UNIVERSITI PUTRA MALAYSIA

DESIGN AND DEVELOPMENT OF PINEAPPLE ROLL TART MAKING MACHINE

PUA MING YEE

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By

PUA MING YEE

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

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Specially dedicated to…

My loving parents…

My wonderful siblings…

My friends…

For their support and encouragement…

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

DESIGN AND DEVELOPMENT OF A PINEAPPLE ROLLED TART MAKING MACHINE

By

PUA MING YEE

MAY 2011

Chairman: Rosnah Shamsuddin, PhD

Faculty: Engineering

Majority of pineapple rolled tarts are produced manually. Production is therefore slow and supply is unable to meet the market demand. A rolled tart making machine is essential for the efficient mass production of pineapple rolled tart. A machine that would reduce processing time, labour, and operating cost and at the same time, affordable for small-scale industries, was designed. Since food properties are varying with time, prior to design processes, effect of dough and jam formulations on its properties and kinetic studies of jam were studied. Effects of pineapple bakery jams with different sugar compositions (0% to 33.3%) were evaluated at ambient temperature based on total soluble solid (TSS), pH, viscosity, and moisture content. Simultaneously, effects of different butter (23% to 45%), sugar (0% to 20%) and corn flour (0% to 15%) compositions on hardness and stickiness of pineapple tart short dough were determined. There were significantly increased ($p < 0.05$) in total soluble solids (TSS), viscosity, and moisture content of jams at different sugar percentages, but no significant changes in

pH were observed. In textural analytical test, significant changes ($p < 0.05$) in hardness and stickiness of pineapple tart short dough with different compositions of butter, sugar, and corn flour were found. Cooking rate of pineapple bakery jam was investigated and the effects of cooking temperature (70°C to 100°C), stirring speed (20 rpm to 100 rpm) and batch volume (2 to 6 liters) on rate constant were examined. The linear relationship between the logarithmic total soluble solids gain ratios of cooked jam and the cooking time showed that the cooking rate followed the equation of first-order chemical reaction. The cooking rates increased with cooking temperature and stirring speed, but decreased with increasing batch volume. The activation energy of cooking process was 42.49 kJ/mol. Present investigation of cooking rate constant will be useful in designing more efficient jam cookers with higher ratio of effective heating surface to batch volume of fruit pulp.

Engineering design processes were carried out to develop the conceptual designs, which were generated with Computer Aided Design (CAD) software and evaluated based on customers' requirements. The basic decision matrix was used as a decision making tool for selecting the best design. The fabricated machine was tested at different screw rotating speeds and dough formulations. The rolled tart throughput rates increased significantly ($p<0.05$) with screw rotating speeds and butter percentages of dough. However, it decreased significantly ($p<0.01$) with sugar and corn flour percentages. The hardness of baked tart and the hardness and stickiness of unbaked tarts showed no significant difference between various screw rotating speeds and the manual method. It was found that the rolled tart produced by this machine was acceptable in texture and

mouth feel. The maximum and minimum rates for the standard dough formula were 4320 pieces per hour and 720 pieces per hour, respectively. The operating costs of making tarts using the machine with the highest rate were reduced by 92.05%, compared to the manual method. This machine achieved the objectives of research which can produce tarts at high rate, low operating and labour costs and affordable for small scale industries. This research provided the guideline how to manipulate the dough and jam formulation, and simple way to determine the end point of jam cooking.

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

REKAAN DAN PEMBANGUNAN MESIN NANAS TART GULUNG

By

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Majoriti nanas tart gulung yang dihasilkan secara manual. Produktivitinya adalah sangat rendah dan tidak dapat memenuhi permintaan pasaran. Sebuah mesin untuk membuat tart gulung sangat penting dalam pengeluaran nanas tart gulung. Sebuah mesin direkakan untuk mengurangkan masa pemprosesan, kos tenaga kerja dan kos operasi. Ia juga sesuai untuk industri kecil. Sifat makanan adalah berbeza-beza dengan masa. Sebelum proses rekabentuk dijalankan, kesan ramuan adunan dan jem ke atas sifatnya dan kinetik masakan jem dikaji. Pengaruh komposisi gula (0%-33.3%) terhadap jem nanas diuji pada suhu bilik berdasarkan jumlah pepejal terlarut (TSS), kepekatan, pH dan kadar air. Secara bersamaan, kesan komposisi gula (0%-20%), mentega (23%-45%) dan tepung jagung (0%-15%) terhadap kekerasan dan kelekitan adunan ditentukan. Terdapat perubahan yang signifikan ($p < 0.05$) pada TSS, kepekatan dan kadar air jem dengan peratusan gula yang berbeza. Namun, tidak ada perubahan signifikan dalam pH. Pada ujian analisis tekstur, signifikan ($p < 0.01$) perubahan dalam kekerasan dan

kelekitan adunan dijumpai dengan komposisi yang berbeza mentega, gula dan tepung jagung. Kadar masakan jem nanas telah dikajikan dengan pengaruh suhu memasak (70°C-100°C), kelajuan pengadukan (20rpm-100rpm) dan isipadu bac (2-6liter) diperiksa. Hubungan linear antara logaritma jumlah pepejal nisbah dan masa memasak menunjukkan bahawa tahap memasak mengikut persamaan reaksi kimia tertib pertama. Kadar masakan jem meningkat dengan suhu dan kelajuan pengadukan, tapi menurun dengan isipadu bac. Tenaga pengaktifan proses memasak adalah 42.49 kJ / mol. Penyelidikan masakan jem berguna dalam mereka bentuk periuk yang memasak jem dengen lebih efisien and efektif. Kejuruteraan proses rekaan dilakukan untuk mengembangkan rekaan konseptual. Rekaan konseptual yang dihasilkan dengan *Computer Aided Design* (CAD) perisian dan ia dinilai berdasarkan keperluan pelanggan. Keputusan dasar matriks digunakan sebagai alat untuk memilih rekaan terbaik. Mesin itu telah diuji pada kelajuan skru berputar dan formulasi adunan yang berbeza. Pengeluaran tart gulung meningkat secara signifikan ($p < 0.05$) dengan kelajuan skru berputar dan peratusan mentega. Namun, ia menurun secara signifikan ($p < 0.01$) dengan peratusan gula dan tepung jagung. Kekerasan tart gulung yang dipanggang, kekerasan and kelekitan tart gulung yang belum dipanggang tiada perbezaan yang signifikan di antara pelbagai kelajuan skru berputar dan kaedah manual. Hal ini ditemui bahawa tart gulung yang dihasilkan oleh mesin ini dapat diterima di tekstur dan mulut terasa. Pengeluaran maksimum dan minimum untuk formula adunan piawa adalah 4320 ketul per jam dan 720 ketul per jam. Kos operasi pembuatan tart gulung yang menggunakan mesin dengan pengeluaran tertinggi dikurangkan sebanyak 92.05 %, berbanding dengan kaedah manual. Mesin ini mencapai objektif penyelidikan yang boleh menghasilkan tart

dengan kadar yang tinggi, kos operasi and kos buruh yang rendah, dan ia adalah munasabah untuk industri skala kecil. Kajian ini menyediakan garis panduan mengenai bagaimana untuk memanipulasi doh dan penggubalan jem, dan cara mudah untuk menentukan titik akhir masakan jem.

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I certify that a Thesis Examination Committee has met on 28 June 2011 to conduct the final examination of Pua Ming Yee on his thesis entitled "Design and Development of A Pineapple Rolled Tart Making Machine" 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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DECLARATION

I declare that the thesis is my original work except for the quotations and citations which have been duly acknowledged. 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.

PUA MING YEE

Date:

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