



UNIVERSITI PUTRA MALAYSIA

**EFFECTS OF THERMAL AND NONTHERMAL TREATMENTS ON
KINETICS OF MASS TRANSFER AND SELECTED QUALITY
ATTRIBUTES DURING OSMOTIC DEHYDRATION OF SEEDLESS
GUAVA (*PSIDIUM GUAJAVA* L.)**

ALI GANJLOO

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By

ALI GANJLOO

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfillment of the Requirement for the Degree of Doctor of Philosophy**

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It seems to me that all sciences are vain and full of error that are not born of experience, mother of all certainty, and are not tested by experience, that is to say, that do not at the origin, middle or end pass through any of the five senses.

Leonardo da Vinci 1452-1519



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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Chairman: Professor Russly Abdul Rahman, PhD

Faculty: Food Science and Technology

This study evaluated the effect of some process parameters and selected enhancement techniques on the kinetics of mass transfer as well as selected quality attributes for osmotic dehydration of seedless guava. Experimental results revealed that higher values of solution concentration and temperature resulted in higher flows of water (39%) and solids (8%) through the seedless guava. In all cases, Peleg equation adequately ($R^2 > 0.92$) described the kinetics of mass transfer during osmotic dehydration. Total color difference increased up to 21% while hardness decreased around 32% with increase process variables. A zero order kinetic model was fitted to the experimental data adequately for quality parameters ($R^2 > 0.88$). The osmotic dehydration process was optimized for maximum water loss, weight reduction and minimum solute gain through response surface methodology. Results suggested optimum processing conditions of 30% w/w sucrose concentration at 33 °C after 179 min would result in 0.15 gg⁻¹ weight reduction, 0.2 gg⁻¹ water loss



and 0.03 gg^{-1} solid gain. Results showed that at the studied range of process parameters, the values of mass transfer terms were not in accordance with an efficient osmotic dehydration process in which 40–60% water loss and <10% solid gain are expected (Eren and Kaymak-Ertekin, 2007). In order to improve the rate of mass transfer a number of enhancement methods such as hot water blanching, thermosonication, ultrasound and centrifugal force were applied. The effect of hot water pretreatment at the temperature range of 80-95°C was evaluated and compared with osmotic dehydration at optimum condition. It improves the kinetics of mass transfer in terms of weight reduction, solid gain, water loss and normalized moisture content up to 15-30%, 2-6%, 16-46% and 7-20% at the temperature range of 80-90 °C, respectively. Traditional blanching lead to 17% increase and 54% decrease in total color difference and hardness values, respectively. For the first time, the simultaneous application of heat and ultrasonic wave (thermosonication) was investigated in order to reduce the intensity of heat treatments which can impair sensorial and nutritional properties of foods. Thermosonication at 90 °C at different amplitude levels (25-75%) lead to the enhancement of mass transfer of water (up to 4%) and solid (up to 1%) during osmotic dehydration without significant ($p>0.05$) changes of optical and textural properties in comparison with traditional blanching. Finally, the influence of ultrasonic wave and centrifugal force as nonthermal treatment on osmotic dehydration process was investigated to overcome the drawbacks of thermal treatment. Application of ultrasonic treatment compared with osmotic dehydration at optimized condition enhanced water loss and solid gain up to 23% and 3.3%, respectively. It improved “L” value without any significant effect ($p>0.05$) on “a” and “b” values whereas hardness value was significantly ($p<0.05$) affected. Centrifugal force treatment increased water loss around 34%, however,

retarded solid gain. The combination of centrifugal force with osmotic dehydration leads to decrease in hardness of samples (5%) whereas there is no significant ($p < 0.05$) effect on color of samples.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**PENGARUH- PENGARUH PERAWATAN TERMA DAN NONTHERMAL
PADA KINETIKA TRANSFER MASSA DAN ATRIBUT KUALITAS
PILIHAN SELAMA DEHIDRASI OSMOTIK JAMBU BIJI TANPA BIJI
(*PSIDIUM GUJAVA L.*)**

Oleh

ALI GANJLOO

April 2011

Pengerusi: Profesor Russly Abdul Rahman, PhD

Fakulti: Sains dan Teknologi Makanan

Kajian ini menilai kesan beberapa parameter proses teknik maju terpilih keatas kinetik pemindahan jisim serta beberapa atribut kualiti terpilih bagi penyahidratan osmotik buah jambu batu tanpa biji. Keputusan kajian menunjukkan bahawa nilai yang lebih tinggi bagi konsentrasi larutan dan suhu menyebabkan aliran yang lebih tinggi bagi air dan pepejal melalui jambu tanpa biji. Dalam semua kes, persamaan Peleg adalah mencukupi ($R^2 > 0.92$) untuk menggambarkan kinetik pemindahan jisim semasa penyahidratan osmotik. Perbezaan warna total meningkat manakala kekerasan menurun apabila pembolehubah proses meningkat. Satu model kinetik orde sifar dimasukkan dengan data dari eksperimen dan menunjukkan keputusan yang mencukupi bagi parameter kualiti ($R^2 > 0.88$). Proses penyahidratan osmotik telah dioptimalkan untuk kehilangan air maksimum, penurunan berat dan **penambahan** larutan minimum melalui metodologi respon permukaan. Keputusan kajian menunjukkan keadaan pemprosesan optimum adalah pada 30% w/w

konsentrasi sukrosa, 33 °C suhu selepas 179 minit proses akan menghasilkan 0.15 gg⁻¹ pengurangan berat, 0.2 gg⁻¹ kehilangan air dan 0.03 gg⁻¹ **penambahan** gula. Keputusan kajian menunjukkan bahawa pada julat parameter proses, nilai terma-terma pemindahan jisim adalah tidak **bersesuaian** dengan proses penyahidratan osmotik cekap di mana kehilangan air pada kadar 40-60% dan <10% peningkatan pepejal diharapkan dapat di capai (Eren and Kaymak-Ertekin, 2007). Untuk meningkatkan pemindahan jisim beberapa kaedah peningkatan seperti penceluran air panas, thermosonikasi, ultrabunyi dan daya emparan digunakan. Kesan prarawatan air panas pada julat suhu 80-95°C dinilai. Ini telah meningkatkan kinetik pemindahan jisim pada julat suhu 80-90°C. Penceluran tradisional menyebabkan kenaikan 17% dan penurunan 54% dalam perbezaan warna total dan nilai-nilai kekerasan, masing-masing. Oleh kerana haba boleh merosakkan sifat pancaindera dan nutrisi makanan, terdapat minat dalam mencari teknologi baru yang mampu mengurangkan kesan rawatan panas. Dari fakta ini, untuk pertama kalinya, aplikasi serentak haba dan gelombang ultrasonik pada pelbagai peringkat intensiti diselidiki. Thermosonikasi mengarah kepada peningkatan pemindahan jisim semasa penyahidratan osmotik tanpa perubahan signifikan ($p>0.05$) sifat optik dan tekstur dibandingkan dengan **penceluran** tradisional. Seterusnya, pengaruh keamatan ultrasonik dan daya emparan sebagai rawatan bukan termal semasa proses penyahidratan osmotik diselidiki. Rawatan ultrasonik secara signifikan meningkatkan kinetik pemindahan jisim berbanding dengan sampel yang tidak dirawat. Ia meningkat kan nilai-L tanpa memberi kesan yang signifikan ($p>0.05$) pada nilai-a dan nilai-b tetapi nilai kekerasan secara signifikan ($p<0.05$) terjejas. Daya emparan meningkatkan kehilangan air, tetapi, menurunkan peningkatan pepejal oleh produk. Kombinasi daya emparan dengan penyahidratan osmotik menyebabkan

penurunan kekerasan sampel sedangkan ia tidak mempunyai pengaruh signifikan pada warna sampel. Dapat disimpulkan bahawa penyahidratan osmotik emparan adalah sesuai jika kehilangan air dapat ditingkatkan dan peningkatan gula dapat dihadkan.

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I certify that a Thesis Examination Committee has met on 29 April 2011 to conduct the final examination of Ali Ganjloo on his thesis entitled "Effects of Thermal and Nonthermal Treatments on Kinetics of Mass Transfer and Selected Quality Attributes during Osmotic Dehydration of Seedless Guava (*Psidium Guajava* L.)" 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 Doctor of Philosophy.

Members of the Thesis Examination Committee were as follows:

Azis Ariffin, PhD

Associate Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Chairman)

Badlishah Sham Baharin,

Associate Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Internal Examiner)

Mohd Nordin Ibrahim, PhD

Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Kirk D. Dolan, PhD

Associate Professor
Michigan State University
(External Examiner)

BUJANG KIM HUAT, PhD

Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:



This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of Supervisory Committee were as follows:

Russly Abdul Rahman, PhD

Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Chairman)

Jamilah Bakar, PhD

Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Member)

Azizah Osman, PhD

Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Member)

HASANAH MOHD GHAZALI, PhD

Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:



DECLARATION

I declare that the thesis is my original work except for 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 at any other institutions.

ALI GANJLOO

Date: 29-April-2011

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