UNIVERSITI PUTRA MALAYSIA

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MASTER OF SCIENCE

UNIVERSITI PUTRA MALAYSIA

2010

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By

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

March 2010

Abstract of thesis presented to senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master in Science

OSMOTIC DEHYDRATION COMBINED WITH AIR DRYING OF RED PITAYA FRUIT CUBES

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ASSAL HAJ NAJAFI

March 2010

Chairman :Yus Aniza Yusof, PhD

Faculty : Engineering

The main objectives of this study are to investigate the effects of different temperatures on osmotic dehydration of red cubical pitaya fruit and subsequently physical quality evaluations, in developing dried pitaya cubes as a new healthy snack product. Two major steps were involved (i) an osmotic dehydration process was used as a pre-treatment and (ii) an air drying process in a cabinet dryer was used for further drying. The effect of sugar solution concentration (40, 50 and 60%), temperature (25, 30 and 35 ˚C) and air velocity (1 and 3 ms^{-1}) and also air temperature for the air drying process (40, 50 and 60 ˚C) were studied. Sampling was performed every 15 minutes for 2 hours, then at 4, 6, 24, 48 and 72 hours of immersion. Then pitaya slices were removed from the solution in order to investigate dehydration efficiency and equilibrium stage of dehydration. Osmotic dehydration kinetics was modelled according to Peleg, and Page equations. Both models were evaluated using two statistical measures, correlation coefficient, and root means square error. The statistical parameters (R^2 and RMSE) indicated that both models can predict good fitting with moisture content, weight reduction, and

sugar gain and water loss. But the best fitting for weight reduction and sugar gain were obtained using Peleg equation. The Page empirical model presented a good fit of the water loss experimental data.

Addition of sucrose to osmotic solutions decreased the driving force of the process and resulted in higher water loss and sugar gain. Colour saturation values increased, denoting colour intensification during the process of osmotic dehydration. Lightness of the pitaya cubes decreased as the sugar concentration increased. The greatest changes in Total Colour Difference of osmotic dehydrated samples occurred in 50 and 60% sugar solutions. An increase of concentration and passing time cause softer texture in product compared to the fresh pitaya. However, based on the air drying process, the best osmotic dehydration condition was a sugar concentration of 60% at 35 ˚C with a contact time of 2 hours. This treatment could remove more water of the samples, therefore air drying time reduced.

Pitaya samples were air dried in a cabinet dryer at 40, 50 and 60 ˚C with two different air velocities of 1 and 3 ms^{-1} for 8 hours. Among the pre-treatment conditions, the sucrose concentration, temperature and immersion time significantly ($p < 0.05$) influenced the air drying time. Osmotic dehydrated pitayas that were air dried at 60 ˚C showed a large moisture decline in the early drying periods similar with the drying rates of untreated samples. At the beginning of the drying process of fresh pitaya, drying rate was influenced by air temperature. Air dried samples at 40 ˚C showed lower drying rates attributed to sugars concentration on the outer layers of pitaya tissue and their crystallization during drying, but had better colour retention during drying. In the air dried osmotic dehydrated samples at 60 ˚C a greater texture hardening was observed.

The best product was obtained in the following operational condition: air temperature of 60 ˚C, air velocity of 1 and 3 ms^{-1} and contact time of around 5 hours (with 22.78% to 22.3% moisture content) for air drying. Because of the short time of drying these conditions help to improve colour and texture of the osmotic dehydrated pitaya cubes. This study provides an extensive understanding of osmotic dehydration of red cubical pitaya at lower temperatures. The results indicate that the process is feasible and may represent a new product for pitaya fruit.

Absrak tesis yang dikemukakan kepada senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENYAHHIDRATAN OSMOSIS BERGABUNG DENGAN PENGERINGAN UDARA KE ATAS KIUB BUAH NAGA MERAH

Oleh

ASSAL HAJ NAJAFI

March 2010

Pengerusi : Yus Aniza Yusof, PhD

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Tujuan utama kajian ini dijalankan adalah untuk mengkaji kesan perbezaan suhu pada penyahhidratan osmosis ke atas kiub buah naga merah dan seterusnya penilaian kualiti fizikal, dalam mempertingkatkan kiub buah naga kering sebagai salah satu produk makanan ringan yang sihat. Dua langkah utama yang terlibat ialah (i) proses penyahhidratan osmosis yang digunakan sebagai pra-eksperimen dan (ii) proses pengeringan udara di dalam kabinet kering sebagai proses pengeringan seterusnya. Kesan kepekatan larutan gula (40, 50 dan 60%), suhu (25, 30 dan 35%), dan halaju udara (1 dan 3 ms^{-1}) dan juga suhu udara dalam proses pengeringan (40, 50 dan 60 ^{o} C) telah dikaji. Sampel diuji setiap 15 minit dalam tempoh 2 jam. Kemudian pada 4, 6, 24, 48 dan 72 jam rendaman, hirisan buah naga dikeluarkan dari larutan untuk dikaji kecekapan dan tahap keseimbangan penghidratan. Kinetik penghidratan osmosis telah dimodelkan mengikut persamaan “Peleg” dan “Page”. Kedua-dua model dinilai menggunakan penilaian statistik, hubungan pemalar dan perbezaan punca kuasa dua. Parameter statistik (R^2 dan RMSE) menunjukkan kedua-dua model

boleh memberi hubungan yang baik dengan kelembapan, pengurangan berat, penambahan gula dan kehilangan air. Tetapi hubungan yang terbaik untuk pengurangan berat dan penambahan gula diperolehi menggunakan persamaan "Peleg". Secara empirikal, model "Page" menunjukkan hubungan yang baik dengan data eksperimen kehilangan air. Penambahan sukrosa kepada larutan osmosis telah menurunkan kuasa memandu proses dan menyebabkan peningkatan dalam kehilangan air dan penambahan gula. Nilai ketepuan warna meningkat, menandakan peningkatan warna berlaku dalam proses penghidratan osmosis. Kecerahan kiub buah naga menurun dengan peningkatan kepekatan gula. Perubahan terbesar dalam Jumlah Perbezaan Warna daripada sampel penghidratan osmosis berlaku pada 50 dan 60% larutan gula. Peningkatan kepekatan dan pemanjangan tempoh menyebabkan tekstur produk lembut berbanding buah naga segar. Namun demiluian, dengan berasasken proses pengeringan, keadaan penghidratan osmosis terbaik adalah kepekatan gula 60% pada suhu 35^{o}C dalam masa 2 jam. Keadaan ini boleh mengeluarkan lebih air dari sampel dalam seterusnya mengurangkan masa pengeringan udara.

Sampel kiub buah naga telah dikeringkan dalam kabinet pengering pada suhu 40,50 dan 60^{o}C pada dua jenis halaju udara 1 dan 3 ms^{-1} untuk tempoh 8 jam. Antara keadaan pra-eksperimen, kepekatan sukrosa, suhu dan tempoh rendaman mempengaruhi masa pengeringan udara dengan kepentingan ($p < 0.05$). Buah naga ternyahhidrat osmosis yang telah dikeringkan pada 60^{o}C menunjukkan penurunan kelembapan terbesar pada peringkat permulaan pengeringan dan kadar yang sama juga dilakukan pada sampel yang tidak ternyahhidrat. Pada permulaan proses pengeringan buah naga segar, kadar pengeringan mempengaruhi suhu udara. Sampel yang dikeringkan pada 40^{o}C menunjukkan kadar pengeringan terendah disebabkan

kepekatan gula pada permukaan luaran buah naga dan penghabluran semasa pengeringan, tetapi mempunyai pengekalan warna terbaik semasa pengeringan. Sampel ternyahhidrat osmosis yang telah dikeringkan pada 60^{o}C didapati teksturnya telah mengeras.

Produk terbaik telah diperolehi melalui keadaan operasi seperti berikut: suhu udara pada 60^{o}C, halaju udara di antara 1 dan 3 ms^{-1} dalam tempoh masa selama 5 jam (22.78 sehingga 22.3 kelembapan) untuk proses pengeringan udara. Ini disebabkan, pengeringan dalam tempoh masa yang singkat dapat membantu memperbaiki warna dan tekstur kiub buah naga yang ternyahhidrat secara osmosis. Kajian ini menyediakan pemahaman yang mendalam tentang penyahhidratan osmosis ke atas kiub buah naga merah pada suhu rendah. Keputusan kajian telah menunjukkan proses ini boleh dilaksanakan dan boleh dijadikan sebagai alternatif baru dalam pengeluaran produk buah naga.

ACKNOWLEDGEMENTS

I pray to Almighty ALLAH who give me the thoughts, the will, and guided me to complete this work. I pray that ALLAH will bless this work and make it useful for mankind, and that He will forgive us.

My sincere and deepest gratitude to Dr.Yus Aniza Yusof, the chairman of my supervisory committee for her guidance, encouragement, patience and continuous follow up during the course of this study. My appreciation and gratitude is also extended to members of my supervisory committee, Professor Dr Russly Abdul Rahman and Dr. Chin Nyuk Ling for their advice, punctuate comments and support. My gratitude is also due to all the staff of the Faculty of Food Science and Technology, UPM for their cooperation. My special appreciation is extended to my friends for their kind help and friendly attitude.

I would also like to give my thanks to my dearest husband, Hadi Mohammad Zadeh who brightens my life with his support, encouragement, sacrifice and patience.

Last but not least, I must express my deepest gratitude to my wonderful parents who continuously encouraged me and presented me the most beautiful World. At the same time, I would also like to thank my family for all supports throughout this period.

I certify that a Thesis Examination committee has meet on 31.March.2010 to conduct the final examination of Assal Haj Najafi on her thesis entitled "Osmotic Dehydration Combined with Air Drying of Red Pitaya Fruit Cubes" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1988. The committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master with dissertation.

The members of the supervisory were as follows:

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Date: 15 July 2010

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 institution.

Assal Haj Najafi

Date: 3 June 2010

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