CHARACTERISTICS OF FIG (*Ficus carica* L. var. IPOH BLUE GIANT) SYCONIUM DURING GROWTH, MATURATION AND ON-TREE RIPENING

By

NUR ATHIRAH BINTI MAT JUSOH

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

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Chair : Associate Professor Phebe Ding, PhD
Faculty : Agriculture

Lately, fig (*Ficus carica*) has become one of the new crops among Malaysian growers. It was suggested that it is a potential crop that can improve Malaysian horticultural and downstream product industries. Even so, the study on fig grown in country is very lacking. Most of the previous studies were mainly conducted in subtropical countries. Therefore, a study on common fig that grown under Malaysia climate was carried out to determine its characteristics during growth, maturation and on-tree ripening. This study was carried out on fig trees cultivated commercially at the Selangor Fruit Valley, Rawang, Selangor. The bud of fig was tagged and its development was monitored weekly. Data were recorded from 1st week after bud emergence (WAB) until syconium matured and fully ripened on tree. The physical, physiological, chemical and structural characteristics of fig syconium during growth, maturation and on-tree ripening was obtained. Results obtained showed that fig var. Ipoh Blue Giant (IBG) cultivated in Malaysia took 12 WAB to develop from a tiny bud into a mature syconium and followed by 6 days on-tree ripening and finally senescent. Based on fruit size (diameter, volume and weight), IBG fig exhibited a double sigmoid growth curve. From the physiological characteristics, IBG fig exhibited climacteric ripening by having a burst in ethylene and carbon dioxide emission during ripening at day 0 with 24.35 µL $C_2H_4.kg^{-1}.h^{-1}$ and 74.5 mL $CO_2.kg^{-1}.h^{-1}$, respectively. The green colour of syconium gradually disappeared and turned red as it matured and ripened. The pulp firmness increased as weeks after bud emergence progressed, and decreased to 1.38 N as ripening took place. The soluble solids concentration increased as week after bud emergence progressed and peaked to 16.69% SSC at ripening day 5. The titratable acidity was initially increased as weeks after bud emergence progressed and peaked to 8.32% during 11 WAB but decreased as it ripened. While, the pH showed inversely trend with titratable acidity where pH decreased from 6.29 to 4.93 during weeks after bud emergence progressed, but increased gradually as fig ripened. Results of analysis also revealed that the sugar content increased as on-tree ripening days progressed with more than 65% increment. However, the

total pectin content did not show any significant changes during growth and development**.** The observation of structural changes of fig syconium during growth, maturation and on-tree ripening were in accordance with the changes in syconium size. Fig syconium underwent cell division during 1 WAB, cell enlargement during 4 and 7 WAB and enlargement of intercellular spaces during day 3 of on-tree ripening. In brief, the optimum harvesting stage of IBG fig grown under Malaysia climate is at day 2 of on-tree ripening. As it has become a new potential crop in Malaysia, information on the optimum harvesting stage is crucial especially on postharvest handling process in order to reduce the loss faced by growers and sellers.

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

CIRI-CIRI SYCONIUM TIN (*Ficus carica* L. var. IPOH BLUE GIANT) SEMASA PERINGKAT PERTUMBUHAN, KEMATANGAN DAN RANUM DI POKOK

Oleh

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Kebelakangan ini, tin (*Ficus carica*) telah menjadi salah satu tanaman baharu dikalangan penanam Malaysia. Ia telah diusulkan sebagai tanaman berpotensi untuk meningkatkan industri hortikultur dan produk hiliran di Malaysia. Walaupun begitu, kajian terhadap tanaman tin di negara ini adalah sangat berkurangan. Kebanyakan kajian terdahulu lebih tertumpu di negara-negara subtropika. Oleh itu, satu kajian terhadap tin biasa yang ditanam di bawah iklim Malaysia telah dilakukan bertujuan untuk mengesahkan ciri-cirinya semasa peringkat pertumbuhan, kematangan dan ranum di pokok. Kajian ini telah dijalankan terhadap pokok-pokok tin yang telah ditanam secara komersial di Selangor Fruit Valley, Rawang, Selangor. Tunas tin telah ditanda dan perkembangannya dipantau setiap minggu. Data dari minggu 1 selepas tunas bercambah (WAB) sehingga syconium matang dan ranum sepenuhnya di pokok telah dicatat. Ciri-ciri fizikal, fisiologikal, kimia dan struktur syconium tin semasa pertumbuhan, kematangan dan ranum di pokok telah diperoleh. Hasil perolehan menunjukkan bahawa tin var. Ipoh Blue Giant (IBG) yang telah ditanam di Malaysia mengambil masa 12 WAB untuk berkembangan daripada tunas yang kecil kepada syconium yang matang dan diikuti dengan 6 hari ranum di pokok dan akhirnya penuaan. Berdasarkan saiz buah (garis pusat, isi padu, dan berat), tin IBG mempamerkan jenis pola pertumbuhan sigmoid berganda. Daripada ciri fisiologi, tin IBG mempamerkan kematangan klimaterik dengan menghasilkan cetusan pelepasan etilena dan karbon dioksida semasa ranum pada hari 0 dengan masing-masing 24.35 µL $C_2H_4.kg^{-1}.h^{-1}$ and 74.5 mL $CO_2.kg^{-1}.h^{-1}$. Warna hijau pada syconium beransur hilang dan bertukar merah apabila ianya matang dan ranum. Kekerasan pulpa bertambah seiring minggu selepas tunas bercambah berkembang, dan berkurangan hingga ke 1.38 N apabila keranuman berlaku. Kepekatan pepejal terlarut meningkat seiring minggu selepas tunas bercambah berkembang dan memuncak sehingga 16.69% SSC ketika hari 5 ranum. Asid tersirat pada mulanya meningkat seiring minggu selepas tunas bercambah berkembang hingga memuncak ke 8.32% ketika 11 WAB tetapi menurun setelah

ranum. Manakala, pH menunjukkan arah aliran yang berlawanan berlawanan dengan asid tersirat dimana pH menurun dari 6.29 kepada 4.93 semasa minggu selepas tunas bercambah berkembang, tetapi meningkat secara beransur-ansur apabila tin ranum. Hasil analisis juga mendedahkan yang kandungan gula bertambah seiring dengan keranuman di pokok dengan kenaikan lebih daripada 65%. Walau bagaimanapun, jumlah kandungan pektin tidak menunjukkan perubahan yang ketara semasa pertumbuhan dan perkembangan. Pemerhatian terhadap perubahan struktur syconium tin semasa pertumbuhan, kematangan dan ranum di pokok selaras dengan perubahan saiz syconium. Syconium tin mengalami pembahagian sel semasa 1 WAB, pembesaran sel semasa 4 dan 7 WAB dan peningkatan ruang antara sel-sel semasa hari 3 ranum di pokok. Secara ringkas, peringkat optimum penuaian tin IBG yang ditanam di bawah iklim Malaysia ialah pada hari 2 ranum di pokok. Memandangkan ia telah menjadi tanaman baru berpotensi di Malaysia, informasi berkenaan peringkat optimum penuaian adalah sangat penting terutamanya dalam proses pengendalian pasca tuai bagi mengurangkan kerugian yang akan dialami oleh penanam dan juga peniaga.

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parenchyma cells can be observed clearly (250×; bar = 100 µm). (C) Under higher magnification, intercellular spaces among spongy parenchyma cells can be observed clearly and the shape of cells became irregular instead of rigid round-tube shape (250×; bar = 100 µm). is = intercellular spaces, vb = vascular bundle.

LIST OF ABBREVIATIONS

A	Absorbance
*a**	Red – green axis
ABTS	2,2-azino-bis(3-ethylbenthiazoline-6-suphonic acid
AIS	Alcohol insoluble solids
a.m.	Ante meridiem
ANOVA	Analysis of variance
*b**	Yellow – blue axis
*C**	Chroma
C_2H_4	Ethylene
CIE	Commision Internationale de l'Eclairage
CO_2	Carbon dioxide
CRD	Completely randomized design
cv.	Cultivar
DF	Dilution factor
DMRT	Duncan's multiple range test
DPPH	2,2-diphenyl-1-picrylhydrazyl
ε	Extinction coefficient
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
FRAP	Ferric reducing antioxidant power
h	Hour
h°	Hue angle
HPLC	High-performance liquid chromatography
HPO_3	Meta-phosphoric acid

IBG	Ipoh Blue Giant
*L**	Lightness
LM	Light microscope
min	Minute
MV	Molecular weight
N	Newton
Na_2CO_3	Sodium carbonate
NaOH	Sodium hydroxide
P	Probability
p.m.	Post meridiem
r	Correlation coefficient
RI	Refractive index
ROS	Reactive oxidation species
SAS	Statistical Analysis System
SEM	Scanning electron microscope
SSC	Soluble solids concentration
TA	Titratable acidity
TEAC	Trolox equivalent antioxidant capacity
TP	Total pectin
TPC	Total phenolic content
TPTZ	2, 4, 6-Tripyridyltriazine
USDA	United States Department of Agriculture
var.	Variety
WAB	Week after bud emergence

CHAPTER 1

INTRODUCTION

Botanically, fruit is defined as swollen ovary after successful fertilization with seed development and maturation in the ovary (White, 2002). Uniquely, it is a little bit twist for fig 'fruit'. Fig which comes from the *Ficus* species has a special feature where development of their 'fruit' is not flower bears fruit (fruit developed as flower's ovary become swollen), which normally happened. But it looks like fruit that bears flower (Crane, 1986; Ikegami et al., 2013). Fig is well known world-wide not only due to its unique features, but also due to its nutritious value. Fig was reported as fruit that rich in fiber, potassium, calcium, iron, and also claimed as sodium-, fat- and cholesterol-free (Crisosto et al., 2011).

Fig is well discovered in all of the holy books of a few religions (Aksoy, 1998). In the Quran, fig has been mentioned in Surah At-Tin. Hazrat Abu Darda (RA) has narrated the Prophet Muhammad SAW that fig fruit was sent from heaven to cure haemorrhoids and rheumatism (Marwat et al., 2011). In the Bible, it is referred generally as tree in the Garden of Eden and it is also used in Jewish Passover celebration traditional food (Aksoy, 1998). For the Buddhist, it was believed that Siddhartha Gautama has received the revelation that formed Buddhism basis while sitting under a Bodhi fig tree (*Ficus religiosa*) (Aksoy, 1998). Based on these, it can be stated that fig has its own precious value in every religion.

1.1 Problem statement

Globally, Turkey, Egypt and Algeria are the major producers of fig as fig thrive well in these countries (FAOSTAT, 2019). Fig cutting was brought into Malaysia by hobbyist way back 2015. Unexpectedly, the cutting is able to survive and bear fruit under Malaysia climate with better eating quality than its origin. The price of Malaysian grown fresh fig is range from RM40 to RM150 per kilogram depending on its cultivar. This has attracted growers to grow fig for commercial purpose either as fresh fruit or downstream processing. However, there are few barriers for Malaysian to produce fig commercially. One of it is lack of knowledge in harvesting fruit at its optimum stage, thus affecting fig quality and postharvest life. In directly, cause the postharvest loss.

1.2 Justification

It has been proven that fruit maturity and harvesting stage is able to affect postharvest quality of a fruit (Ding and Syazwani, 2016; Mijin et al., 2021; Mariani et al., 2018). Harvesting stage of fig fruit is very crucial. Fig fruit that harvested prior to complete ripening could not reach the commercial desirable, while late harvested lead to loss due to over ripeness and susceptible to pathogens (Lama

et al., 2019). In order to determine harvesting stage of fruit, it is important to understand the growth and development characteristic of the fruit which include life cycle of fruit from fruit set to senescence, physico-chemical and cellular structure changes. For example, knowing the growth and development of jackfruit syncarp, the fruit can be harvested at optimum stage to accommodate different distance of markets (Mijin et al., 2021).

1.3 Research objectives

Since fig is a newly introduced crop into Malaysia, the information on fruit growth and development in tropical climate and also its optimum harvesting stage is almost nil. The lack of knowledge in handling of fig especially among growers could lead them to face the losses due to surplus of produce and finally reducing the value of fig fruit as potential crop in Malaysia. To fill up this gap, a study was conducted to determine fruit growth and development of fig from fruit set until senescence. The specific objectives of this study were:

(i) to determine fig var. Ipoh Blue Giant characteristics during growth, maturation and on-tree ripening under Malaysia climate, and

(ii) to elucidate its physical, physiological, chemical and cellular structure changes during growth, maturation and on-tree ripening under Malaysia climate.

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