UNIVERSITI PUTRA MALAYSIA

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

LEE WAI CHENG

FSTM 2006 23
OPTIMIZATION OF PROCESSING CONDITIONS FOR THE PRODUCTION OF CLARIFIED BANANA (Musa sapientum) JUICE DRINK AND ITS STORAGE STABILITY

By

LEE WAI CHENG

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

October 2006
To My Family

Dad, Mom and Brother
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 (35-95°C) and time (30-120 min). The effects of these extraction conditions on juice yield, total soluble solids (°Brix), 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 (°Brix), 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 37°C. 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 4°C 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.
PENGOPTIMUMAN KEADAAN PEMPROSESAN BAGI PENGHASILAN MINUMAN JUS PISANG (*Musa sapientum*) JERNIH DAN KESTABILAN PENYIMPANANNYA

Oleh

LEE WAI CHENG

Oktober 2006

Pengerusi : Professor Salmah Bt. Yusof, PhD
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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 pengekstr akan (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, R², 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). Kesimpulan daripada rawatan enzim ke atas ketapisan, kejernihan, kekeruhan and kelikatan jus dikaji dengan menggunakan rekabentuk komposit pusat susunan kedua. Penentuan koefisien, R², untuk ketapisan, kejernihan, kekeruhan and kelikatan jus adalah melebihi 0.900. Analisis statistik menunjukkan bahawa ketapisan, kejernihan, kekeruhan dan kelikatan jus adalah berhubungan 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 responsnya 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.
I would like to express my deepest gratitude and appreciation to the chairperson of my supervisory committee, Prof. Salmah bte.Yusof for her invaluable guidance, suggestions, encouragement and help throughout the course of this study. I also wish to express my heartfelt appreciation and thanks to Dr. Nazimah Sheikh Abdul Hamid, one of the supervisory committee members, who kindly provided me with her knowledge, guidance, constant patience and advice in carrying out this study as well as completion of this thesis. Many thanks also to Assoc. Prof. Badlishah Sham Baharin, for his helpful comments and intellectual contributions which have made me clear about this work.

I also would like to thank the laboratory staff in the faculty who have directly or indirectly giving me the assistance, cooperation, and facilities during this study. I also would like to thank my fellow friends, graduate and undergraduate students for their endless care, help and moral support given me.

Last but not least, I would like to express my deepest gratitude to my beloved family for their unstinting love, endless encouragement, concern, patience and sacrifices which had helped me in undertaking and completing this study. I could not ask for a better one as without them, my study would have never been possible.
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
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEDICATION</td>
<td>ii</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>iii</td>
</tr>
<tr>
<td>ABSTRAK</td>
<td>vi</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>ix</td>
</tr>
<tr>
<td>APPROVAL</td>
<td>x</td>
</tr>
<tr>
<td>DECLARATION</td>
<td>xii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>xvi</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xix</td>
</tr>
<tr>
<td>LIST OF PLATE</td>
<td>xxii</td>
</tr>
<tr>
<td>LIST OF ABBREVIATIONS/NOTATIONS</td>
<td>xxiii</td>
</tr>
</tbody>
</table>

## CHAPTER

### I INTRODUCTION

### II LITERATURE REVIEW

- Banana
  - Description of Cultivars
  - Berangan Banana
  - Nutrient Composition
- Post Harvest Handling
  - Fruit Quality
- Processing of Banana Fruit
  - Processed Product
- Cellular Structure and Juice Extraction
- Pectic Substances
  - Pectic Enzymes
  - Enzyme Treatment of Pulp for Juice Extraction
  - Liquefaction
  - Maceration
- Clarified Juices
  - Juice Clarification
  - Membrane Technology
  - Microfiltration
  - Enzymatic Clarification
    - Mechanism of Enzyme Clarification
- Fining Treatment
  - Bentonite
  - Gelatin
I

Haze in Juices
  Protein-Polyphenol Haze
  Haze Active Protein
  Haze Active Polyphenol
  Haze Active Proteins and Polyphenol Interaction
  Starch-Based Haze
  Arabinan-Based Haze
  Miscellaneous Haze
  Bacteria and Yeast
  Pattern of Haze Development
  Optimization Using Response Surface Methodology
  Sensory Evaluation: Quantitative Descriptive Analysis

III  OPTIMIZATION CONDITIONS FOR HOT WATER EXTRACTION OF BANANA JUICE USING RESPONSE SURFACE METHODOLOGY (RSM)
  Introduction
  Materials and Methods
    Fruits
    Extraction of Banana Juice
    Determination of Juice Yield
    Determination of Total Soluble Solids
    Sensory Evaluation
    Experimental Design and Statistical Analysis
  Results and Discussion
    Statistical Analysis
    Effect of Extraction Temperature and Time
    Optimization
  Conclusions

IV  OPTIMIZING CONDITIONS FOR ENZYMATIC CLARIFICATION OF BANANA JUICE USING RESPONSE SURFACE METHODOLOGY (RSM)
  Introduction
  Materials and Methods
    Fruits
    Enzyme Source
    Juice Extraction Process
    Enzymatic Treatment
    Filterability
    Clarity
    Turbidity
    Viscosity
    Experimental Design and Statistical Analysis
  Results and Discussion
    Statistical Analysis
    Effect of Enzyme Concentration, Temperature and Time
    Optimization
  Conclusions
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Different banana cultivars</td>
</tr>
<tr>
<td>2.2</td>
<td>Nutrient composition of several banana varieties</td>
</tr>
<tr>
<td>2.3</td>
<td>Elements relative to release and extraction of juice from the cells and its separation</td>
</tr>
<tr>
<td>2.4</td>
<td>Technological roles and applications of pectic enzymes</td>
</tr>
<tr>
<td>2.5</td>
<td>Application of pectic enzymes in fruits and vegetables processing</td>
</tr>
<tr>
<td>2.6</td>
<td>Fining agents used in juice and wine processing</td>
</tr>
<tr>
<td>2.7</td>
<td>The application of RSM in food research</td>
</tr>
<tr>
<td>3.1</td>
<td>The central composite experimental design (in coded level of two variables) employed for hot water extraction of banana juice</td>
</tr>
<tr>
<td>3.2</td>
<td>The central composite experimental design and experiment data hot water extraction of banana juice</td>
</tr>
<tr>
<td>3.3</td>
<td>Regression coefficients, $R^2$, and $p$ or probability values for four dependent variables for hot water extraction of banana juice</td>
</tr>
<tr>
<td>4.1</td>
<td>The central composite experimental design (in coded level of three variables) employed for enzymatic clarification of banana juice</td>
</tr>
<tr>
<td>4.2</td>
<td>Effect of enzyme concentration, temperature and time on four dependent variables</td>
</tr>
<tr>
<td>4.3</td>
<td>Regression coefficients, $R^2$, and $p$ or probability values for four dependent variables for enzymatic clarification of banana juice</td>
</tr>
<tr>
<td>5.1</td>
<td>Main and interaction effects of fining treatment, storage temperature and storage time on turbidity, clarity, total polyphenol, protein content, browning index, colour (L, a and b value), pH, titratable acidity (TA) and total soluble solids (TSS) of clarified banana juice</td>
</tr>
<tr>
<td>5.2</td>
<td>Main effect of fining treatment, storage temperature and storage time on the turbidity, clarity, total polyphenol, protein content, browning index, colour (L, a and b value), pH, titratable acidity (TA) and total soluble solids (TSS) of clarified banana juice during storage</td>
</tr>
</tbody>
</table>
5.3 (a) Interaction of fining treatment with storage time on quality attributes of clarified banana juice during storage 114

5.3 (b) Interaction of storage temperature with storage time on quality attributes of clarified banana juice during storage 117

5.3 (c) Interaction of fining treatment with storage temperature on quality attributes of clarified banana juice during storage 118

5.4 Correlation analysis between turbidity, clarity, total polyphenol, protein content, browning index, colour (L, a and b value), pH, titratable acidity (TA) and total soluble solids (TSS) of clarified banana juice 121

5.5 Main and interaction effects of fining treatment, storage temperature and storage time on sensory attributes of clarified banana juice 137

5.6 Main effect of fining treatment, storage temperature and storage time on various sensory attributes of clarified banana juice during storage a 138

5.7 (a) Interaction of fining treatment with storage time on various quality attributes of clarified banana juice during storage 139

5.7 (b) Interaction of storage temperature with storage time on quality attributes of clarified banana juice during storage 140

5.7 (c) Interaction of fining treatment with storage temperature on various quality attributes of clarified banana juice during storage 142

A-1 Changes in turbidity of clarified banana juice under different fining treatment and temperature during storage 165

A-2 Changes in clarity of clarified banana juice under different fining treatment and temperature during storage 166

A-3 Changes in total polyphenol of clarified banana juice under different fining treatment and temperature during storage 167

A-4 Changes in protein content of clarified banana juice under different fining treatment and temperature during storage 168

A-5 Changes in protein browning index of clarified banana juice under different fining treatment and temperature during storage 169

A-6 Changes in colour (L value) of clarified banana juice under different fining treatment and temperature during storage 170
A-7 Changes in colour (a value) of clarified banana juice under different fining treatment and temperature during storage 171
A-8 Changes in colour (b value) of clarified banana juice under different fining treatment and temperature during storage 172
A-9 Changes in pH of clarified banana juice under different fining treatment and temperature during storage 173
A-10 Changes in titratable acidity (TA) of clarified banana juice under different fining treatment and temperature during storage 174
A-11 Changes in total soluble solids (TSS) of clarified banana juice under different fining treatment and temperature during storage 175
A-12 Changes in clarity (panel scores) of clarified banana juice under different fining treatment and temperature during storage 176
A-13 Changes in yellowness (panel scores) of clarified banana juice under different fining treatment and temperature during storage 177
A-14 Changes in fruitiness (odour) (panel scores) of clarified banana juice under different fining treatment and temperature during storage 178
A-15 Changes in fruitiness (taste) (panel scores) of clarified banana juice under different fining treatment and temperature during storage 179
A-16 Changes in overall acceptability (panel scores) of clarified banana juice under different fining treatment and temperature during storage 180
A-17 Interaction of fining treatment, storage temperature and storage time on quality attributes of clarified banana juice during storage 181
A-18 Interaction of fining treatment, storage temperature and storage time on quality attributes of clarified banana juice during storage 184
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Products from Banana</td>
<td>14</td>
</tr>
<tr>
<td>2.2</td>
<td>Diagram of a Mature Parenchymatic Plant Cell Common to Many Fruits and Vegetables (Idealized)</td>
<td>17</td>
</tr>
<tr>
<td>2.3</td>
<td>New Pectin Model and Enzymatic Pectin Degradation</td>
<td>20</td>
</tr>
<tr>
<td>2.4</td>
<td>Fragment of a Pectin Molecule and Points of Attack of Pectic Enzymes</td>
<td>26</td>
</tr>
<tr>
<td>2.5</td>
<td>Splitting of Glycosidic Bonds in Pectin by Hydrolysis (Polygalacturonase) and by β-elimination (Pectate Lyase and Pectin Lyase)</td>
<td>27</td>
</tr>
<tr>
<td>2.6</td>
<td>Flow Diagram of Fruit Manufacture. Arrows Indicate Eventual Enzyme Treatments by (a) Pectinases for Clarification; (b) Pectinases for Pulp Enzyming; (c) Pectinases and C1 Cellulases for Liquefaction; and, (d) Polygalacturonase, Pectin Lyase, or Pectate Lyase for Maceration</td>
<td>29</td>
</tr>
<tr>
<td>2.7</td>
<td>A Suggested Theory of Floc Formation during Enzyme Treatment of the Juice</td>
<td>38</td>
</tr>
<tr>
<td>2.8</td>
<td>Bentonite Hydration and the Formation of the ‘House of Cards’</td>
<td>40</td>
</tr>
<tr>
<td>2.9</td>
<td>Structure of the Proanthocyanidin Monomers Typically Found in Beer</td>
<td>46</td>
</tr>
<tr>
<td>2.10</td>
<td>Structure of Proanidin B3 and Prodelphinidin B3, the Prominent Proanthocyanidin Dimmers in Beer</td>
<td>46</td>
</tr>
<tr>
<td>2.11</td>
<td>Concept of Protein-Polyphenol Interaction</td>
<td>49</td>
</tr>
<tr>
<td>2.12</td>
<td>Possible Mechanisms Accounting for the Observed Pattern of Haze Development in Beer</td>
<td>53</td>
</tr>
<tr>
<td>2.13</td>
<td>Three Dimensional Diagram of Response Surface Methodology</td>
<td>55</td>
</tr>
<tr>
<td>2.14</td>
<td>Two Dimensional or Contour Diagram of Response Surface Methodology</td>
<td>55</td>
</tr>
<tr>
<td>3.1</td>
<td>Response Surfaces Showing the Effect of Extraction Temperature and Time on Juice Yield</td>
<td>68</td>
</tr>
</tbody>
</table>
3.2 Response Surface Showing the Effect of Extraction Temperature and Time on Total Soluble Solids (ºBrix) 68
3.3 Response Surface Showing the Effect of Extraction Temperature and Time on Banana Odour Response 70
3.4 Response Surface Showing the Effect of Extraction Temperature and Time on Banana Taste Response 70
3.5 Contour Plot Showing the Effect of Extraction Temperature and Time on Juice Yield 72
3.6 Contour Plot Showing the Effect of Extraction Temperature and Time on Total Soluble Solids (ºBrix) 72
3.7 Contour Plot Showing the Effect of Extraction Temperature and Time on Banana Odour Response 74
3.8 Contour Plot Showing the Effect of Extraction Temperature and Time on Banana Taste Response 74
3.9 Optimum Hot Water Extraction Conditions as a Function of Temperature and Time After Combined Contour Plots 75
4.1 Response Surface for Filterability of Banana Juice as a Function of (a) Temperature and Enzyme Concentration (at 75 min) and (b) Time and Enzyme Concentration (at 40ºC) 87
4.2 Response Surface for Clarity of Banana Juice as a Function of (a) Temperature and Enzyme Concentration (at 75 min) and (b) Time and Enzyme Concentration (at 40ºC) 88
4.3 Response Surface for Turbidity of Banana Juice as a Function of (a) Temperature and Enzyme Concentration (at 75 min) and (b) Time and Enzyme Concentration (at 40ºC) 90
4.4 Response Surface for Viscosity of Banana Juice as a Function of (a) Temperature and Enzyme Concentration (at 75 min) and (b) Time and Enzyme Concentration (at 40ºC) 92
4.5 The Contour Plots of Filterability of Enzymatic Treated Banana Juice as a Function of Enzyme Concentration, Temperature and Incubation Time 93
4.6 The Contour Plots of Clarity of Enzymatic Treated Banana Juice as Function of Enzyme Concentration, Temperature and Incubation Time 93
4.7 The Contour Plots of Turbidity of Enzymatic Treated Banana Juice as a Function of Enzyme Concentration, Temperature and Incubation Time 94

4.8 The Contour Plots of Viscosity of Enzymatic Treated Banana Juice as a Function of Enzyme Concentration, Temperature and Incubation Time 94

4.9 Superimposed Contour Plots for Optimization of Filterability, Clarity, Turbidity and Viscosity when Temperature was Kept Constant at Central Point (40°C) 95

4.10 Superimposed Contour Plots for Optimization of Filterability, Clarity, Turbidity and Viscosity when Time was Kept Constant at Central Point (75 minutes) 96

4.11 Superimposed Contour Plots for Optimization of Filterability, Clarity, Turbidity and Viscosity when Enzyme Concentration Kept Constant 96

5.1 Flow Chart for Processing of Clarified Banana Juice 102

5.2 Effect of Different Treatments on Turbidity of Clarified Banana Juice During Storage 113

5.3 Effect of Different Treatments on Clarity of Clarified Banana Juice During Storage 120

5.4 Effect of Different Treatments on Total Polyphenol of Clarified Banana Juice During Storage 123

5.5 Effect of Different Treatments on Protein Content of Clarified Banana Juice During Storage 127

5.6 Effect of Different Treatments on Browning Index of Clarified Banana Juice During Storage 129

5.7 Effect of Different Treatments on Colour (a) L value, (b) a value and (c) b value of Clarified Banana Juice During Storage 132

5.8 Effect of Different Treatments on (a) pH, (b) Total Acidity (TA) and (c) Total Soluble Solids (TSS) of Clarified Banana Juice During Storage 134

B-1 Standard Curve for Total Polyphenol 187

B-2 Standard Curve for Protein 187
# LIST OF PLATE

<table>
<thead>
<tr>
<th>Plate</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Berangan Banana Fruit on the Tree</td>
<td>7</td>
</tr>
</tbody>
</table>
## LIST OF ABBREVIATIONS/ NOTATIONS

### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
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