.

UNIVERSITI PUTRA MALAYSIA

POSTHARVEST QUALITY OF PAPAYA FRUIT (*CARICA PAPAYA*) ASSOCIATED WITH APPLICATIONS OF CALCIUM AND CHITOSAN

ABDUL RAQEEB ALI AHMED AL ERYANI

FP 2008 30

POSTHARVEST QUALITY OF PAPAYA FRUIT (*CARICA PAPAYA*) ASSOCIATED WITH APPLICATIONS OF CALCIUM AND CHITOSAN

By

ABDUL RAQEEB ALI AHMED AL ERYANI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Doctor of Philosophy

December 2008

DEDICATION

Dedicated to my beloved parents

Abstract of thesis submitted to the Senate of Universiti Putra Malaysia in fulfilment of the requirements of Doctor of Philosophy

POSTHARVEST QUALITY OF PAPAYA FRUIT (*CARICA PAPAYA*) ASSOCIATED WITH APPLICATIONS OF CALCIUM AND CHITOSAN

By

ABDUL RAQEEB ALI AHMED AL ERYANI

December 2008

Chairman: Associate Professor Mahmud Tengku Muda Mohamed, PhD

Faculty: Agriculture

A study was conducted to evaluate calcium and chitosan effects on storage life, anthracnose disease incidence, quality, physiological changes and enzymes activities of papaya. Mature green papaya fruits of colour index 2 were used for conducting the experiments. In the first experiment, papaya fruits were treated with different concentrations of chitosan, 0, 0.5, 0.75 and 1%, and stored at 13±1°C for 28 days. Chitosan concentrations 0.75 and 1% showed the best effect on extending storage life by 26 and 28 days, respectively while maintaining the quality compared with 0.5% and control. However, there was no significant difference between 0.75 and 1% treatments. In the second experiment, calcium at different concentrations 1.5, 2.5 or 3.5% were applied as a postharvest treatment for papaya fruits using vacuum infiltration and dip application techniques. Calcium infiltration at 2.5% significantly extended the storage life up to 26 days and retained the quality better than other treatments. Since, chitosan with its coating ability to retard weight loss of fruits and antifungal property while

calcium provides better fruit firmness, a study was conducted using calcium at different concentrations 1.5, 2.5 or 3.5% and chitosan at 0.75% or their combination. From the i*n vitro* experiment, calcium at different concentrations had slight inhibition effects on C. *gloeosporioides* spore germination but did not show any significant effects on mycelial growth. Chitosan treatment significantly inhibited spore germination and mycelia growth compared to calcium treatments and their control. Calcium at 2.5 in combination with chitosan (0.75%) had significantly better effects on inhibition of spore germination and mycelial growth of C. *gloeosporioides* compared to calcium individual treatments. Anthracnose disease incidence (%) on papaya fruits was significantly controlled (5.6%) using calcium at 2.5% and chitosan compared with the other treatments. This combined treatment of 2.5% calcium with chitosan 0.75% extended the storage life up to 33 days while retaining the quality of fruits compared with the other treatments. To look at the effect of this combined treatment over different storage intervals, experiment has been conducted. The effectiveness of the treatments was assessed by evaluating their impacts on the quality characteristics during 35 days of storage period. Calcium 2.5% in combination with chitosan 0.75% treatment had better retention of fruits firmness, weight loss, retarding changes in color and preserving chemical characteristics during storage compared to the other treatments. Furthermore, experiment on the physiological and ultrastructures changes and enzyme activities during storage was conducted. The combined treatment of calcium 2.5% and chitosan 0.75% markedly reduced the respiration rate, ethylene production and maintaining the integrity of the waxy cuticle and epidermal cells. Polygalacutronase (PG) degrading enzyme activity was retarded and the induction of defense response of fruits against anthracnose disease was enhanced by eliciting peroxidase enzyme activities (POD).

Abstrak tesis yang dikemukakan kepada Senat University Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

APLIKASI KALSIUM DAN CHITOSAN TERHADAP KUALITI LEPASTUAI BUAH BETIK (*CARICA PAPAYA*)

Oleh

ABDUL RAQEEB ALI AHMED AL ERYANI

December 2008

Pengerusi: Profesor Madya Mahmud Tengku Muda Mohamed, PhD

Fakulti: Pertanian

Kajian ini dijalankan untuk menilai kesan kalsium dan chitosan terhadap jangkamasa penyimpanan, jangkitan penyakit antraknos, kualiti, perubahan fisiologi dan aktiviti enzim buah betik. Buah betik yang matang berwarna hijau berada pada indeks 2 digunakan dalam kajian ini. Pada permulaan eksperimen ini, buah betik tersebut dirawat dengan kepekatan chitosan yang berbeza iaitu pada kepekatan 0, 0.5, 0.75 dan 1%. Kemudian disimpan pada suhu 13±1ºC selama 28 hari. Kepekatan chitosan pada 0.75 dan 1% menunjukkan kesan yang paling baik terhadap pemanjangan jangkamasa penyimpanan dari 26 hingga 28 hari di samping mengekalkan kualiti buah tersebut berbanding dengan 0% (kawalan) dan 0.5% kepekatan chitosan. Walaubagaimanapun tidak terdapat sebarang perbezaan yang signifikan diantara rawatan 0.75 hingga 1% kepekatan chitosan. Eksperimen kedua yang dijalankan adalah untuk mengukur kadar kepekatan kalsium yang berbeza iaitu 1.5, 2.5, dan 3.5% yang merupakan salah satu proses rawatan lepastuai untuk buah betik dengan menggunakan kaedah penyerapan

vakum dan teknik rendaman. Kaedah penyerapan kalsium pada 2.5% signifikan memanjangkan jangkamasa penyimpanan hinggs ke 26 hari serta mengekalkan kualiti buah tersebut daripada menggunakan kaedah rawatan yang lain. Selain itu, chitosan juga mempunyai lapisan yang berkebolehan merencatkan kadar kehilangan berat buah dan antikulat manakala kalsium dapat mengekalkan kekerasan buah tersebut. Eksperimen yang menggunakan kepekatan kalsium yang berbeza iaitu 1.5, 2.5, 3.5 % dan 0.75% chitosan atau kepekatan yang berkombinasi dijalankan. Eksperimen in-vitro yang dijalankan menggunakan kadar kepekatan kalsium yang berbeza dapat menghalang percambahan spora *C. gloesporioides* tetapi tidak menunjukkan sebarang kesan yang signifikan pertumbuhan mycilial. Namun bagi rawatan menggunakan chitosan sigfikan dapat menghalang percambahan spora dan pertumbuhan mycilia berbanding menggunakan keadah rawatan kalsium dan kawalan. Kalsium pada kadar 2.5 dan 3.5% berkombinasi dengan chitosan (0.75%) dapat memberikan kesan yang signifikan bagi menghalang percambahan spora dan pertumbuhan mycilial *C. gloesporioides* berbanding menjalankan rawatan kalsium dan chitosan secara berasingan. Jangkitan penyakit antraknos (%) terhadap buah betik nyata sekali dapat dikawal (5.6%) menggunakan kalsium pada 2.5% dan chitosan berbandingan rawatan lain. Kombinasi rawatan 2.5 % kalsium dan 0.75 % chitosan dapat memanjangkan jangkamasa simpanan sehingga 33 hari dan mengekalkan kualiti buah berbanding rawatan lain. Eksperimen dijalankan bagi melihat kesan kombinasi rawatan terhadap perbezaan jangkamasa simpanan, keberkesanan rawatan dapat ditaksir dengan menilai kesan ke atas cirri-ciri kualiti sepanjang 35 hari tempoh penyimpanan. Kombinasi rawatan kalsium dan chitosan lebih baik dalam mengekalkan kekerasan buah, kehilangan berat, merencatkan perubahan warna dan ciri-ciri kimia pra tuai sepanjang penyimpanan berbanding dengan

rawatan yang lain. Tambahan pula, kajian terhadap fisiologi dan perubahan struktur ultra serta aktivti enzim sepanjang penyimpanan turut dijalankan. Kombinasi kaedah rawatan diantara kalsium dan chitosan merupakan kaedah yang terbaik bagi melambatkan kadar respirasi, penghasilan etilen dan mengekalkan kutikel lilin serta sel epidermis buah tersebut. Aktiviti penurunan enzim polygalacutronose (PG) adalah terencat dan meransang tindakbalas pertahanan terhadap serangan jangkitan penyakit antraknos dapat ditingkatkan dengan mendapatkan aktiviti enzim peroxidase (POD) semasa menggunakan kombinasi rawatan berbanding rawatan yang lain.

ACKNOWLEDGEMENTS

In the name of Allah the Beneficial and the Compassionate

Praise be to Allah SWT, upon His permission I could complete this thesis smoothly. Contributions of individuals and institution for the successful completion of this thesis are also deeply acknowledged.

I would like to express my sincere thank and profound appreciation to the chairman of my supervisory committee, Assoc. Prof. Dr. Mahmud Tengku Muda Mohamed, Department of Crop Science, Faculty of Agriculture for his supervision, kind support beyond supervisory duties and for being so patient and understanding. I am indebted to him where, without his gaudiness this study could not be completed smoothly. I am also indebted to Assoc. Prof. Dr. Syed Omar Bin Syed Rastan, my co-supervisor for his time and advice, as well as for his encouragement and friendship. Special thanks to Assoc. Prof. Dr. Mohamad Zaki Ab. Rahman as a member of my supervisory committee for his critical comments and suggestion during the course of this project.

My appreciation and honest thanks are due to all lecturers and staff members of Faculty of Agriculture in particular Dr. Zakrya, Dr. Siti Hazar Ahmad, Dr. Phebe, Dr. Yahya Awang, Dr. Jugah Kadir, Prof. Zahrah, Dr. Anwar and Dr. Osmanu Haruna for their willing assistance and help during my studies

Completion of this research work is also much owes to my family, for their continuous encouragement and in particular my beloved sons Mohammed, Ryan and Aus and my beloved daughter Aiah who provided the comfort and for being the constant source of inspiration for me to complete this research.

My special appreciation and gratitude goes to my beloved parents, I pray to Allah to bless them, who guided and supported me to achieve the highest level of education. I also wish to express my sincere gratitude to my brothers Dr. Abdul Rahman and Amin and my sisters for their constant encouragement, love and ever ready to give helping hands.

My appreciations and honest thanks are due to all Lecturers and staff members in Sana'a University, Faculty of Agriculture, Department of Horticultural Science in particular Prof. Dr. Ahmed Hamzah, Prof. Dr. Mane'e, Dr. Mehasen, Prof. Dr. Hussin Al waard, Dr. Hassan Al dobai, Dr. Taha, Dr. Mansor Al Thobibi, Dr. Mansor Al thobhani as well as for their encouragement and friendship.

A word of 'thank you' is never sufficient to express my appreciation to my friends for their generous support and encouragement in particular Mohammed Al Hitar, Monther Tahat, Abdul Moamen, Dr. Adnan, James, Ameera, Angela, Soak Meng, Munirah, Liza, Balqes, Najat, Ganeah and others whom not listed along.

Finally, most profound thanks go to the Malaysian government and people represented by Universiti Putra Malaysia, for financial support of graduate research assistantship and giving me this opportunity to study in their prestigious and reputed institute.

I certify that an Examination Committee has met on **date of viva voce** to conduct the final examination of **Abdul Raqeeb Ali Ahmed Al Eryani** on his **Doctor of Philosophy** thesis entitled "**Postharvest Quality of Papaya (*Carica papaya*) Associated with Applications of Calcium and Chitosan**" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the student be awarded the Doctor of Philosophy.

Members of the Examination Committee were as follows:

Name of Chairperson, PhD
Title
Faculty of Agriculture
University Putra Malaysia
(Chairman)

Name of Examiner 1, PhD
Title
Name of Faculty
University Putra Malaysia
(Internal Examiner)

Name of Examiner 2, PhD
Title
Name of Faculty
University Putra Malaysia
(Internal Examiner)

Name of External Examiner, PhD
Title
Name of Department and/or Faculty
Name of Organisation (University/Institute)
Country
(External Examinar)

_____

Name
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of **Doctor of Philosophy**. The members of the Supervisory Committee were as follows:

Mahmud Tengku Muda Mohamed, PhD
Associate Professor
Faculty of Agriculture
University Putra Malaysia
(Chairman)

Syed Omar Bin Syed Rastan, PhD
Associate Professor
Faculty of Agriculture
University Putra Malaysia
(Member)

Mohamad Zaki Ab. Rahman, PhD
Associate Professor
Faculty of Sceince
University Putra Malaysia
(Member)

HASANAH MOHD. GHAZALI, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 15 January 2009

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

_____

ABDUL RAQEEB ALI AHMED AL ERYANI

Date:

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Papaya (*Carica papaya*) is an important fruit crop grown widely in tropical and subtropical lowland regions (Gebhardt and Thomas, 2002). Papaya is one of the promising tropical fruits traded in the world market. Malaysia, as one of the major exporters of papaya accounted for USD 22.5 million in 2004. Malaysia currently is the second most important exporter of papaya in the world after Mexico (Rabu and Mat., 2005). However, an impediment to the expansion of the papaya fruit industry is the short postharvest life, susceptibility to postharvest diseases, chilling injury caused by storage at low temperature and high shipment cost.

Worldwide postharvest losses have been estimated at 50% much of which is due to fungal and bacterial infection (El Ghaouth *et al*., 1997). Among the postharvest pathogens, fungal diseases are, in fact, one of the major causes of fruit decay as they account for 80-90% of all losses in postharvest industry and to the consumer (Sommer, 1985; Gullino, 1995). Papaya is vulnerable to a large number of diseases and pests with anthracnose being the cosmopolitan and devastating of them during storage (Kader, 2002; Bautista-Banos *et al*., 2003; 2006). Due to the latency of the pathogen in early ontogeny of the fruits, the symptoms normally only become apparent during ripening (Snowdon, 1990).

Traditionally, anthracnose on papaya is controlled by fungicides such as prochloraz and propiconazole (Sepiah, 1993), hot water dipping at 43-49°C for 20 minutes, or dipping in hot water laced with fungicides (Couey *et al*., 1984). However, the hot water treatment can affect the fruit ripening and also cause heat injury (Paull, 1995). Other practice using fungicide over the long term may lead to the development of resistance (Spotts and Cervantes, 1986). In addition, the fungicide residues on the fruits may be toxic to the consumer (Ragsdale and Sisler, 1994). As such, the use of fungicides is under review all over the world. Storing the papaya at low temperatures can prolong shelf life, but sustained cold treatment results in chilling injury (Chen and Paull, 1986; An and Paull, 1990). Therefore, low temperature cannot be used effectively to extend storage life as, for example, can be done for apples. Indeed, all the conventional storage processes currently in use pose problems. These problems have prompted a search for safer alternatives for disease management.

On the other hand, increasing respiration, transpiration and ethylene production are major factors contributing to the deterioration of fresh fruits and vegetables as well as affect the storage life. The lowest possible reduction of these biochemical processes by storage technologies enable the postharvest life of fresh produce to be prolonged (De-Ell *et al*., 2003). Being papaya a climacteric fruit, characterized by the increase in respiration and ethylene production during ripening (Ali *et al*., 1994). There is an opportunity with climacteric fruit, however, to slow down ripening after harvest and, thus, extend the storage life while maintaining the quality for the fruits to be competitive in the market. This can be done with modified atmosphere packaging (MAP) or with controlled atmosphere (CA) storage (Abeles *et al*., 1992; De-Ell *et al*., 2003). However,