UNIVERSITI PUTRA MALAYSIA

# OPTIMIZATION OF PROCESSING PARAMETERS FOR THE PRODUCTION AND STORAGE OF DRUM-DRIED JACKFRUIT (*ARTOCARPUS HETEROPHYLLUS*) POWDER

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FSTM 2006 18

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**By**

**PUA CHUN KIAT**

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

**July 2006**

**ESPECIALLY DEDICATED TO MY BELOVED FAMILY**

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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**July 2006**

**Chairman : Nazimah Sheikh Abdul Hamid, PhD**

**Faculty : Food Science and Technology**

This study concerns with the optimization of formulation and processing parameters of drum-dried jackfruit powder using response surface methodology (RSM). In formulating the jackfruit powder, various concentrations of soy lecithin and gum arabic ranging from 1 to 5% and 5 to 15 %, respectively were tested. The optimum formulation for jackfruit powder contained 2.65% of soy lecithin and 10.28% of gum arabic with 40% v/w water. Soy lecithin and gum arabic significantly ($p$<0.05) affected the moisture content, bulk density, Hunter *L, a, b* values and hedonic scores of jackfruit powder with each response following the second-order polynomial model.

Optimum processing parameters for drum drying were found when drum clearance of drum dryer was set at 0.01 inch, pool level at 10 cm, and drum rotation speed of 1 to 3 rpm with 3.0 to 4.4 bars of steam pressure. The results showed that the moisture content,

water activity, solubility, Hunter *L, a, b* value, and sensory attributes of jackfruit powder were significantly ($p<0.05$) influenced by both steam pressure and rotation speed of the drum dryer. The optimum steam pressure and rotation speed of drum dryer were 3.36 bars and 1.2 rpm respectively with predetermined drum clearance of 0.01 inch and 10 cm of pool level.

Total colour difference ($\Delta E$), moisture sorption rates and sensory attributes of drum-dried jackfruit powder packaged in aluminum laminated polyethylene (ALP) and metallized co-extruded biaxially oriented polypropylene (BOPP/MCPP) pouches stored at accelerated storage (38$^{o}$C, with 50, 75 and 90% relative humidity (RH)) were determined over 12 weeks period. The changes in total colour followed zero order reaction kinetics. Packaging materials, storage temperature and RH values significantly ($p<0.05$) influenced the moisture sorption rates of jackfruit powder. There was a significant ($p<0.05$) decrease in the intensities of the fruity odour, taste and increase in the lumpiness of the jackfruit powder stored at 38$^{o}$C with 90% RH. The shelf life of jackfruit powder stored at 38$^{o}$C and 90% RH was limited by both overall acceptability and the three sensory attributes intensities at week 8 of storage. Jackfruit powder stored at 28$^{o}$C remained stable and acceptable throughout the storage period for all RH values. The powder packaged in ALP significantly ($p<0.05$) reduced total colour change, moisture sorption rates, lumpiness intensity of jackfruit powder and was rated higher in terms of overall acceptability over BOPP/MCPP. Results of this study suggested that ALP packaging with storage conditions of 28$^{o}$C and RH less than 75% was better suited for keeping jackfruit powder.

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

**PENGOPTIMUMAN PARAMETER PEMPROSESAN UNTUK PENGHASILAN DAN PENYIMPANAN SERBUK NANGKA (*ARTOCARPUS HETEROPHYLLUS*) YANG DIKERINGKAN SECARA DRAM**

Oleh

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Kajian ini berkenaan pengoptimuman rumusan dan parameter pemprosesan serbuk nangka yang dikeringkan secara dram dengan menggunakan metodologi respons permukaan (“Response Surface Methodology”, RSM). Dalam merumuskan serbuk nangka, pelbagai kepekatan lesitin soya dan gam arabic dalam lingkungan 1 hingga 5% dan 5 hingga 15%, masing-masing telah diuji. Rumusan yang optimum bagi serbuk nangka mengandungi 2.65% lesitin soya dan 10.28% gam arabic dengan 40% v/w air. Lesitin soya dan gam arabic mempengaruhi kandungan kelembapan, ketumpatan pukal, nilai Hunter *L, a, b* dan skor hedonik serbuk nangka secara bererti ($p$<0.05) dengan setiap respons mengikuti model polinomial turutan kedua.

Parameter pemprosesan yang optimum bagi pengeringan dram didapati apabila jurang antara dram bagi pengering dram telah ditetapkan pada 0.25 mm, paras takungan pada

10 sm, dan kelajuan putaran dram pada 1 hingga 3 rpm dengan 3.0 hingga 4.4 bar tekanan stim. Keputusan menunjukkan bahawa kandungan kelembapan, aktiviti air, keterlarutan, nilai Hunter *L, a, b* dan ciri sensori serbuk nangka telah dipengaruhi oleh kedua-dua tekanan stim dan kelajuan putaran pengering dram secara bererti ($p<0.05$). Tekanan stim dan kelajuan putaran pengering dram yang optimum adalah 3.36 bar dan 1.2 rpm, masing-masing dengan jurang antara dram 0.25 mm dan paras takungan 10 sm yang dipratentukan.

Jumlah perbezaan warna ($\Delta E$), kadar penyerapan lembapan dan ciri sensori serbuk nangka yang dikeringkan secara dram telah dibungkus dengan beg polietilina yang dilapisi aluminium (ALP) dan beg polipropilena berarahkan dua-paksi yang disaluti logam (BOPP/MCPP) yang disimpan pada keadaan penyimpanan yang dipercepatkan (38$^{o}$C, dengan 50, 75 dan 90% lembapan relatif (RH)) telah ditentukan selama 12 minggu. Perubahan pada jumlah warna mengikuti tindakbalas kinetik turutan sifar. Jenis bahan pembungkus, suhu penyimpanan dan nilai RH mempengaruhi kadar penyerapan lembapan serbuk nangka secara bererti ($p<0.05$). Terdapat pengurangan yang bererti ($p<0.05$) pada keamatan bau, rasa buah dan penambahan pada pengetulan serbuk nangka yang disimpan pada suhu 38$^{o}$C dengan 90% RH. Jangka hayat serbuk nangka yang disimpan pada 38$^{o}$C dan 90% RH telah dihadkan oleh kedua-dua kebolehterimaan keseluruhan dan keamatan tiga ciri sensori pada minggu penyimpanan yang ke-lapan. Serbuk nangka yang disimpan pada 28$^{o}$C tetap stabil dan boleh diterima sepanjang jangka masa penyimpanan untuk semua nilai RH. Serbuk yang dibungkus dengan ALP menunjukkan jumlah perbezaan warna, kadar penyerapan lembapan, keamatan pengetulan serbuk nangka yang rendah lagi bererti ($p<0.05$) dan telah dinilai lebih tinggi dari segi penerimaan keseluruhan daripada BOPP/MCPP. Keputusan kajian ini mencadangkan bahawa pembungkusan ALP dengan keadaan penyimpanan 28$^{o}$C dan RH kurang daripada 75% adalah sesuai untuk penyimpanan serbuk nangka.

**ACKNOWLEDGEMENTS**

I would like to express my most sincere gratitude and appreciation to my supervisory committee chairman, Dr. Nazimah Sheikh Abdul Hamid, for her invaluable guidance, advice and constant encouragement throughout the course of my research study. Her constructive criticisms and suggestions provided me the strength and perseverance to complete this thesis despite several obstacles encountered throughout the course of this research, which at times seemed insurmountable. Appreciation also goes to the members of my supervisory committee, Professor Dr. Gulam Rusul Rahmat Ali and Professor Dr. Russly Abdul Rahman for their support and invaluable suggestions to guide me during my study.

I wish to express my gratitude to all members of the Faculty of Food Science and Technology, UPM for providing the research facilities and technical assistance during my graduate study. Acknowledgement is also due to all my friends, Voon Yit Yang, Ong Bee Tein, Chin Sung Tong, Kuan Tuck Keong, Lee Wai Cheng; and those who have given me the moral encouragement and support to complete my graduate study.

I would like to thank Dr. Patrick Loi from Packaging Research Centre Sdn. Bhd. (Shah Alam, Selangor, Malaysia) for his valuable advice regarding packaging material and contributing the packaging materials used in my study. I would like to acknowledge the financial support provided by IRPA grant (03-02-04-0156-EA001) awarded to Dr. Nazimah Sheikh Abdul Hamid for this study. Acknowledgement is also due to the PASCA scholarship for granting me the opportunity to pursue my master degree.

I am also greatly indebted to my beloved parents and siblings, for their love, spiritual encouragement and support. I wish also to express my deepest appreciation to my girl friend, for her understanding, concern, faith and love.

I certify that an Examination Committee has met on 7 July 2006 to conduct the final examination of Pua Chun Kiat on his Master of Science thesis entitled "Optimization of Processing Parameters for the Production and Storage of Drum-Dried Jackfruit (*Artocarpus heterophyllus*) Powder" 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.

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**PUA CHUN KIAT**

Date:

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| $\Delta E$ | Total Colour Difference |
| ANOVA | Analysis Of Variance |
| ALP | Aluminum Laminated Polyethylene |
| $a_w$ | Water Activity |
| BOPP/MCPP | Biaxially Oriented Polypropylene laminated with Metallized Cast Polypropylene |
| FFA | Free Fatty Acid |
| HDPE | High Density Polyethylene |
| HDPP | High Density Polypropylene |
| HMF | Hydroxymethyl Furfural |
| IR | Infra Red |
| LDPE | Low Density Polyethylene |
| LLDPE | Linear Low Density Polyethylene |
| MPP | Metallized Polyester/Polyethylene |
| OTR | Oxygen Transmission Rate |
| PET | Polyethylene Terephthalate |
| PP | Polypropylene |
| ppm | Part Per Million |
| psi | Pound Per Square Inch |
| Q | Quality Attribute |
| QDA | Quantitative Descriptive Analysis |
| RH | Relative Humidity |

| | |
|---|---|
| rpm | Revolution Per Minute |
| RSM | Response Surface Methodology |
| TBA | Thiobarbituric Acid |
| UV | Ultra Violet |
| v/w | Volume Over Weight |
| w/v | Weight Over Volume |
| WVTR | Water Vapour Transmission Rate |
| w/w | Weight Over Weight |

# CHAPTER I

## GENERAL INTRODUCTION

Jackfruit (*Artocarpus heterophyllus*) belongs to the family of *Moraceae*. The genus *Artocarpus* contains about 50 species; most are native to Asia and jackfruit is one of the 15 species that produce edible starchy fruits (Nakasone & Paull, 1998). The jackfruit bulbs are normally eaten fresh but also processed into various products such as canned jackfruit juice (Seow & Shanmugam, 1992), jackfruit leather (Che Man & Sin, 1997) and carbonated beverage (John and Narasimham, 1993). In a mature state, the water content of jackfruit makes it more susceptible to decomposition by microorganisms, chemical and enzymatic reactions. As a climacteric fruit, jackfruit is extremely perishable and cannot be marketed or exported as fresh produce. The development of a shelf stable product from fresh fruit is an important consideration to reduce post-harvest losses.

Food dehydration is a process particularly important for fruit and vegetables, which contain a large proportion of water, and their preservation becomes critical (Tsami et al., 1999). According to Fitzpatrick and Ahrné (2005), the development of formulation engineering concepts in food manufacturing and the demand for diversity in food products have driven a substantial market increase for food ingredients. Drum drying is extensively used in commercial drying of a variety of foodstuffs such as yeast creams, fruit purees, baby foods, mashed potatoes, dry soup mixtures and pregelatinized starches (Bonazzi et al., 1996; Moore, 1995). The main advantage of drum dryers compared to other continuous flow dryers is their much shorter retention time and their ability to maintain a high drying capacity even when the initial moisture of the product is extremely high (Kristensen et al., 2005).

Emulsifiers are widely used in foods in order to improve texture, reduce crumb firmness, and complex with starches (baked goods); to improve the shelf life of flavours; and to increase stability and prevent phase separation in food emulsions (Stauffer, 1996). Lecithin is used in many food products, such as chocolate, confectionery products, margarines, bakery goods and pasta products. Many of these applications are still active today for its emulsifying, wetting, colloidal, antioxidant, and physiological properties. Gum arabic is a hydrocolloid emulsifier and exists in nature as a neutral or slightly acidic salt of a complex polysaccharide. Its major use as a food additive is to provide desirable properties that affect viscosity, body, and texture of foods (Enriquez et al., 1989). It is used as an emulsifier in beverages for citrus oil and flavours, as a crystallization retarder and emulsifier in confectioneries, and as a stabilizer in dairy and bakery products (Somogyi, 2005).

The major food powder issue with regard to food ingredient powders is maintaining the stability of ingredient functionality from production right through to final powder application. Environmental factors such as temperature, humidity, oxygen, and light can trigger several reaction mechanisms that may lead to food degradation. Maintaining the quality of the dehydrated product during storage will depend on the choice of packaging material capable of preventing or retarding deteriorative reactions such as, loss of nutrients, non-enzymatic browning, lipid oxidation, discolouration and increase of moisture to critical levels (Labuza, 1982).

There is considerable evidence in the literature that temperature plays a major role in causing changes in food quality during storage. Higher storage temperatures generally lead to increased quality deterioration. Some researchers have done extensive studies on the quality changes of mango powder during storage. Kumar and Mishra (2004) reported that colour change in mango soy fortified yoghurt powder was affected by both storage time and packaging material under accelerated storage condition (38±1$^{o}$C, 90% RH). Jaya and Das (2005) predicted the shelf life of vacuum-dried mango powder to be 114.68 days and reported that the colour change of powder followed first order reaction kinetics under accelerated storage condition (38±2$^{o}$C, 90% RH). Hymavathi and Khader (2005) reported that physicochemical and nutrient changes were less pronounced in the mango powders packaged in metallized polyester/polyethylene than the powders in the polypropylene packaging. According to Esse and Saari (2004), many manufactured food products are adversely affected by moisture changes which directly impact their shelf-life and quality. These foods will lose desirable texture characteristics if allowed to lose or gain excessive moisture.

Therefore, the objectives of this study were:

1. To determine the optimum concentration of soy lecithin and gum arabic in producing drum-dried jackfruit powder.
2. To determine the optimum drum drying processing parameters for jackfruit powder production.

3. To study the stability of jackfruit powder packaged in aluminium laminated polyethylene (ALP) and metallized co-extruded biaxially oriented polypropylene (BOPP/MCPP) pouches during accelerated storage (38$^{o}$C, with 50, 75 and 90% RH).