



**UNIVERSITI PUTRA MALAYSIA**

***DESIGN AND DEVELOPMENT OF AN  
INTEGRATED GRATING AND SLICING MACHINE  
FOR STARCHY VEGETABLES***

**LOK CHUNG YEE**

**FK 2012 120**

**DESIGN AND DEVELOPMENT OF AN  
INTEGRATED GRATING AND SLICING MACHINE  
FOR STARCHY VEGETABLES**

**By**

**LOK CHUNG YEE**

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

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## DEDICATION

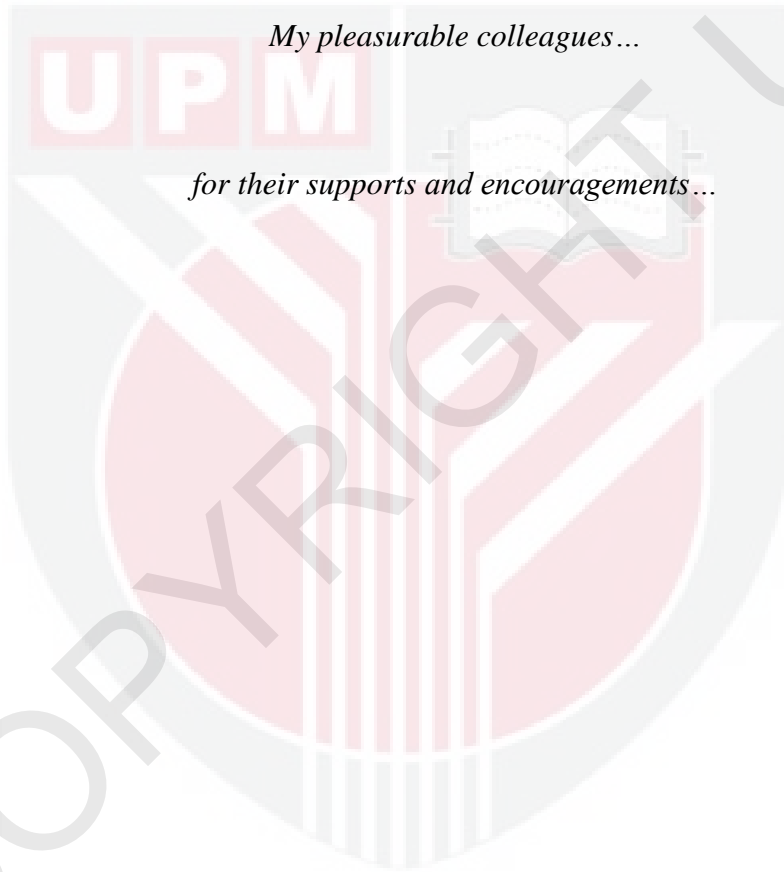
*Specially dedicated to...*

*My respectable parents ...*

*My honourable brothers...*

*My pleasurable colleagues...*

*for their supports and encouragements...*



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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the Degree of Master of Science

**DESIGN AND DEVELOPMENT OF AN INTEGRATED GRATING AND SLICING MACHINE FOR STARCHY VEGETABLES**

By

**LOK CHUNG YEE**

**July, 2012**

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Conventional processes of grating and slicing that produce both grated and sliced products normally involved two units of independently operated machines. In this study, grating and slicing processes have been combined into a single operation through an integrated machine for simultaneous operations. The purpose of integrating both processes is to reduce operation cost, time, energy consumption, and the number of unit operations involved in the processing system, both grating and slicing production. Three objectives were outlined to achieve in this research. The first objective was to determine the selected physical properties of starchy vegetables (white potato, sweet potato, tapioca, and yam) to be applied to the new machine. The second objective was to develop and design an integrated grating and slicing machine

for simultaneous operation. The final objective was to evaluate the performance of an integrated machine for production of grating and slicing starchy vegetables.

Two selected physical properties of starchy vegetables that were studied are hardness and moisture content. These properties were measured using a destructive testing method of texture and moisture analyzer. The information on the properties of starchy vegetables hardness and moisture content are important to be determined prior to design the food processing equipments which relates to the grating and slicing processes. The selected starchy vegetables used for this study were white potato, sweet potato, tapioca and yam. It was found that the maximum hardness of white potato, yam, sweet potato and tapioca were 65.43 N, 117.82 N, 166.57 N and 196.98 N respectively. The range of moisture content of these vegetables is 60 to 78%. Based on the hardness results, it was determined that the minimum requirement for the cutting force of the integrated machine must not be less than 700 N/m.

During the design and development phase, the machine's design specifications were identified to ensure that the simultaneous grating and slicing operations in an integrated machine are capable to process the raw materials. The design methodology was first begun with product development process, conceptual design, design selection, detail design, prototype development and finally, machine and production assessment. This machine is developed to overcome the problems faced in conventional grating and slicing processes using two units of independent operation machines. The present state of this machine is suitable for use in industrial processing level, leading to greater improvement in reducing energy and operating consumption (lower power at 750 W with variable speed at 0 – 180 rpm) with lower

speed for grated production range at 750 – 1200 kg/hr and sliced production range at 250 – 400 kg/hr. This newly designed machine is easy to setup, handle, store, clean, service, and maintain as well as capable to produce quality grated (10 x 10 mm at 750 to 1200 kg/hr) and sliced (2 mm thick at 250 – 400 kg/hr) products. This study has demonstrated that the newly integrated machine is ready to be used for the production of food chips and finger products.



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

**REKABENTUK DAN PEMBANGUNAN MESIN PEMARUT DAN  
PENGHIRIS BERSEPADU UNTUK SAYURAN BERKANJI**

Oleh

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Proses memarut dan menghiris konvensional biasanya menghasilkan produk parutan dan hirisan yang melibatkan dua unit mesin yang beroperasi secara bebas. Dalam kajian ini, proses memarut dan menghiris telah digabungkan ke dalam satu operasi melalui mesin bersepadu untuk operasi memarut dan menghiris secara serentak. Tujuan mengintegrasikan kedua-dua proses tersebut adalah untuk mengurangkan kos operasi, masa, penggunaan tenaga, dan bilangan unit operasi yang terlibat dalam sistem pemprosesan bagi pengeluaran hasil parutan dan hirisan. Tiga objektif telah ditetapkan untuk mencapai matlamat kajian ini. Objektif pertama adalah untuk menentukan sifat-sifat fizikal bagi sayur-sayuran berkanji terpilih (ubi kentang putih, keledek, ubi kayu dan keladi) untuk digunakan dalam mesin baru. Objektif kedua adalah untuk membangun dan mereka bentuk mesin parutan dan hirisan bersepadu

untuk operasi serentak. Objektif terakhir adalah untuk menilai prestasi mesin bersepadu tersebut bagi hasil pengeluaran parutan dan hirisan untuk sayur-sayuran berkanji.

Dua sifat fizikal yang dikaji ialah kekerasan dan kandungan lembapan. Ciri ini diukur dengan menggunakan penganalisa tekstur dan kelembapan melalui kaedah ujian destruktif. Maklumat tentang sifat kekerasan dan kandungan lembapan bagi sayur-sayuran berkanji adalah penting untuk dikaji sebelum mereka bentuk peralatan pemrosesan makanan yang berkaitan dengan proses parutan dan hirisan. Sayuran berkanji terpilih yang digunakan untuk kajian ini adalah ubi kentang putih, keledak, ubi kayu dan keladi. Didapati bahawa kekerasan maksimum ubi kentang putih, keladi, ubi keledak dan ubi kayu ialah 65.43 N, 117.82 N, 166.57 N and 196.98 N masing-masing. Julat kandungan kelembapan sayur-sayuran ini adalah 60 hingga 78%. Berdasarkan kepada hasil keputusan kekerasan, keperluan minimum bagi daya pemotongan mesin bersepadu mestilah tidak kurang daripada 700 N/m.

Semasa dalam fasa pembangunan dan reka bentuk, spesifikasi reka bentuk mesin telah dikenal pasti untuk memastikan bahawa kedua-dua proses memarut dan menghiris dalam mesin bersepadu mampu untuk memproses bahan mentah. Metodologi reka bentuk bermula dengan proses reka bentuk produk, reka bentuk konsep, pemilihan reka bentuk, reka bentuk perincian, reka bentuk prototaip dan akhirnya, penilaian mesin dan penghasilannya. Mesin ini direka bentuk untuk mengatasi masalah yang dihadapi dalam proses memarut dan menghiris konvensional yang menggunakan dua unit mesin yang beroperasi secara bebas. Mesin baharu ini sesuai digunakan untuk industri pemrosesan yang membawa kepada peningkatan

dalam pengurangan penggunaan tenaga dan operasi (kuasa yang lebih rendah pada 750 W dengan kelajuan boleh ubah dari 0 – 180 rpm) dengan kelajuan yang lebih rendah) bagi lingkungan pengeluaran parutan pada 750 – 1200 kg/jam dan lingkungan pengeluaran hirisan pada 250 – 400 kg/jam. Mesin baharu ini juga mudah untuk disedia, dikendali, disimpan, dibersihkan, disenggara, dan dikawal serta mampu untuk menghasilkan produk parutan (10 x 10 mm dalam 750-1200 kg/jam) dan hirisan (2 mm tebal dalam 250 - 400 kg/jam) yang berkualiti. Kajian ini menunjukkan bahawa mesin bersepadu ini boleh digunakan untuk pengeluaran produk makanan kerepek keping dan jejari.

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This thesis is dedicated to Dr. Siti Mazlina Bt. Mustapa Kamal, with heartfelt appreciation for her willingness to share her knowledge and insights with me.



**APPROVAL**

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I certify that a Thesis Examination Committee has met on 16th of July, 2012 to conduct the final examination of Lok Chung Yee on his thesis entitled “Design and Development of an Integrated Grating and Slicing Machine for Starchy Vegetables” in accordance with the Universities and Universities Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The committee recommends that the candidate be awarded the Master of Science.

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## DECLARATION

I declare that the thesis is my original work except for the quotations and citations that 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 at other institutions.



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**LOK CHUNG YEE**

Date: 16 July 2012

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