UNIVERSITI PUTRA MALAYSIA

OPTIMIZATION OF PROCESSING CONDITIONS FOR THE PRODUCTION OF CLARIFIED BANANA (*Musa sapientum*) JUICE DRINK AND ITS STORAGE STABILITY

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OPTIMIZATION OF PROCESSING CONDITIONS FOR THE PRODUCTION OF CLARIFIED BANANA (*Musa sapientum*) JUICE DRINK AND ITS STORAGE STABILITY

By

LEE WAI CHENG

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To My Family

Dad, Mom and Brother

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

OPTIMIZATION OF PROCESSING CONDITIONS FOR THE PRODUCTION OF CLARIFIED BANANA (*Musa sapientum*) JUICE DRINK AND ITS STORAGE STABILITY

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October 2006

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Faculty : Food Science and Technology

This study was carried out on the optimization of hot water extraction and enzymatic treatment for producing clarified banana juice. A response surface methodology (RSM) was used to determine the optimum extraction temperature and time to produce banana juice extract. Banana juice was extracted using hot water at different extraction temperatures (35-95ºC) and time (30-120 min). The effects of these extraction conditions on juice yield, total soluble solids (ºBrix), banana odour and taste were studied by employing a second-order central composite design. The coefficient of determination, R^2, for juice yield, total soluble solids (ºBrix), banana odour and taste were greater than 0.900. Analysis of the regression coefficients showed that temperature was the most important factor that affected the characteristics of the banana juice extract as it exerted a highly significant influence ($p<0.001$) on all the dependent variables. An increase in temperature and extraction

time of hot water extraction resulted in an increase in juice yield, total soluble solids, banana odour and taste of the banana juice extract. Based on response surface and contour plots, the optimum conditions obtained for hot water extraction of banana juice were 95ºC for 120 minutes. This optimum condition gave maximum juice yield (39.55 %), total soluble solids (9.19 °Brix), banana odour (6.91 scores) and taste (5.87 scores).

Optimization of enzymatic treatment of the banana juice extract was then carried out using pectinase (Pectinex Ultra SP-L) at various enzyme concentrations (0.01–0.1%), temperatures (30–50ºC) and times (30–120 min). The effect of these enzyme treatments on filterability, clarity, turbidity and viscosity of the juice were studied by employing a second order central composite design. The coefficient of determination, R^2 values for filterability, clarity, turbidity and viscosity were greater than 0.900. Statistical analysis showed that filterability, clarity, viscosity and turbidity were significantly ($p<0.05$) correlated to enzyme concentration, incubation temperature and incubation time. Enzyme concentration was the most important factor affecting the characteristics of the banana juice as it exerted a highly significant influence ($p<0.01$) on all the dependent variables. An increase in time and/or concentration of enzyme treatment was associated with an increase in filterability and clarity, and decrease in turbidity and viscosity. Based on response surface and contour plots, the optimum conditions for clarifying banana juice obtained were: 0.084% enzyme concentration, incubation temperature of 43.2ºC and incubation time of 80 min. The response functions were calculated from the final polynomial, and the response were filterability (0.073 second $^{-1}$), clarity (0.006 Abs), turbidity (0.92 NTU) and viscosity (1.89 cps).

The storage stability of clarified banana juice was evaluated for 24 weeks using bentonite and a combination of gelatin and bentonite as fining agents and stored at 4, 25 and 37ºC. The results indicated that fining agents, storage temperature and storage time had a significant ($p<0.001$) effect on turbidity, clarity, total polyphenol, protein content and browning index, colour (L, a and b values), pH, titratable acidity (TA), total soluble solids (TSS) of clarified banana juice. It was observed that both bentonite and combination of gelatin and bentonite treatments produced juice of better quality than control. These treatments were effective in reducing turbidity, total polyphenol, protein content and browning while improving clarity and lightness of the clarified banana juice. Bentonite treated juice was the least turbid and its organoleptic quality did not change significantly throughout storage. The temperature used for storage of juice had a marked effect on the rate and amount of haze formed during storage. Bentonite treated juice stored at 4ºC was found to be the most suitable storage combination with the lowest rate of increase in turbidity and colour change as well as lowest rate of decrease in clarity, total polyphenol and protein content during storage.

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

PENGOPTIMUMAN KEADAAN PEMPROSESAN BAGI PENGHASILAN MINUMAN JUS PISANG (*Musa sapientum*) JERNIH DAN KESTABILAN PENYIMPANANNYA

Oleh

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Kajian ini dijalankan untuk pengoptimuman pengekstrakan air panas dan rawatan enzimatik untuk pemprosesan jus pisang jernih. Kaedah respon permukaan (RSM) digunakan untuk penentuan suhu dan masa pengekstrakan optimum untuk menghasilkan ekstrak jus pisang. Jus pisang diekstrak dengan air panas pada suhu pengekstrakan (35-95ºC) dan masa pengekstrakan (30-120 minit) yang berlainan. Kesan keadaan pengekstrakan ke atas hasilan jus, pepejal terlarut (ºBrix), bau dan rasa pisang telah dikaji dengan menggunakan rekabentuk komposit pusat susunan kedua. Penentuan koefisien, R^2, bagi hasilan jus, pepejal terlarut (ºBrix), bau dan rasa pisang adalah melebihi 0.900. Analisis regresi koefisien menunjukkan bahawa suhu adalah faktor terpenting yang mempengaruhi ciri-ciri ekstrak jus pisang, memandangkan ia memberi kesan yang bermakna ($p<0.01$) pada pembolehubah bergantung. Peningkatan suhu dan masa pengekstrakan air panas mengakibatkan peningkatkan hasilan jus, pepejal terlarut, bau dan rasa ekstrak jus pisang.

Berdasarkan pada respon permukaan dan plot kontor, keadaan optimum yang dicapai bagi pengekstrakan air panas jus pisang adalah pada 95ºC selama 120 minit. Keadaan optimum ini memberikan hasilan jus (39.55 %), pepejal terlarut (9.19 °Brix), dan skor bau pisang (6.91) dan rasa pisang (5.87) yang maksimum.

Pengoptimuman rawatan enzim untuk ekstrak jus pisang kemudian dijalankan dengan menggunakan pektinase (Pectinex Ultra SP-L) pada pelbagai kepekatan enzim (0.01-0.1%), suhu (30-50ºC) dan masa (30-120 minit). Kesan daripada rawatan enzim ke atas ketapisan, kejernihan, kekeruhan and kelikatan jus dikaji dengan menggunakan rekabentuk komposit pusat susunan kedua. Penentuan koefisien, R^2, untuk ketapisan, kejernihan, kekeruhan and kelikatan jus adalah melebihi 0.900. Analisis statistik menunjukkan bahawa ketapisan, kejernihan, kekeruhan dan kelikatan jus adalah berhubungkaitan secara bermakna ($p<0.05$) dengan kepekatan enzim, suhu dan masa pengeraman. Kepekatan enzim adalah faktor terpenting yang mempengaruhi ciri-ciri jus pisang, memandangkan ia memberi kesan yang bermakna ($p<0.01$) ke atas semua pembolehubah bergantung. Peningkatan dalam masa dan/atau kepekatan enzim rawatan adalah berkaitan dengan peningkatan dalam ketapisan dan kejernihan, dan penurunan dalam kekeruhan dan kelikatan. Berdasarkan respon permukaan dan plot kontor, keadaan optimum yang dicapai bagi proses penjernihan jus pisang adalah: 0.084% kepekatan enzim, suhu pengeraman pada 43.2ºC dan masa pengeraman selama 80 minit. Fungsi respon dikira dari polinomial akhir, dan responnya adalah 0.073 $saat^{-1}$ bagi ketapisan, 0.006 Abs bagi kejernihan, 0.92 NTU bagi kekeruhan dan 1.89 cps bagi kelikatan.

Kestabilan penyimpanan jus dikaji selama 24 minggu dengan menggunakan bentonit dan kombinasi gelatin dan bentonit sebagai agen “fining” pada suhu penyimpanan 4, 25 dan 37ºC. Keputusan menunjukkan bahawa agen “fining”, suhu dan tempoh masa penyimpanan mempunyai kesan yang bermakna ($p<0.001$) terhadap kekeruhan, kejernihan, jumlah polifenol, kandungan protein, indeks pemerangan, warna (nilai L, a dan b), pH, pentitratan asid, dan jumlah pepejal terlarut jus pisang jernih. Dapat diperhatikan bahawa kedua-dua rawatan bentonit dan rawatan kombinasi gelatin dan bentonit menghasilkan jus yang lebih berkualiti daripada jus kawalan. Rawatan ini adalah berkesan dalam mengurangkan kekeruhan, jumlah polifenol, kandungan protein dan pemerangan di samping meningkatkan kejernihan dan kecerahan jus pisang jernih. Jus yang dirawat dengan bentonit adalah jus yang paling kurang keruh dengan kualiti organoleptik yang tidak berubah secara bermakna sepanjang tempoh penyimpanan. Suhu yang digunakan untuk penyimpanan jus memberi kesan yang mendadak ke atas kadar dan jumlah keladak yang terbentuk semasa penyimpanan. Jus yang dirawat dengan bentonit dan disimpan pada suhu 4ºC merupakan kombinasi penyimpanan yang paling sesuai dengan kadar peningkatan kekeruhan dan perubahan warna paling rendah di samping kadar penurunan kejernihan, jumlah polifenol dan kandungan protein paling rendah semasa penyimpanan.

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I certify that an Examination Committee has met on 11th October 2006 to conduct the final examination of Lee Wai Cheng on her Master of Science thesis entitled "Optimization of processing conditions for the production of clarified banana (*Musa sapientum*) juice drink and its storage stability." in accordance with Universiti Pertanian Malaysia (Higher 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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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 or concurrently submitted for any other degree at UPM or other institutions.

_____

LEE WAI CHENG

Date:12 February 2007

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LIST OF ABBREVIATIONS/ NOTATIONS

Abbreviations

MATRADE	Malaysia External Trade Development Corporation
CA	Controlled Atmosphere
MA	Modified Atmosphere
EP	Edible Portion
PE	Pectin Methylesterases
PG	Polygalacturonases
PAL	Pectic Acid Lyases
PL	Pectin Lyases
Gala	Galacturonic Acid
Ara	Arabinose
OMe	Methylester
Xyl	Ethylester
Gal	Galactose
Rha	Rhamnose
HA	Haze-active
PPO	Polyphenoloxidase
RSM	Response Surface Methodology
QDA	Quantitative Descriptive Analysis
EP	Edible Portion
HWE	Hot Water Extraction
CCD	Central Composite Design
ANOVA	Analysis of Variance

TA	Titrable Acidity
NTU	Nephelometric Turbidity Units
TSS	Total Soluble Solids
UV-VIS	Ultraviolet-Visible
BSA	Bovine Serum Albumin
PDA	Potato Dextrose Agar
PCA	Plate Count Agar
TPC	Total Plate Count
SAS	Statistical Analysis System