate the papaya industry with new F1 hybrid variety called "Frangi" or "Paiola" papaya. MAFC prepared a 15 hectare model business farm with the objective of demonstrating the performance of the new hybrid, innovative cultural practices and effective pests and diseases management especially against bacterial Dieback and fruit flies (Chan and Baharuddin, 2008). MAFC exported Paiola papaya to Hong Kong, Singapore, and Europe countries but not into Japan. In fact, exporting fruits need to pass through the rules and regulations of quarantine of Japan such as Phytosanitary Certificate and vapor heat treatment on fresh commodities (Department of Agriculture Malaysia, 2011).

Postharvest heat treatments on fruits are used to maintain the quality of fruits during storage (Forney, 1995), to modify the sensitivity level of fruits to several of stresses, and insect disinfestations (Paull and Chen, 2000). Vapour heat treatment is the latest effective method of using heat to kill the insect eggs, larva and the pathogen in fruits and vegetables with air saturated with water vapour at temperatures of 40 – 50 ºC (Lurie, 1998). It is to meet quarantine and phytosanitation requirement protocol for the

import's countries of fresh agriculture products before market shipment (Anonymous, 2011). World trade is a leading vector of spread of the quarantine pets (Hansen and Johnson, 2007). During vapor heat treatment, the fruits are exposed to the high temperature and heated by a water saturated atmosphere to a required core temperature (e.g. 46.5 ºC). It can successfully control postharvest disease (Couey, 1989) and fruit flies (*Bactrocea tryoni*) (Jacobi *et al.,* 1993) but it will also cause the chemical, physical and biological changes in the fruit. Vapor heat treatment effects on ripening characteristics of climacteric fruit.

Exposing the fruits to temperatures higher than 35 °C after harvesting can delay or inhibit the ripening of the fruit during storage (Paull, 1990). The strawberry fruit treated at 45 °C for 3 hours in air delayed ripening process of fruit (Vicente *et al.,* 2002). Hot drench brushing on 'Oroblanco' fruit or bell pepper at 56 and 60 ° C can effectively control 'Oroblanco' fruit decay and buttons abscission (Rodov *et al.,* 2000). Moreover, heat treatment applied on fruits can delay the degreening rate or inhibited chlorophyll degradation of fruits such as banana, papaya and broccoli (Tian *et al.,* 1997). The differences in response of commodities and variety during heat treatment could be due to whether a new enzyme has been produced to effect the colour development of products. The respiration rate of the commodities is enhanced initially for the first and the second day by high temperatures of 35- 40 ºC, and a longer exposure time to high temperature would cause the respiration rate to decrease. However, when the fruits are returned into ambient temperature, the respiration rate is lower than untreated fruits. The climacteric respiration peak is directly affected by the temperature and the length of

exposure (Lurie and Klein, 1991). The forming of heat shock proteins (HSP) is a natural respond of fruits to the temperature stress. It is a reaction of organisms when tissues and cells are exposed to sudden heat stress. The mRNA of HSP is formed by the disassociation of polyribosomes and reassociation of some ribosomes into polyribosomes which preferentially translate the mRNA and HSP (Banu, 2009). Furthermore, fruits like avocado, permission and citrus can be stored at a lower temperature because of the presense of HSP which formed during heat treatments increased tolerance to chilling injury (Lurie and Klein, 1991; Woolf *et al.*, 1995).

The negative responses of the heat treatments of the fruits are damages to the external and internal parts of the fruits including poor peel colour development of papaya and mango and the yellowing of the green vegetables and cucumber (Lurie, 1998). The high temperature in the vapor chamber may inhibit the ethylene production due to the accumulation of ACC in the tissue of the fruit. (Biggs *et al.*, 1988; Klein, 1989). The inhibition of ethylene formation is reversible when the fruit is free from heat (Paull and Chen, 1990; Chan, 1991) and the production level of ethylene will be higher in treated than untreated fruit. The softening rates of fruit after being treated with heat treatment vary. The softening rate of mangos and papaya after being heated for 4 hours at 50 º C are higher than the untreated fruit. Synthesis of cell wall hydrolytic enzymes such as polygalacturonase, a-and b-galactosidase are inhibited (Chan *et al.*, 1981). But the synthesis occurred much slower in treated tomatoes, pears and avocado held at 30 and 40 ^{o}C than fruits held at 20 ºC (Biggs *et al.*, 1988).

Ethylene plays an important role postharvest life of many horticultural crops. Ethylene is a simple two carbon natural compound and colourless gas with a faint sweetish smell that is the naturally produced ripening hormone of some fruit. There are two classes of fruit in terms of ethylene production. There are climacteric fruits which produce a burst of ethylene during ripening as well an increase in respiration and the non-climacteric fruits that do not increase ethylene production when they ripen (Wills *et al.,* 2007). The most common used of ethylene is to trigger ripening in some harvested fruits, stimulate chlorophyll degradation on papaya and banana peel during ripening process, promotes tissue softening and cell wall degradation during ripening process and enhances the vitamin C of fruits. However, the high concentration and long application period of ethylene caused yellowing of leafy vegetables, over ripen of fruits and senescence of flowers (Saltveit, 1999). There is lack of information on the response of the new heat treated Paiola to ethylene. The objective of this study was to observe the effects of ethylene gas on postharvest qualities of vapour heat treated Paiola papaya (*Carica papaya* cv Paiola).

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