UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF AN IMPROVED PITAYA JUICE PROCESSING SYSTEM

NUR ‘ALIAA BINTI ABD RAHMAN

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By

NUR 'ALIAA BINTI ABD RAHMAN

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

May 2009

Specially dedicated to….

My loving parents…

My beloved husband…

My wonderful siblings…

My friends…

for their support and encouragements…

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the Degree of Master of Science

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NUR 'ALIAA BINTI ABD RAHMAN

May 2009

Chairman: **Siti Mazlina Mustapa Kamal, PhD**

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The processing of tropical fruit juice has improved nowadays. Dragon fruit or pitaya is one of the tropical fruits that has attracted the attention of consumers, fruit growers and also food processing industry entrepreneurs in this country. Various pitaya products have been marketed in Malaysia. Pitaya juice is well known for its health benefits. Since pitaya processing has just developed, more research should be carried out to increase the production quality of pitaya product such as fruit juice. In the current research, pitaya juice production operations were studied from the peeling process to the production of clear pitaya juice using enzyme. A fruits grater and peeler was invented to ease the peeling process before the fruit is processed into juice. The machine was able to reduce the peeling time up to 94% when compared to manual peeling. This apparatus was proven to ease and speed up the process of peeling pitaya skin. Studies were carried out to obtain the optimum processing condition for enzymatic clarification of red and white pitaya juices. Two types of commercial pectinase enzymes had been used which were Pectinex Ultra SP-L and

Pectinex CLEAR. Response Surface Methodology (RSM) was used to obtain the optimum processing condition in terms of enzyme concentration, temperature and incubation period. The optimum processing condition for enzymatic treatment of red pitaya juice treated with Pectinex Ultra SP-L was found to be at 0.10% enzyme concentration at 40^{o}C for 45 min. The optimum processing condition of red pitaya juice treated using Pectinex CLEAR was reported in other study. For white pitaya juice, the optimum processing condition for enzymatic treatment using Pectinex Ultra SP-L was at 0.06% enzyme concentration at 49^{o}C for 40 min. For white pitaya juice treated with Pectinex CLEAR, the optimum processing condition was at 0.10% enzyme concentration at 40^{o}C for 82 min. The use of this enzyme was proven to increase the recovery of pitaya juice after the filtration process. The data for pitaya composition after processing was also obtained. It was observed that several components such as protein and phenolic contents (antioxide component) had increased after the enzymatic treatment. Research was carried out further by developing a process flow sheet for producing pitaya juice at laboratory-scale (batch processing). Laboratory-scaled processing was carried out to resemble large-scaled continuous processing in the industry. Calculation of material balance was also done based on the process flow sheet that had been developed. Data obtained from this research can be used as a base for developing large-scale pitaya juice production process at industrial level.

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

PEMBANGUNAN SISTEM PEMPROSESAN JUS PITAYA YANG DIPERTINGKATKAN

Oleh

NUR 'ALIAA BINTI ABD RAHMAN

Mei 2009

Pengerusi: **Siti Mazlina Mustapa Kamal, PhD**

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Pada masa kini, pemprosesan jus buah-buahan tropikal telah semakin meningkat maju. Buah naga atau pitaya adalah salah satu daripada buah tropikal yang mula mendapat perhatian di kalangan pengguna, penanam buah, dan juga pengusaha industri pemprosesan makanan di negara ini. Pelbagai produk hasil pitaya telah mula dipasarkan di Malaysia. Jus pitaya juga telah dikenali kerana khasiat kesihatannya. Oleh kerana pemprosesan pitaya baru sahaja berkembang, maka pelbagai kajian perlu dilakukan untuk meningkatkan kualiti pengeluaran produk pitaya seperti jus buah. Dalam penyelidikan ini, operasi penghasilan jus pitaya telah dikaji dari proses pengupasan pitaya kepada penghasilan jus pitaya jernih menggunakan enzim. Sebuah alat pemarut dan pengupas kulit pitaya telah direka bagi memudahkan proses pembuangan kulit pitaya sebelum diproses untuk menjadi jus. Alat ini dapat mengurangkan tempoh pengupasan buah sehingga 94% berbanding dengan pengupasan secara manual. Penghasilan alat ini terbukti dapat memudahkan dan mempercepatkan lagi proses pengupasan kulit pitaya. Kajian turut dijalankan untuk memperoleh keadaan pemprosesan yang optimum bagi proses rawatan berenzim jus

pitaya merah dan putih. Dua jenis enzim pektinase komersil telah digunakan iaitu Pectinex Ultra SP-L dan Pectinex CLEAR. *Response Surface Methodology* (RSM) telah digunakan bagi memperoleh keadaan pemprosesan optimum dari segi kepekatan enzim, suhu dan tempoh masa inkubasi. Keadaan pemprosesan optimum bagi rawatan berenzim jus pitaya merah oleh Pectinex Ultra SP-L adalah pada kepekatan enzim 0.10%, pada suhu 40^{o}C selama 45 minit. Keadaan pemprosesan optimum bagi jus pitaya merah yang dirawat menggunakan Pectinex CLEAR telah dilaporkan di dalam kajian lain. Bagi jus pitaya putih, keadaan pemprosesan optimum bagi rawatan berenzim menggunakan Pectinex Ultra SP-L adalah pada kepekatan enzim 0.06%, pada suhu 49^{o}C selama 40 minit. Bagi jus pitaya putih yang dirawat oleh Pectinex CLEAR, keadaan pemprosesan optimum adalah pada kepekatan enzim 0.10%, pada suhu 40^{o}C selama 82 minit. Penggunaan enzim ini telah terbukti dapat meningkatkan lagi pemerolehan semula jus pitaya selepas melalui proses penapisan. Data-data bagi komposisi pitaya selepas diproses juga telah diperoleh. Didapati bahawa beberapa komponen seperti protein dan fenolik (komponen antioksida) telah meningkat selepas dirawat dengan enzim. Kajian diteruskan lagi dengan pembangunan helaian aliran proses bagi penghasilan jus pitaya berskala makmal (pemprosesan berkelompok). Pemprosesan berskala makmal ini dijalankan bagi menyerupai pemprosesan berskala besar di industri yang menjalankan pemprosesan secara terus-menerus (*continuous*). Pengiraan terhadap keseimbangan bahan juga telah dijalankan berdasarkan pada helaian aliran proses yang telah dibangunkan. Data yang diperoleh dari kajian ini dapat dijadikan asas kepada pembangunan proses penghasilan jus pitaya berskala besar di peringkat industri.

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I certify that a Thesis Examination Committee has met on 6th May 2009 to conduct the final examination of Nur 'Aliaa binti Abd Rahman on her thesis entitled 'Development of An Improved Pitaya Juice Processing System' in accordance with the Universities and University Colleges 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 Science.

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Date: 8 June 2009

DECLARATION

I declare that the thesis is my original work except for the quotations and citations which have been duly acknowledge. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or other institutions.

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NUR 'ALIAA BINTI ABD RAHMAN

Date: 20 May 2009

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LIST OF ABBREVIATIONS

3D	Three-dimensional
abs	Absorbance value
b_0	constant
b_1	Linear coefficient of temperature
b_2	Linear coefficient of enzyme concentration
b_3	Linear coefficient of time
b_{12}	Interaction coefficient of temperature and enzyme concentration
b_{13}	Interaction coefficient of temperature and time
b_{23}	Interaction coefficient of enzyme concentration and time
b_{11}	Quadratic coefficient of temperature
b_{22}	Quadratic coefficient of enzyme concentration
b_{33}	Quadratic coefficient of time
cps	Centipoise
HTST	High-temperature-short-time
L*	Lightness value
p	Probability
RSM	Response surface methodology
rpm	Rotation per minute
R^2	Regression coefficient
TSS	Total soluble solids
X_1	Coded level of maceration temperature
X_2	Coded level of enzyme concentration
X_3	Coded level of maceration time
y	Response function

CHAPTER 1

INTRODUCTION

1.1 Fruit Juice Consumption

Juice is defined as the extractable fluid contents of cells or tissues (Merriam-Webster, 2007). The manufacture of juices from fruits is as old as agriculture (Bates et al., 2001). The demand for fruit beverages is largely based on their nutritive value, flavour, aroma and colour. These quality factors are dependent directly on the structure and chemical composition of the fresh fruit. The process starts with sound fruit, freshly harvested from the field or taken from refrigerated or frozen storage (McLellan and Padilla-Zakour, 2004). Fruits have always played an important role in human nutrition (Horvath-Kerkai, 2006). Fruit juice is a source of vitamins, minerals, carbohydrates, amino acids, flavanoids compounds and other unidentified constituents. Due to the revolutionary development of technical equipment, the appearance of chemicals, and biological substances (enzymes, clarifying and flavouring agents), and the application of new technological procedures, especially the aseptic technique – which enabled the production of fruit juices without preservatives – of fruit juice production became widespread (Horvath-Kerkai, 2006). Since fruit juices are caffeine-free, they are healthier for consumption than any other caffeine-containing beverages. The global market for juice and juice products was estimated to be about 50 billion litres in the late 1990s.

1.2 Pitaya

The pitaya or dragon fruit is also known as pitahaya, strawberry pear, nanettikafruit, thanh long or 'kaktus madu'. It is a cactus species of the genus *Hylocereus* and *Stenocereus*. Generally, pitaya comes in three types, which are *Hylocereus undatus* (white flesh with pink skin), *Hylocereus polyrhizus* (red flesh with pink skin) and *Seleicereus megalanthus* (white flesh with yellow skin) (Anonymous (d), 2007). Pitaya originated in Mexico and Central America and subsequently, the plant has been cultivated widely in countries such as Vietnam, Taiwan and Malaysia.

Pitaya is mildly sweet and low in calories, has attractive flesh and juicy with subtle fruity flavour (melon-like flavour). Pitaya is round or oval; the skin is fuchsia-pink or yellow depending on the species, leathery and slightly leafy; and the fruit usually weighs about 200–1000g. It is rich in potassium, ferum, protein, fibre, sodium and calcium which are good for human health. It also contains zinc, vitamin B1, vitamin B2, vitamin B3, vitamin C, carotene and phosphorus. Pitaya can be converted into juice, jam and red wine.

Recently, pitaya juice is becoming popular due to its nutritional benefits despite its colourant properties. All the research done on pitaya (*Hylocereus polyrhizus*) focused on the betalain contents. In the process of obtaining pitaya juice, the fruits were cut in halves and the peels were removed manually (Herbach et al., 2006). Subsequently, the fruit pulp was strained using a finisher. The strained pulp was centrifuged and the supernatant juice was flushed with nitrogen and stored at -30^{o}C until use. In the research done by Moβhammer et al. (2005) to study the colour of fruit juice blends

from *Opuntia* and *Hylocereus* cacti, the process of obtaining pitaya juice was similar as done by Herbach et al. (2006).

Currently this fruit utilization is further expanded to produce dragon fruit enzyme and dragon fruit concentrated juice. These products are now available in the market. This expansion has promoted dragon fruit as a great source of functional beverages. However, less attention is being given to the appearance and texture of the drinking products. The undesirable texture of the concentrated juice causes difficulties in mixing the concentrate with water to be drunk. This situation may not attract the consumers to buy this product again. Hence, action should be taken to overcome this problem.

1.3 Enzymatic Clarification of Fruit Juice

Enzyme is an essential tool in juice processes, both in terms of quality improvement and cost saving (Ramadan and Moersel, 2007). Fruit and vegetable juice production is nowadays unthinkable without the use of enzymes (Baumann, 1981). The degradation of plant cell walls by exogenous enzymatic treatment results in easier release of the components contained in cells (Janser, 1997).

The cloudiness in the juice is mainly caused by the presence of polysaccharides such as pectin and starch. The pectin can be associated with plant polymers and the cell debris, which has a fibre-like molecular structure and makes the clarification process harder. Enzyme-catalyzed breakdown of the plant cell-wall matrix and middle lamella may first increase the immediate turbidity in the juice, which is generally

assumed to be mainly due to the presence of pectin and other fractions of fruit cell-wall material (Grassin and Fauquembergue, 1996). Therefore, enzymatic treatment by using pectinase is an effective way to reduce the pectin in the fruit juices because pectinase has the ability to hydrolyze pectin and cause pectin–protein complexes to flocculate (Rai et al., 2004; Lee et al., 2006; Liew Abdullah et al., 2007; Sin et al., 2006), which could be easily removed by filtration. A complete enzymatic breakdown of pectin is the key for producing clear and stable fruit juices. Though hard to believe, juice clarification is the oldest and still largest market for commercial pectinases (Baumann, 1981).

1.4 Fruit Processing Operation

The major unit operations in fruit processing are peeling, pulping, enzymation, centrifugation, filtration, pasteurization, hot filling and cooling. Each step has its own importance to the fruit processing operations. Fruit peeling has its own impact towards the efficiency of the whole system.

In the processing of fruits, fruit peeler is needed to reduce the time required for peeling process. It is crucial for the fruit processing industry to operate at minimal operating costs. Peeling using hands is time consuming and may require several workers to perform the operation, and thus may increase the operating costs.

Different types of fruits have different shapes and sizes. Thus, several different machines are provided for separately processing each of the fruits. Therefore, processing of a particular fruit, such as removing the skin from an orange, is usually