UNIVERSITI PUTRA MALAYSIA

EFFECTS OF MATURITY STAGES AT HARVEST, PACKAGING MATERIALS AND STORAGE DURATION ON PHYSICO-CHEMICAL CHARACTERISTICS OF LEMONGRASS (*Cymbopogon citratus* Stapf*)*

NOR ELLIZA BINTI TAJIDIN

FP 2012 5

EFFECTS OF MATURITY STAGES AT HARVEST, PACKAGING MATERIALS AND STORAGE DURATION ON PHYSICO-CHEMICAL CHARACTERISTICS OF LEMONGRASS (*Cymbopogon citratus* Stapf*)*

NOR ELLIZA BINTI TAJIDIN

MASTER OF AGRICULTURAL SCIENCE
UNIVERSITI PUTRA MALAYSIA

2012

EFFECTS OF MATURITY STAGES AT HARVEST, PACKAGING MATERIALS AND STORAGE DURATION ON PHYSICO-CHEMICAL CHARACTERISTICS OF LEMONGRASS (*Cymbopogon citratus* Stapf*)*

By

NOR ELLIZA BINTI TAJIDIN

Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Agricultural Science

June 2012

Abstract of thesis is presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirements for the degree of Master of Agricultural Science

EFFECTS OF MATURITY STAGES AT HARVEST, PACKAGING MATERIALS AND STORAGE DURATION ON PHYSICO-CHEMICAL CHARACTERISTICS OF LEMONGRASS (*Cymbopogon citratus* Stapf*)*

By

NOR ELLIZA BINTI TAJIDIN

June 2012

Chairman : Siti Hajar Binti Ahmad, PhD

Faculty : Agriculture

Lemongrass, a perennial and lemon-aromatic grass, is harvested normally at 4 to 8 months after planting. There is a lack of information on its harvesting time for commercial production. Harvesting at the right maturity stages will give satisfactory biomass yield, high citral and nutritional content. Longer storage duration for pseudostem causes the formation of red pigmentation, wilting and the reduced lemon aroma. The first experiment was to determine the optimum maturity stages at harvest by using plant growth indicator and citral content of lemongrass. Lemongrass was planted at the Universiti Agricultural Park, Universiti Putra Malaysia, Serdang, Selangor, using a randomized complete block design (RCBD) with four replications. Harvestings were done at 5.5, 6.5, and 7.5 months after planting. There were quadratic relationships between clump gross and dry matter weights and maturity stages of lemongrass plants. There were linear increases in both the weights when the plants were harvested at 6.5

compared to 5.5 months, followed by gradual decreases at 7.5 months after planting. Clump height and leaf blade showed significant linear increases as maturity advances. However, pseudostem length showed a quadratic increase when lemongrass was harvested between 5.5 to 7.5 months after planting. Total tiller weight and tiller number showed similar quadratic relationships as clump gross and clump dry matter weights. N contents in leaf blade and pseudostem showed quadratic decreases as maturity advances. There were quadratic increases in P, K, Ca and Mg content of lemongrass when harvested at 6.5 months compared to 5.5 months after planting. However, the nutrients in the leaf blade and pseudostem were decreased when the lemongrasses were harvested at 7.5 months after planting. There were significant effects of maturity stages on citral contents of lemongrass. Thirteen compounds always were detected at each maturity stage. The citral contents of lemongrass harvested were higher at 6.5 months after planting compared to at 5.5 and 7.5 months, respectively, after planting. Citral content was highest at 7± 0.3 months after planting, when it reached 78%. The results indicated that the correlations between citral content and clump characters such as clump gross weight (r=0.86) and clump dry matter weight (r=0.88) were significantly positive. Also, there were significant and positive correlations between citral content and pseudostem length (r=-0.80), and total tiller weight (r=0.82) and total tiller number (r=0.89) per clump. The correlation coefficients between the citral content and percentage of major nutrient concentrations in leaf tissues, such as P (r=0.75) and K (r=0.78) were significantly positive, and so were the minor nutrient such as Ca (r=0.67) and Mg (r=0.69). These correlations indicated that any of these characters could be used as an indicator for citral content in lemongrass.

The second experiment was carried out to determine the effects of maturity stages at harvest, packaging materials and storage duration on the physico-chemical characteristics of lemongrass. At 5.5, 6.5 and 7.5 months after planting, the lemongrass pseudostems were cut to 20 cm in length. Then, five pseudostems were packed into two types of packaging materials; black and clear polyethylene (PE) bags. Bags were sealed, then were stored at 10 ^{0}C. The physico-chemical characteristics of the lemongrass were evaluated for firmness, chlorophyll, anthocyanin, ascorbic acid, and total phenolic contents, soluble solids concentration, titratable acidity, and pH. Measurements were made at 0, 5, 10 and 15 days after storage. Results indicated that there were no interaction effects between the treatments on firmness, ascorbic acid, titratable acidity and pH. Firmness increased as maturity stage advances from 5.5 to 7.5 months after planting, but decreased as storage duration increased. Both ascorbic acid and titratable acidity decreased with increased in maturity stages and storage duration. However, pH of lemongrass decreased with increasing maturity, but the pH was not affected by storage durations. During the storage, data showed that firmness, ascorbic acid, titratable acidity and pH were not affected by the use of the clear and black polyethylene (PE) packaging materials (bag). Chlorophyll content of lemongrass harvested at 5.5, 6.5 and 7.5 months after planting tended to decrease during storage. In contrast, the anthocyanin content increased when the storage duration was increased, but it was lower in pseudostem that were packed in black PE bag then those packed with clear PE bag. There was a significant interaction effect of maturity stage at harvest and storage duration of lemongrass on total phenolic content of lemongrass pseudostems. Total

phenolic content increased by 35.90%, 35.80% and 56.52% when lemongrass was harvested at 5.5, 6.5 and 7.5 months after planting, respectively, as storage duration increased to 15 days of storage. By the end of the storage duration, lemongrass harvested at 7.5 months after planting contained the highest total phenolic content compared to those harvested at 5.5 and 6.5 months after planting.

In conclusion, this study showed that maturity stage at harvest influenced the plant growth characteristics, essential oil composition and citral content of lemongrass. The packaging materials used to wrap the lemongrass pseudostems during storage significantly affected the total phenolic content of lemongrass. The anthocyanin content of lemongrass harvested at 5.5 months was less than the other lemongrasses harvested at 6.5 and 7.5 months after planting. The anthocyanin caused the red pigmentation on lemongrass pseudostem. The pseudostem were less firm, and had a lower content of total phenolic when harvested at 5.5 months compared to those harvested at 6.5 and 7.5 months after planting. Longer storage duration increased soluble solids concentration, and anthocyanin and total phenolic contents, which are indicators of senescence process. Losses of ascorbic acid were high as the storage duration increased. Thus, lemongrass should be harvested between 6.5 to 6.9 months after planting to obtain optimum growth performance and essential oil with a high composition of citral.

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

KESAN PERINGKAT KEMATANGAN, BAHAN PEMBUNGKUSAN DAN TEMPOH PENYIMPANAN TERHADAP CIRI-CIRI FISIKO-KIMIA SERAI (*Cymbopogon citratus* Stapf)

Oleh

NOR ELLIZA BINTI TAJIDIN

Jun 2012

Pengerusi : Siti Hajar Binti Ahmad, PhD

Fakulti : Pertanian

Serai merupakan sejenis tumbuhan saka yang mempunyai aroma lemon, dan biasanya ia dituai pada 4 hingga 8 bulan selepas ditanam. Walau bagaimanapun, masih terdapat kekurangan maklumat mengenai peringkat kematangan yang sesuai bagi tujuan pengeluaran serai secara komersil. Menuai pada waktu peringkat kematangan yang sesuai akan memberikan hasil tuaian yang baik dengan kandungan citral dan nutrisi yang tinggi. Di samping itu, tempoh penyimpanan yang lama akan menyebabkan pembentukan pigmentasi merah, kelayuan dan juga pengurangan aroma serai. Eksperimen pertama adalah bertujuan untuk menentukan peringkat kematangan yang sesuai dengan menggunakan penanda aras pertumbuhan serai dan juga kandungan 'citral'. Serai ditanam di Taman Pertanian Universiti, Universiti Putra Malaysia, dan kajian dijalankan menggunakan rekabentuk blok lengkap berawak dengan empat replikasi. Penuaian serai dilakukan pada 5.5, 6.5 dan 7.5 bulan selepas ditanam. Terdapat hubungan secara kuadratik di antara berat kasar rumpun dan berat kering rumpun serai dengan peringkat kematangan serai. Terdapat peningkatan secara linear pada kedua-dua berat tersebut apabila rumpun serai dituai

pada 6.5 bulan, dibandingkan dengan tuaian pada 5.5 bulan selepas ditanam. Kemudian diikuti pula dengan penurunan kedua-dua berat tersebut secara kudratik apabila dituai pada 7.5 bulan selepas ditanam. Tinggi rumpun dan panjang bilah daun serai menunjukkan peningkatan linear yang signifikan sepanjang peningkatan peringkat kematangan. Namun, panjang batang serai menunjukan peningkatan secara kuadratik apabila serai dituai pada 5.5 hingga 7.5 bulan selepas ditanam. Jumlah berat batang dan bilangan batang serumpun serai menunjukkan hubungan kuadratik yang sama seperti dengan berat kasar serumpun dan berat kering serumpun serai. Kandungan N di dalam bilah daun dan batang serai menunjukkan penurunan secara kuadratik sepanjang peningkatan peringkat kematangan. Terdapat peningkatan secara kuadratik kandungan P, K, Ca dan Mg di dalam serai apabila dituai pada 6.5 bulan berbandingkan dengan serai yang dituai pada 5.5 bulan selepas ditanam. Namun, terdapat penurunan kandungan nutrien di dalam bilah daun dan batang serai apabila serai dituai pada 7.5 bulan selepas ditanam. Terdapat kesan signifikan di antara peringkat kematangan terhadap kandungan citral di dalam serai. Hanya 13 komposisi kimia minyak pati serai yang dapat dikesan pada setiap peringkat kematangan. Kandungan citral paling tinggi dalam serai adalah pada 6.5 bulan selepas ditanam berbanding dengan serai yang dituai pada 5.5 and 7.5 bulan selepas ditanam. Kandungan citral (78%) paling tinggi ialah pada 7± 0.3 bulan selepas tanam. Hasil kajian ini juga menunjukan kolerasi adalah signifikan secara positif di antara kandungan citral dan karakter pertumbuhan rumpun serai iaitu berat kasar rumpun (r=0.86) dan berat kering rumpun (r=0.88). Juga terdapat kolerasi signifikan yang positif di antara kandungan citral dan panjang batang (r=-0.80), jumlah berat batang serumpun (r=0.82), dan bilangan batang serai serumpun (r=0.89). Korelasi koefisin di antara citral dan peratusan utama kandungan nutrien P (r=0.75) dan K (r=0.78) juga signifikan secara positif dan begitu juga dengan kandungan nutrien yang lain seperti Ca (r=0.67) dan Mg (r=0.69).

Korelasi ini menandakan bahawa salah satu sifat pertumbuhan serai boleh dijadikan sebagai penunjuk kepada kandungan citral di dalam serai.

Eksperimen kedua yang dijalankan adalah untuk menentukan kesan peringkat kematangan, bahan pembungkusan and tempoh penyimpanan terhadap sifat fisiko-kimia serai. Pada 5.5, 6.5 dan 7.5 bulan selepas ditanam, batang serai dipotong kepada 20 cm panjang. Lima batang serai dimasukkan kepada dua jenis bahan pembungkusan iaitu beg polietilena (PE) hitam dan jernih. Beg pembungkusan tersebut dikedapkan dan disimpan pada suhu 10 ^{0}C. Ciri-ciri fisiko-kimia yang dinilai ialah kekerasan, klorofil, anthosianin, asid ascorbik, kandungan fenolik, kandungan pepejal terlarut, asid tertitrat dan pH. Penilaian kualiti terhadap ciri-ciri fisiko-kimia dilakukan pada hari 0, 5, 10 dan 15 selepas disimpan. Keputusan yang diperolehi menunjukkan bahawa tidak terdapat interaksi di antara rawatan ke atas kekerasan, asid askorbik asid tertitrat dan pH. Kekerasan batang serai meningkat apabila peringkat kematangan meningkat, namun menurun apabila tempoh penyimpanan meningkat. Asid askorbik dan asid tertitrat menurun apabila peringkat kematangan dan tempoh penyimpanan meningkat. Namun, pH serai menurun apabila peringkat kematangan meningkat tetapi kandungan pH tidak dipengaruhi oleh tempoh penyimpanan. Kekerasan, asid askorbik, asid tertitrat dan pH tidak dipengaruhi oleh penggunaan bahan pembungkusan sepanjang tempoh penyimpanan. Kandungan klorofil serai yang dituai pada 5.5, 6.5 dan 7.5 bulan selepas ditanam cenderung untuk menurun sepanjang tempoh penyimpanan. Sebaliknya, kandungan anthosianin meningkat apabila tempoh penyimpanan meningkat. Tetapi kandungan anthosianin adalah rendah apabila batang serai dibungkus menggunakan beg PE yang berwarna hitam berbanding dengan kandungan anthosianin yang dibungkus dengan menggunakan beg PE yang jernih. Terdapat interaksi sigfikan terhadap kesan

peringkat kematangan dan tempoh penyimpanan batang serai ke atas kandungan fenolik. Kandungan fhenolik meningkat sepanjang tempoh penyimpanan sebanyak 35.90%, 35.80% dan 56.52% apabila serai dituai pada 5.5, 6.5 and 7.5 bulan selepas ditanam. Serai yang dituai pada 7.5 bulan mengandungi kandungan fenolik yang tinggi berbanding dengan serai yang dituai pada 5.5 dan 6.5 bulan selepas ditanam.

Kesimpulannya, peringkat kematangan serai mempengaruhi karakter pertumbuhan, komposisi minyak pati dan kandungan citral. Bahan pembungkusan yang digunakan untuk membungkus batang serai sepanjang tempoh penyimpanan menunjukan kesan signifikan terhadap kandungan fenolik serai. Serai yang dituai pada 5.5 bulan selepas ditanam mengandungi kurang kandungan anthosianin. Anthosianin merupakan penyebab kepada pigmentasi merah di batang serai. Tetapi, serai yang dituai pada 5.5 bulan lebih lembut dan mengandungi kandungan fenolik yang rendah apabila dibandingkan dengan serai yang dituai pada 6.5 dan 7.5 bulan selepas tanam. Tempoh penyimpanan yang panjang akan meningkatkan kandungan pepejal terlarut, anthosianin dan kandungan fenolik. Ini adalah penunjuk bahawa berlakunya proses senensen. Jumlah pengurangan asid askorbik adalah tinggi apabila tempoh penyimpanan meningkat. Oleh itu, serai sesuai sekali dituai di antara 6.5 hingga 6.9 bulan selepas ditanam bagi memperolehi tahap pertumbesaran serai yang optimum dan kandungan komposisi citral yang tinggi di dalam minyak pati.

ACKNOWLEDGEMENTS

This dissertation would not have been possible without the guidance and help of several individuals who in one way or another contributed and extended their valuable assistance in the preparation and completion of this study.

First and foremost, my utmost gratitude to my lovely supervisor, Assoc. Prof. Dr. Siti Hajar Ahmad for her enlightening, suggestions and patient guidance from preliminary to the end of this study. She has been my inspiration as I hurdle all the obstacles in completing this work. I am also grateful to Assoc. Prof. Dr. Datin Rosenani Abu Bakar for being the committee member and for her generous, patience, and steadfast support to complete this study.

I am deeply indebted to my dear family [(Mr. Tajidin Bin Chik and Mrs. Ramlah Binti Mat Noor), who deserve special mention for their inseparable support. To my brothers (Shamsul Omar, Anas Ruzaini, Mohammad Azmi and Muhammad Hafiz), sisters (Elliyana and Nor Azlina Idris) and nephews (Muhammad Amirul Hazim, Muhammad Aqil Haziq and Muhammad Adam Hafidh), thank you for being supportive and caring siblings].

It is my utmost pleasure to thank En. Azhar Othman, who always was ready to lend a hand during my labwork. I owe deepest gratitude to Miss Bunga Raya Ketaren, Mrs. Nasim Shadmani, Miss Surisa Phornvillay, Mr. Mohammad Humam Wan Mansoor and Mrs Munirah Mohamad for all those advices, guidance, comments and explanation, thank you very much. I love all of you.

I am also grateful to all my friends whose help and camaraderie are so much appreciated. Last but not least, the one above all of us, the omnipresent ALLAH SWT, for answering my prays for giving me the strength to plod on despite my constitution wanting to give up and throw in the towel, thank you so much ALLAH SWT and my salawat and salam to His messenger, Prophet Muhammad SAW.

I would like to dedicate this thesis to my late grandmother Mrs. Hawariah Hassan, who kindly raised me with her caring and love. You are always in my heart.

Nor Elliza Binti Tajidin

I certify that an Examination Committee has met 13 June 2012 to conduct the final examination of Nor Elliza Binti Tajidin on her Master of Agricultural Science thesis entitled "Effects of Maturity Stages at Harvest, Packaging Materials and Storage Duration on Physico-chemical Characteristics of Lemongrass (*Cymbopogon citratus* Stapf)" in accordance with Universities and University College Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The committee recommends that the student be awarded the Master of Agricultural Science.

Members of the Thesis Examination Committee were as follows:

Siti Aishah Hassan, Ph.D
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Mahmud Tengku Muda Mohamed, Ph.D
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Internal Examiner)

Anuar Abdul Rahim, Ph.D
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Internal Examiner)

Zakaria Wahab, Ph.D
Professor
School of Bioprocess Engineering,
Universiti Malaysia Perlis
(External Examiner)

SEOW HENG FONG, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 29 November 2012

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

Siti Hajar Binti Ahmad, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Rosenani Binti Abu Bakar, PhD
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

_____
BUJANG BIN KIM HUAT, 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.

_____

NOR ELLIZA BINTI TAJIDIN

Date: 13 June 2012

TABLE OF CONTENTS