PHYSICO-CHEMICAL CHARACTERISTICS OF BANANA (*MUSA* AAA 'WILLIAM' CAVENDISH) RIPENED AT DIFFERENT TEMPERATURES

By

NORHELALIAH BINTI ISA

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

June 2006

Dedicated To

My Parents, Sisters, Husband and friends

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

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Chairman: Associate Professor Siti Hajar Ahmad, PhD

Faculty : Agriculture

Mature green *Musa* AAA 'William' Cavendish was obtained from a fruit trading company in Selayang, Selangor. The fruit was transported to the Postharvest Laboratory at Faculty of Agriculture, UPM for quality characteristics and chlorophyll analysis. Fatty acid analysis was carried out at the Chemistry Laboratory, Faculty of Science, UPM. The fruit was ripened at two ripening temperatures (18 and 27 ^{o}C) for 5 days. The quality characteristics analyzed included colour values (L*, a*, b*, C* and h^{o}), firmness, soluble solids concentration (SSC), titratable acidity (TA), sugar/acid ratios, pH and vitamin C. The analyses were done at each ripening temperature (18 and 27 ^{o}C) and each ripening day (Day 0, 1, 2, 3, 4 and 5). During ripening at 18 ^{o}C, L*, a*, b* and C* of Cavendish peel increased rapidly (P<0.01) while h^{o} decreased rapidly (P<0.01) indicating that the mature-green peel had changed to full yellow. The change of peel colour was due to the reduction (P<0.01) in chl *a*, chl *b* and total chl of the peel throughout ripening days. The full yellow peel was associated with a soft and sweet pulp as evidenced by the decrease of firmness and an increase of SSC and sugar/acid ratios. TA and

vitamin C reached a maximum value at ripening day 3.14 and 2.85, respectively, while pH reached a minimum value at ripening day 2.71. Myristic, palmitic, stearic, oleic, linoleic and linolenic acid were found in Cavendish banana peel. The additional of two other fatty acids were found in Cavendish banana pulp; palmitoleic and hexadecadienoic acid. However, only palmitic, linoleic and linolenic acid showed significant changes when ripened at 18 ^{o}C and 27 ^{o}C. During ripening at 18 ^{o}C, palmitic, linoleic and linolenic acid increased linearly both in the peel and pulp. When ripened at 27 ^{o}C, palmitic, linoleic and linolenic acid in the peel and pulp showed a quadratic decrease. These indicated that the change of fatty acids in the peel was associated with the change of fatty acids in the pulp either ripened at 18 ^{o} C or 27 ^{o}C. During ripening at 27 ^{o}C, L*, a*, b* and C* of Cavendish banana peel increased slowly (P<0.05) while h^{o} decreased slowly (P<0.05), thus resulting in a pale-green peel. The pale-green peel occurred due to the slow degradation (P<0.05) of chl *a*, chl *b* and total chl during ripening. Pale green Cavendish banana was associated with very soft texture and sweet tasting pulp as evidenced by a rapid loss (P<0.01) of firmness and rapid increase (P<0.01) of SSC and sugar/acid ratios. TA and vitamin C reached a maximum value at ripening day 2.93 and 2.06 respectively, while pH reached a minimum value at ripening day 2.92. Palmitic, linoleic and linolenic acid in Cavendish banana peel and pulp were significantly increased at ripening day 1 followed by a decrease until day 5 of ripening. This indicated that insufficient fatty acids in both peel and pulp during ripening had an effect in producing a pale green Cavendish banana. Results from this research can be used for gene manipulation of Cavendish banana to produce a cultivar that can be ripen

normally at tropical temperature by inducing palmitic, linoleic and linolenic acid during genetic modification process.

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

KRITERIA FISIKO-KIMIA TERHADAP PISANG CAVENDISH 'WILLIAM' YANG DIPERAM PADA SUHU BERBEZA

Oleh

NORHELALIAH BINTI ISA

Jun 2006

Pengerusi: Profesor Madya Siti Hajar Ahmad, PhD

Fakulti : Pertanian

Pisang Cavendish yang telah hijau matang diperolehi daripada peniaga buah-buahan di Selayang, Selangor. Buah tersebut telah dibawa ke Makmal Lepas Tuai di Fakulti Pertanian, UPM untuk analisis kualiti dan klorofil, dan juga dibawa ke Makmal Kimia, Fakulti Sains untuk analisis asid lemak. Buah pisang telah diperam pada dua suhu berbeza iaitu 18 dan 27 ^{o}C selama 5 hari. Analisis qualiti termasuk warna (L*, a*, b*, C* and h^{o}), kekerasan, kandungan pepejal terlarut (KPT), keasidan tertitrat (KT), pH dan vitamin C telah dilakukan pada setiap suhu pemeraman (18 dan 27 ^{o}C) dan setiap hari pemeraman (Hari 0, 1 2, 3, 4 and 5). Pada suhu pemeraman 18 ^{o}C, L*, a*, b* dan C* meningkat dengan cepat (P<0.01), menunjukkan bahawa pisang yang hijau matang telah bertukar ke warna kuning sepenuhnya. Perubahan warna ini terbukti dengan penurunan cepat (P<0.01) yang ditunjukkan oleh klorofil *a*, *b*, dan jumlah klorofil. Pisang yang kuning sepenuhnya

mempunyai isi yang lembut dan manis seperti yang ditunjukkan oleh penurunan kekerasan dan peningkatan KPT. KT dan vitamin C masing-masing mencapai nilai maksima pada hari pemeraman 3.14 dan 2.85 manakala pH mencapai nilai minima pada hari pemeraman 2.71. Asid miristik, palmitik, sterik, oleik, linoleik dan linolenik ditemui dalam kulit buah pisang manakala dua lagi asid lemak ditemui dalam isi pisang iaitu palmitoleik dan heksadekadienoik. Walaubagaimanapun, hanya asid palmitik, linoleik dan linolenik menunujukkan perbezaan bererti bagi setiap suhu pemeraman. Pada suhu pemeraman 18 ^{o}C, asid palmitik, linoleik dan linolenik dalam isi dan kulit pisang Cavendish meningkat secara linear. Pada suhu pemeraman 27 ^{o}C, asid palmitik, linoleik dan linolenik dalam isi dan kulit pisang Cavendish menurun secara kuadratik. Ini menunjukkan bahawa perubahan asid lemak dalam kulit pisang disertai oleh perubahan asid lemak dalam isi pisang. Pada suhu pemeraman 27 ^{o}C, L*, a*, b* dan C* pada kulit pisang meningkat secara perlahan (P<0.05) manakala h^{o} menurun dengan perlahan (P<0.05), menghasilkan pisang yang berwarna hijau pucat. Pisang hijau pucat terhasil akibat penurunan klorofil *a*, *b* dan jumlah klorofil yang lambat semasa pemeraman. Buah ini mempunyai isi yang terlalu lembut dan terlalu manis berikutan penurunan cepat (P<0.05) kekerasan dan peningkatan cepat (P<0.01) kandungan pepejal terlarut. KT dan vitamin C masing-masing mencapai nilai maksima pada hari pemeraman 2.93 and 2.06 manakala pH mencapai nilai minima pada hari pemeraman 2.92. Asid palmitik, linoleik dan linolenik asid dalam isi dan kulit pisang Cavendish meningkat sehingga hari pemeraman 1 diikuti dengan penurunan hingga ke hari pemeraman 5. Ini menunjukkan bahawa kekurangan asid lemak semasa tahap klimakterik memberi kesan dalam menghasilkan pisang Cavendish yang berwarna hijau pucat.

Keputusan daripada kajian ini boleh digunakan bagi menghasilkan genetik baru bagi pisang Cavendish yang boleh masak kuning apabila diperam pada suhu tropika dengan menambah asid palmitik, linoleik dan linolenik semasa prosess pengubahsuaian genetik.

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Thank you all of you, may God bless u.

I certify that an Examination Committee has met on 7th Jun 2006 to conduct the final examination of Norhelaliah binti Isa on her Master of Science thesis entitled "Physico-chemical characteristics of banana (*MUSA* AAA 'William' Cavendish) ripened at different temperatures" in accordance with Universiti Pertanian Malaysia (High Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis 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 are as follows:

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Date: 12 OCTOBER 2006

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously on concurrently submitted for any other degree at UPM or other institutions.

NORHELALIAH BINTI ISA

Date: 07 AUGUST 2006

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LIST OF ABBREVIATIONS

ALA	**δ-aminolevulinic**
ANOVA	**Analysis of variance**
ATP	**Adenosine triphosphate**
BHT	**Butylated hydroxytoluene**
C*	**Chromaticity**
CaC_2	**Calcium carbide**
C_2H_4	**Ethylene**
C_2H_2	**Acetylene**
Chl	**Chlorophyll**
d	**Day**
DGDG	**Digalactosyldiglycerides**
DMRT	**Duncan multiple range test**
FAME	**Fatty acid methyl ester**
FID	**Flame ionization detector**

h	**Hour**
ha	**Hectare**
h^o	**Hue**
HPO_3	**Metaphosphoric acid**
L*	**Lightness**
MGDG	**Monogalactosyldiglycerides**
mt	**Metric tonne**
MeOH	**Methanol**
MUFA	**Monounsaturated fatty acid**
MW	**Molecular weight**
NADP	**Nicotinamide adenine dinucleotide phosphate**
NaOH	**Sodium hydroxide**
NAP3	**Third National Agriculture Policy**
NS	**Non significant**
PC	**Phosphatidylcholin**
PI	**Phosphatidylinositol**
PUFA	**Polyunsaturated fatty acid**
R^2	**Regression coefficients**
r^2	**Correlation coefficients**
RCBD	**Randomized complete block design**
RD	**Ripening duration**
RRF	**Relative response factor**
RT	**Ripening temperature**
Rt	**Retention time**

s	**Seconds**
SL	**Sulfoquinovosyldiglycerides**
SSC	**Soluble solids concentration**
TA	**Titratable acidity**