UNIVERSITI PUTRA MALAYSIA

PHYSICO-CHEMICAL, ANTIOXIDANTS AND STRUCTURAL CHANGES DURING DEVELOPMENT OF RED-FLESHED DRAGON FRUIT (Hylocereus polyrhizus)

NUR ADILLA JAMALUDIN

FP 2010 13

PHYSICO-CHEMICAL, ANTIOXIDANTS AND STRUCTURAL CHANGES DURING DEVELOPMENT OF RED-FLESHED DRAGON FRUIT (*Hylocereus polyrhizus*)

NUR ADILLA JAMALUDIN

MASTER OF SCIENCE
UNIVERSITI PUTRA MALAYSIA

2010

PHYSICO-CHEMICAL, ANTIOXIDANTS AND STRUCTURAL CHANGES DURING DEVELOPMENT OF RED-FLESHED DRAGON FRUIT (*Hylocereus polyrhizus*)

By

NUR ADILLA JAMALUDIN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

September 2010

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

PHYSICO-CHEMICAL, ANTIOXIDANTS AND STRUCTURAL CHANGES DURING DEVELOPMENT OF RED-FLESHED DRAGON FRUIT (*Hylocereus polyrhizus*)

By

NUR ADILLA JAMALUDIN

September 2010

Chairman: Phebe Ding, PhD

Faculty: Agriculture

A study was conducted on the changes in physico-chemical, antioxidant content and cellular structures of red-fleshed dragon fruit at every 5 days interval starting from 5 until 35 day after pollination (DAP). The experiment was conducted using randomized complete block design with four replications. Three fruits per replicate were used. Data from measurements of length, diameter, stomatal density, peel and pulp fresh and dry weight, moisture content, ethylene and carbon dioxide rate, pulp firmness, soluble solids concentration (SSC), titratable acidity, pH, peel and pulp betacyanin content and chlorophyll content were analyzed using analysis of variance and differences between means were determined by Duncan's New Multiple Range Test. Peel and pulp L*, C* and h° values were determined by regression. Correlation carried out using Pearson's correlation coefficient. Fruit colour changes and cellular structure were documented as photographs and micrographs, respectively. In this

study, fruit were non-climacteric with no respiration and ethylene peaks were observed. A decrease in stomatal density with closed stomata was found throughout fruit development and maturation. The moisture content in peel increased, while decreased in pulp was observed as DAP progressed. Colour changes of red-fleshed dragon fruit in pulp occur earlier than the peel. The manifestations of red-violet betacyanin only appear after seeds have matured, then followed by pulp colour changes and finally peel change from green to red-violet. The red-violet betacyanin manifested itself gradually in pulp at 25 DAP followed by peel at 30 DAP. The high retention of betacyanin content during development and maturation had caused it to correlate significantly with soluble solids concentration as in process of betacyanin synthesis, sugar derivatives was needed to form red-violet betacyanin. Titratable acidity and pH in fruit were not correlated with betacyanin content in peel but titratable acidity significantly correlate with betacyanin content in pulp. There were significant relationship between DAP with L*, C* and h° value of peel and pulp. Betacyanin determination using reversed-phase HPLC-photodiode array detection, was confirmed betanin and isobetanin in the fruit. Fruit has high content of antioxidant activity, yet relatively low levels of ascorbic acid and total phenolic contents. This suggest that major source of antioxidant activity of fruit may not contributed from ascorbic acid or phenolics but rather from betacyanin. The developmental processes of fruit were examined using scanning electron microscope (SEM). As DAP progressed, parenchymatous cell lose their integrity due to cell hydrolysis which leads to losing of firmness. The SEM micrographs had revealed that starch granules in pulp decreased in size and intensity as DAP progressed. The degradation of starch granules contribute to softening of pulp tissue. Various form and shape of crystals such as raphides and druses were observed

in scale tissues. It is clear, the physico-chemical and betacyanin accumulation of red-fleshed dragon fruit changed as fruit developed, matured and ripened which coincide with structural changes.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan keperluan untuk ijazah Master Sains

FISIKO-KIMIA, KANDUNGAN ANTIOKSIDA DAN PERUBAHAN STRUKTUR SEL SEPANJANG PERTUMBUHAN BUAH NAGA MERAH (*Hylocereus polyrhizus*)

Oleh

NUR ADILLA JAMALUDIN

September 2010

Pengerusi: Phebe Ding, PhD

Fakulti: Pertanian

Kajian ini dijalankan untuk melihat perubahan fisiko-kimia, kandungan antioksida dan perubahan struktur sel buah naga merah. Kajian dijalankan pada setiap 5 hari bermula pada hari ke-5 sehingga hari ke-35 selepas pendebungaan (DAP). Eksperimen dijalankan menggunakan blok lengkap secara rawak dengan empat replikasi. Tiga sampel buah bagi setiap replikasi. Hasil dapatan data dari ukuran panjang, diameter, kepadatan stomata, berat kering dan berat basah kulit dan isi buah, kandungan air, kadar etilena dan karbon dioksida, kerapuhan isi, kandungan pepejal larut (SSC), keasidan boleh titrat, pH, kandungan pigmen merah-violet betacyanin dan kandungan klorofil dianalisis menggunakan analisis varians manakala perbezaan min dianalisis menggunakan Ujian Duncan New Multiple Range. Nilai L*, C* dan h° kulit dan isi buah naga merah dianalisis menggunkan regresi analisis. Korelasi menggunakan koefisien korelasi Pearson. Perubahan warna dan struktur sel buah naga merah masing-masing didokumentasikan dalam bentuk foto dan mikrofoto. Keputusan kajian

menunjukkan buah naga merah boleh diklasifikasikan sebagai buah tidak klimaterik apabila tiada puncak respirasi dan pengeluaran etilena didapati. Semasa perkembangan dan kematangan buah naga merah, liang stomata dalam keadaan tertutup. Manakala, kepadatan stomata di bahagian kulit buah naga merah didapati menurun sepanjang DAP berlaku. Semasa DAP berlaku, didapati kandungan lembapan pada kulit buah naga meningkat, sementara penurunan lembapan berlaku di bahagian isi buah. Perubahan warna buah naga merah di bahagian isi berlaku lebih awal berbanding perubahan warna pada kulitnya. Pengeluaran pigmen merah-ungu betasianin hanya berlaku selepas biji buah naga merah matang dan diikuti dengan perubahan warna pada isi buah pada hari ke-25 DAP dan perubahan warna pada kulit daripada warna hijau berubah menjadi warna merah pada hari ke-30 DAP. Pengeluaran pigmen merah-ungu betasianin sepanjang pengembangan dan pematangan buah menyebabkan korelasi yang signifikan dengan SSC. Ini disebabkan oleh gula derivatif diperlukan semasa proses penghasilan untuk membentuk pigmen merah-ungu betasianin. Keasidan boleh titrat dan pH kulit buah naga merah didapati tidak mempunyai korelasi signifikan dengan kandungan pigmen merah-ungu betasianin tetapi keputusan keasidan boleh titrat pada isi buah naga merah mempunyai korelasi signifikan dengan keasidan boleh titrat. Hubungan regresi diantara DAP dan nilai L*, C* dan h° kulit dan isi buah naga didapati signifikan. Untuk mengenalpasti kandungan pigmen merah-ungu betasianin dengan menggunakan HPLC-fotodioda array pengesanan, di mana ia mengesahkan kandungan betanin dan isobetanin di dalam buah naga. Buah naga merah mempunyai kandungan aktiviti antioksida yang tinggi, tetapi kandungan askorbik asid dan kandungan fenol total (TPC) yang rendah. Ini menunjukkan kandungan aktiviti antioksida bukanlah daripada askorbik asid tetapi adalah

disebabkan oleh kandungan pigmen merah-ungu betasianin. Proses pengembangan buah diteliti dengan menggunakan Scanning Elektron Mikroskop (SEM). Sepanjang DAP berlaku, sel parenkima kehilangan integritinya disebabkan pemecahan sel yang mana menyebabkan buah naga merah hilang kekerasannya. Microfoto SEM menunjukkan granul gula di bahagian isi buah berkurang dari segi saiz dan kepadatan sepanjang DAP berlangsung. Penguraian granul gula didapati penyumbang kepada isi buah hilang kerapuhan. Juga didapati pelbagai bentuk dan corak hablur yang dikenali sebagai raphide dan druses dibahagian tisu sisik buah naga. Jelas sekali perubahan fisiko-kimia dan penghasilan pigmen merah-ungu betacyanin semasa pengembangan dan pematangan mempunyai hubungkait yang rapat dengan perubahan struktur sel buah naga merah.

ACKNOWLEDGEMENT

This thesis would not have been possible, and I would like to begin by giving praise to the Almighty God, the great I AM, Alhamdulillah. Without His grace and mercy, none of this would have been possible.

Next, I would like to show my gratitude to my supervisor, Dr. Phebe Ding for her enlightening suggestions and patient guidance from the preliminary to the end of this process. Without which I would not be able to make it to the end. I am also grateful to Prof. Dr. Azizah Abdul Hamid for being the committee.

I am deeply indebted to my dear family members as they had shown ceaseless support the whole time especially to my parents (Dr. Jamaludin Badusah and Mrs. Hashimah Hashim) and my brothers (Mr. Mohd Illuddin, Mr. Mohd Nasruddin and Mr. Mohd Latif). They had lent a helping hand whenever I faced any difficulties. I remain indebted to my husband, Mr. Mardian Matasan and my beautifully daughter Baby Marha Nabilah who stand beside me and had accepted my selfish time all the while, starting from first year right until this very day. It is because of their loving kindness which motivates me to fight hard and never give up until the end. Words cannot express my appreciation towards their time and effort.

To family members of Postharvest Laboratory, I would like to thank each and every one of you for your valuable advices and feedbacks. It is through your scrutinizing observations which made this system complete without error. To Miss Joanna Cho, I am grateful to the companion. The project can come to its completion was a result of our knowledge exchange and sharing. I owe my deepest gratitude to Miss Atiqah Sharif, Miss Nor Elliza Tajidin Miss Munirah Mohamad, and Mr. Humam Wan Mansor for all those constructive advices and formulae explanation, thank you very much.

Lastly, I offer my regards and blessings to all of those who supported me in any respect during the completion of the project.

I would like to dedicate this thesis to my late grandfather (Mr. Badusah Abas) and late uncle (Mr. Bekkari Badusah) as both gave me moral support I required within two and half years of completion.

Nur Adilla Jamaludin

APPROVAL 1

I certify that an Examination Committee has met on (date of viva voce) to conduct the final examination of Nur Adilla Jamaludin on her Master of Science thesis entitled "Physico-chemical, Antioxidant and Cellular Structure of Red-fleshed dragon fruit during Development and Maturation" in accordance with Universiti Pertanian Malaysia (High Degree) Act 1980 and Universiti Pertanian Malaysia (High Degree) Regulations 1981. The Committee recommends that the student be awarded the Master of Science.

Members of the Examination Committee were as follows:

Siti Aishah Hassan, PhD (Chairperson)
(Associate Professor)
Faculty of Agriculture
Universiti Putra Malaysia

Yahya Awang, PhD (Internal Examiner)
(Associate Professor)
Faculty of Agriculture
Universiti Putra Malaysia

Mahmud Tengku Muda Mohamed, PhD (Internal Examiner)
(Associate Professor)
Faculty of Agriculture
Universiti Putra Malaysia

Ruzita Ahmad, PhD (External Examiner)
Head Cluster of Integrative Medicine
Advanced Medical and Dental Institute
Universiti Sains Malaysia
Pulau Pinang, Malaysia

BUJANG KIM HUAT, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

APPROVAL 2

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Phebe Ding, PhD
Lecturer
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Azizah Abdul Hamid, PhD
(Associate Professors)
Faculty of Food Science
Universiti Putra Malaysia
(Member)

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

Date:

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.

_____

NUR ADILLA BT. JAMALUDIN

Date: 23 September 2010

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AA	-	Ascorbic acid
DAP	-	Day after pollination
DOPA	-	Dihydroxyphenylalanine
DPPH	-	1,1-diphenyl-2-picrl-hydrazil
FRAP	-	Ferric-reducing antioxidant power
SEM	-	Scanning electron microscope
SSC	-	Soluble solids concentration
TA	-	Titratable acidity
TPC	-	Total phenolics content

TABLE OF CONTENTS