UNIVERSITI PUTRA MALAYSIA

EFFECTS OF HOT-AIR DRYING ON PHYSICOCHEMICAL CHARACTERISTICS, FLAVOUR PROFILES AND SENSORY ACCEPTANCE OF *Citrus hystrix* AND *Etlingera elatior* Jack

NURUL HANISAH JUHARI

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By

NURUL HANISAH JUHARI

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

June 2012

Especially dedicated to my beloved parents, my family and also my husband. Thank you for your unconditional support with my studies. Thank you for believing in me; for allowing me to further my studies. Please do not ever doubt my dedication. I love you.

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

EFFECTS OF HOT-AIR DRYING ON THE PHYSICOCHEMICAL CHARACTERISTICS, FLAVOUR PROFILES AND SENSORY ACCEPTANCE OF *Citrus hystrix* AND *Etlingera elatior* Jack

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Chair: Associate Professor Lasekan Olusegun, PhD

Faculty: Food Science and Technology

Herbs and spices play important roles in Malay cuisine. The usage of kaffir lime (*C. hystrix*) leaves and torch ginger (*E. elatior*) are not only limited to the addition of flavour and enhancement of palatability of food but they also act as antioxidants. Both herbs were grown for both flavouring and medicinal purposes. However, this herb is highly perishable in nature, have short shelf life and deteriorate rapidly after harvesting that leads to loss of flavour and quality. So, drying is an important technology for preserving the product quality and also preventing the spoilage of the product during storage. Thus, this study was conducted to optimize the effects of hot-air drying conditions (drying time, drying temperature and loading capacity) on physicochemical characteristics (moisture content, water activity, texture and colour) of *C. hystrix* and *E. elatior* that could be used for a high food grade spicing material. Secondly, the flavour profiles of *C. hystrix* and *E. elatior* were determined between fresh and optimally dried herbs. The herbs inclusion/infusion parameters levels (size, temperature and concentration of

herbs) on sensory acceptance of Vichyssoise soup and sorbet were also optimized. The results showed that the best response for torch ginger, within the range studied, was reached when the drying time was 4.1 h, the drying temperature, 79 °C and loading capacity, 0.7 kg/m^2 respectively. On the other hand, the overall optimum conditions that resulted in desirable dried kaffir lime leaves, was achieved when the drying time was 4.9 h, the drying temperature, 60 °C and loading capacity, 1.4 kg/m^2. No significant ($p>0.05$) difference was found between the experimental and predicted values, thus ensuring the adequacy of the response surface models employed for describing the effects of hot-air drying on physicochemical properties of torch ginger and kaffir lime leaves. At the second stage, liquid-liquid solvent extraction was employed to extract flavour compounds of the samples which were analyzed using Gas Chromatography (GC) and Gas Chromatography-Mass Spectrometry (GC-MS) with DB-5, BPX-5 as well as Quadrex007CW columns. The finding from GC and GC-MS revealed that fresh torch ginger contained 91 volatile compounds while optimally dried torch ginger contained 104 volatile compounds using Quadrex007CW column. However, only 54 volatile compounds of fresh torch ginger and 147 volatile compounds of optimally dried torch ginger were obtained using DB-5 column. The major aroma components in both fresh and optimally dried torch ginger were alcohol, ester, alkane, carboxylic acid, ketone and aldehyde. A total of 45 compounds were identified in fresh kaffir lime leaves as compared to 41 compounds in optimally dried kaffir lime leaves using BPX-5 column. However, a total of 66 compounds were determined in fresh kaffir lime leaves and 40 compounds in optimally dried kaffir lime leaves using DB-5 column. Monoterpenes and sesquiterpenes were found to be major components. Finally, the herbs inclusion/infusion parameters levels [size of herbs (2-100 mm), concentration of herbs (3-15 g/L) and temperature of inclusion (25-100 °C)] in different types of food systems (liquid and semi

solid) were determined. Sensory evaluations using 50 untrained panelists were utilized to assess colour, aroma, taste and overall acceptability of products. The results from sensory evaluation showed that vichyssoise soup flavoured with optimally dried *C. hystrix* leaves were more highly preferred by panelist compared to vichyssoise soup flavoured with optimally dried *E. elatior* while sorbet flavoured with optimally dried *C. hystrix* were highly preferred by panelist compared to sorbet flavoured with optimally dried *E. elatior*. This study has significantly contributed to the establishment of standardized measurements for the amount of herbs required for various kinds of foods. Potentially, this study also yields herbs that reaches international specification standard and enables worldwide export of Malaysian herbs.

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

KESAN PENGERINGAN UDARA PANAS KE ATAS CIRI-CIRI FIZIKOKIMIA, PROFIL PERISA DAN PENERIMAAN SENSORI BAGI *Citrus hysrix* DAN *Etlingera elatior* Jack

Oleh

NURUL HANISAH JUHARI

Jun 2012

Pengerusi: Prof. Madya Lasekan Olusegun, PhD

Fakulti: Sains dan Teknologi Makanan

Herba dan rempah memainkan peranan penting dalam hidangan Melayu. Penggunaan daun limau purut (*C. hystrix*) dan bunga kantan (*E. elatior*) tidak hanya terhad kepada tambahan perasa dan peningkatan kesedapan makanan tetapi juga bertindak sebagai antioksidan. Kedua-dua herba ini ditanam untuk kegunaan perasa makanan dan perubatan. Bagaimanapun, herba ini amat mudah rosak di alam semula jadi, mempunyai tempoh simpanan yang pendek dan rosak dengan cepat selepas menuai yang membawa kepada kehilangan perasa dan kualiti. Jadi, pengeringan ialah satu teknologi penting untuk mengekalkan kualiti produk dan juga mencegah kerosakan produk semasa penyimpanan. Oleh itu, kajian ini dijalankan untuk mengoptimumkan keadaan pengeringan udara panas (masa pengeringan, suhu pengeringan dan kapasiti pembebanan) ke atas ciri-ciri fizikokimia daun limau purut dan bunga kantan yang boleh digunakan sebagai bahan rempah makanan bergred tinggi. Kedua, profil perasa telah ditentukan diantara herba yang segar dengan herba yang telah dikeringkan secara optimum. Tahap-tahap parameter kemasukan

herba optimum (saiz, suhu dan kepekatan herba) ke atas penerimaan sensori sup Vichyssoisse dan 'sorbet' juga telah ditentukan. Keputusan menunjukkan respon yang terbaik untuk bunga kantan, dalam julat yang dikaji, telah dicapai apabila masa pengeringan ialah 4.1 j, suhu pengeringan, 79 °C dan kapasiti pembebanan, 0.7 kg/m^2 masing-masing. Sebaliknya, keadaan pengeringan optimum yang menyeluruh bagi daun limau purut, telah dicapai apabila masa pengeringan ialah 4.9 j, suhu pengeringan, 60 °C dan kapasiti pembebanan, 1.4 kg/m^2. Tiada perbezaan yang signifikan ($p>0.05$) telah didapati antara nilai percubaan dan nilai ramalan, demikian menjamin kecukupan model permukaan gerak balas yang telah diguna untuk menggambarkan kesan pengeringan udara panas ke atas ciri-ciri fizikokimia bunga kantan dan daun limau purut. Pada peringkat kedua, pengekstrakan pelarut cecair-cecair digunakan untuk menganalisis sebatian perasa menggunakan Kromatografi Gas (GC) dan Kromatografi Gas-Spektrometri Jisim (GC-MS) dengan menggunakan lajur DB-5, BPX-5 dan Quadrex007CW. Penemuan dari GC and GC-MS mendedahkan bahawa bunga kantan segar mengandungi 91 sebatian mudah meruap berbanding bunga kantan yang dikeringkan secara optimum yang mengandungi 104 sebatian mudah meruap setelah menggunakan lajur Quadrex007CW. Walau bagaimanapun, terdapat hanya 54 sebatian mudah meruap bagi bunga kantan segar dan 147 sebatian mudah meruap bagi bunga kantan yang dikeringkan secara optimum setelah menggunakan lajur DB-5. Komponen-komponen aroma utama dalam kedua-dua bunga kantan segar dan juga bunga kantan yang dikeringkan secara optimum ialah alkohol, ester, alkana, asid karboksilik, keton dan aldehid. Sejumlah 45 sebatian telah dikenal pasti dalam daun limau purut yang segar berbanding 41 sebatian dalam daun limau purut yang dikeringkan secara optimum setelah menggunakan lajur BPX-5. Walau bagaimanapun, sejumlah 66 sebatian telah ditentukan untuk daun limau purut yang segar dan 40 sebatian untuk bunga kantan yang dikeringkan secara

optimum setelah menggunakan lajur DB-5. Monoterpena and sesquiterpena telah didapati sebagai komponen utama. Akhirnya, tahap-tahap kemasukan herba optimum [saiz herba (2-100 mm), kepekatan herba (3-15 g/L) dan suhu kemasukan (25-100 °C)] ke dalam sistem makanan yang berbeza (cecair dan separuh pepejal) telah ditentukan. Penilaian deria menggunakan 50 ahli panel tidak terlatih telah digunakan untuk menilai rupa, aroma, rasa dan kebolehterimaan menyeluruh produk. Hasil daripada penilaian sensori menunjukkan bahawa sup vichyssoise berperisa limau purut lebih diterima oleh ahli panel berbanding sup vichyssoise berperisa bunga kantan manakala sorbet berperisa limau purut juga lebih digemari oleh ahli panel berbanding sorbet berperisa bunga kantan. Kajian ini berupaya menyumbang secara signifikan kepada pembentukan piawaian ukuran jumlah untuk herba ke dalam pelbagai jenis makanan. Kajian ini juga berpotensi untuk menghasilkan herba yang telah dikering setanding spesifikasi antarabangsa dan membolehkan herba-herba Malaysia dieksport ke seluruh dunia.

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Last but not least, I would like to express thousand thanks to my colleagues, who have been directly or indirectly helping me to complete this project successfully.

I certify that a Thesis Examination Committee has met on 11 June 2012 to conduct the final examination of Nurul Hanisah Juhari on her thesis entitled "**Effect of Hot-air Drying on Physicochemical Characteristics, Flavour Profiles and Sensory Acceptances of *Citrus hystrix* and *Etlingera elatior* Jack**" 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.

Members of the Thesis Examination Committee were as follows:

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This thesis was submitted to the Senate of university Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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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.

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NURUL HANISAH JUHARI

Date: 11 June 2012

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LIST OF ABBREVIATIONS

AIA	Acid Insoluble Ash
amu	Atomic mass unit
ANOVA	Analysis of Variance
AOAC	Association of Analytical Chemists
ASTA	American Spice Trade Association
A_w	Water activity
°C	Celsius
cm	Centimeter
CCD	Central Composite Design
eV	Electronvolt
ESA	European Standard Association
Eq.	Equation
g	Gram
GC	Gac chromatography
GC-MS	Gas Chromatography – Mass Spectrometry
HCl	Hydrochloric acid
hr	Hour
ICMSF	International Commision on Microbiological Specifications for Foods
ISO	International Standard Organization
kg	Kilogram
LD	Loss on drying
LOD	Limit of detection
LOL	on-line linearity
LOQ	Limit of quantification

min	Minute
m^2	Meter square
mg	Milligram
mm	Millimeter
µm	Micrometer
µl	Micro liter
MS	Mass – Spectrometry
N	morality
NIST	National Institute of Standards and Technology
R^2	Coefficient of determination
RSD	Relative standard deviation
RSM	Response surface methodology
SD	Standard deviation
SDE	Simultaneous Distillation - Extraction
V/O	Volatile oil
W	Watt
wt	Weight
w/w	Weight per weight
3D	Three-dimensional
%	Percentage

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