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LIST OF ABBREVATIONS

%	Percentage
A. graveolens	*Anethum graveolens*
A. deliciosa	*Actinidia deliciosa*
A. drancunculus	*Artemisia drancunculus*
A. paniculata	*Androgaphis paniculata*
A.sativum	*Allium sativum*
ANOVA	Analysis of variance
ASAE	American Society of Argicultural Engineers
a_w	Water activity
BET	Brunauer, Emmett and Teller
C. sinensis	*Citrus sinensis*
CAE	Caffiec acid equivalent
CIE	International Commision of Illumination
d.b	dry basis
D_{eff}	Effective Diffusitivity
df	Degree of freedom
D_o	Arrhenius factor
DR	Drying rate

E. longifolia	*Eurycoma longifolia*
E. purpure	*Echinacea purpure*
E_a	Activation Energy
EMC	Equilibrium Moisture Content
ERH	Equilibrium Relative Humidity
ETP	Economic Transformation Programme
exp	Exponential
F. detoldea	*Ficus detoldea*
F. ulmaria	*Filipendula ulmaria*
FC	Follin-Ciocalteu's
g	gram
GAB	Guggenheim-Anderson-de-Boer
GACP	Guidelines of Collection Procedures for medicinal plants
h	hour
H. sabdariffa	*Hibiscus sabdariffa*
HPLC	High Performance Liquid Chromatography
I. edulis	*Inga edulis*
i.d	internal diameter
ISOPOW	International Symposium on the properties of Water

JMP	John’s Macintosh Project
K	Kelvin
kJ	Kilo joule
kmol	Kilo mole
L	half thickness lenght
L. pumila	*Lubiasa pumila*
ln	natural log
LSD	Least square different
m	meter
M. acuminata	*Musa acuminata*
M. cordifolia	*Mentha cordifolia*
M. crispa	*mentha crispa*
M. officinalis	*Melissa officinalis*
M. piperita	*Mentha piperita*
M. saltiva	*Medicago saltiva*
M. spicata	*Mentha spicata*
m/s	meter per second
m^2	meter square
M_c	Critical moisture content

MC	Moisture content
MC_f	final moisture content
mg	miligram
Mg^+	Magnesium ion
min	minute
ml/ min	mililiter per minute
mm	milimeter
M_o	Monolayer moisture content
MOA	Monistry of Agricultural
MR	Moisture ratio
MS	Mean square
N	umber of observation
N: P: K	Nitrogen: Phosporus: Kalium
NAP	First National Agricultural Policy
NAP3	Third National Agricultural Policy
NKEA	National Key Economic Area
nm	nanometer
O. basilicum	*Ocimum basilicum*
O. stamineus	*Orthosiphon stamineus*

O.europea	*Olea europea*
^{o}C	Degree of Celcius
P	Percent error
P. armenica	*Prunus armenica*
P. crispum	*Petroselinum crispum*
P. niruri	*Phyllanthus niruri*
P. quinquefolium	*Panax quinquefolium*
PPO	Polyphenol oxidase
P_V	water vapour pressure
P-value	Probability
P_V^{o}	Vapour pressure of pure water at saturation
r	Coefficient of correlation
R	Universal gas constant
R. officinalis	*Rosmarinus officinalis*
RA	Rosmarinic acid
RH	Relative Humidity
RMSE	Root mean square error
RP	reverse phase
rpm	rotation per minute

S. alba	*Salix alba*
S. officinalis	*Salvia officinalis*
S. thymbra	*Satureja thymbra*
SE	Standard error
SEN	Sinensetin
SS	Sum of square
T	Temperature
T. daenensis	*Thymus daenensis*
TMF	3’ hydroxy -5, 6, 7, 4’ tetramethoxyflavone
TPC	Total phenolic content
T_R	Absolute temperature of radiating surface
T_s	Surface temperature
U. dioica	*Urtica dioica*
UV	Ultra violet
V. album	*Viscum album*
v/v	volume per volume
vis	visible
W	Watt
w.b	wet basis

w_{dm}	Weight of dry matter
w_f	Final weight
WHO	World Health Organization
y_{exp}	Experimental data
y_{pre}	Predicted data
μm	micrometer

LIST OF SYMBOL

L*	Brightness
a*	Greenneess to yellowness
b*	Yellowness to blue
A,B,C,D	Constant parameter for moisture sorption model
a, b, c, d, n	Constant parameter for thin layer drying models
k	Drying rate constant
β	beta
χ^2	chi-squared
π	pi
Q	Heat
Q_s	Excess binding energy
J_A	Flux of diffusion per unit area of section
D	Diffusion coefficient
C_A	Concentration of diffusing substance
x	Space coordinate measured normal to the section
Q_c	Amount of heat transfer by convection
Q_k	Amount of heat transfer by conduction

Q_R	Amount heat transfer by radiation
U_k	Conduction heat transfer coefficient
h_c	Convection heat transfer coefficient
h_R	Radiation heat transfer coefficient
T_R	Absolute temperature of radiating surface

Ciri-Ciri Pengeringan Lapisan Nipis Dan Kesan Pengeringan Terhadap Kandungan Bahan Aktif Di Dalam Daun Herba Misai Kucing (*Orthosiphon stamineus*)

ABSTRAK

O. stamineus atau misai kucing merupakan tumbuhan herba yang terkenal sebagai ubatan tradisional di Malaysia dan juga negara-negara Asia Tenggara. Herba ini dipercayai dapat mengubati penyakit berkaitan keracunan saluran kencing, batu karang dan pelbagai penyakit lain. Oleh kerana herba misai kucing biasanya disimpan dan digunakan di dalam keadaan kering, maka pengetahuan tentang ciri-ciri pengeringan daun misai kucing sangat penting. Kajian tentang ciri-ciri pengeringan lapisan nipis daun misai kucing termasuklah sifat-sifat penjerapan dan penyerapan kelembapannya, kinetik pengeringan dan kesan-kesan pengeringan terhadap kualiti akhir daun kering tersebut. Pengetahuan yang secukupnya tentang ciri-ciri pengeringan ini dapat menyelesaikan beberapa masalah di dalam pengurusan daun misai kucing kering di mana pengeringan yang baik memanjangkan tempoh simpanannya. Ini boleh mengurangkan masa pengeringan, mengelakkan kehilangan jisim, risiko kerosakan bahan-bahan aktif, dan menjimatkan penggunaan tenaga. Di dalam projek ini, kajian tentang sifat-sifat penjerapan dan penyerapan kelembapan dilakukan pada suhu 5 ^{o}C dan 30 ^{o}C dan pada lima tahap kelembapan relatif udara di antara 11.3% hingga 75.7% menggunakan teknik gravimetrik statik. Manakala, ciri-ciri pengeringan lapisan nipis daun misai kucing pulak dikendalikan pada suhu 30, 40 dan 50 ^{o}C dan pada kelajuan udara 0.8 dan 1.3 m/s. menggunakan alat pengering udara panas yang difabrikasi. Perbandingan di antara data eksperimen dan data anggaran bagi kedua-dua bahagian kajian di atas dilakukan menggunakan kaedah model matematik oleh perisian statistik khas. Kaedah model matematik ini menggunakan lima model-model ternama di dalam penjerapan dan penyerapan kelembapan iaitu Oswin, Peleg, Guggenheim-Anderson-de-Boer (GAB), Brunauer, Emmett, & Teller (BET) dan Chung & Pfost models dan tujuh model-model pengeringan lapisan nipis yang biasa digunakan di dalam kajian-kajian seperti ini iaitu Lewis, Page, Modified Page, Handerson & Pabis, Midili & Kucuk, Two Term Exponential dan Wang & Singh. Kualiti warna daun kering, kandungan fenolic total dan kepekatan bahan bioaktif penunjuk misai kucing (iaitu RA, SEN dan TMF) ditentukan di mana ini digunakan untuk mewakilkan kualiti akhir daun kering tersebut. Penemuan lengkung isoterma penjerapan dan penyerapan kelembapan daun misai kucing menunjukkan ianya mempunyai bentuk jenis lll (bentuk J). Perbandingan di antara data eksperimen dan data anggaran menunjukkan lengkung isoterma penjerapan dan penyerapan kelembapan menghampiri data anggaran oleh model Peleg, manakala untuk kinetik pengeringan lapisan nipis daun misai kucing pula, data eksperimen lebih mirip kepada data anggaran oleh model Midili & Kucuk. Hasil penemuan kajian menunjukkan pengeringan lapisan nipis daun misai kucing berlaku pada fasa kadar menurun sahaja. Tempoh pengeringan pula berkurang apabila suhu dinaikkan, di mana kadar pengeringan meningkat. Kelajuan udara pengeringan tidak menunjukkan kesan yang signifikan terhadap kadar pengeringan untuk semua keadaan. Semua keadaan pengeringan yang dipilih menunjukkan kesan yang signifikan terhadap kualiti warna daun kering, kandungan fenolic total dan kepekatan RA, SEN dan TMF di dalam ekstrak daun kering ($P<0.05$). Kualiti warna daun kering, kandungan fenolik total dan kepekatan RA berkurang apabila suhu dinaikkan. Manakala, kepekatan SEN dan TMF pula menunjukkan kandungan paling tinggi pada suhu 40 ^{o}C. Kesimpulannya, suhu 40 ^{o}C dan kelajuan udara 0.8 m/s dicadangkan sebagai keadaan pengeringan optimum untuk daun misai kucing. Untuk kajian pada masa hadapan, adalah disyorkan supaya pengajian ini diteruskan untuk mengkaji kesan-kesan faktor dalaman sampel iaitu suhu daun, kandungan kelembapan dan struktur daun terhadap ciri-ciri pengeringan daun misai kucing.

Thin Layer Drying Characteristics And Herbal Bioactive Compounds Of Misai Kucing Plant (*Orthosiphon Stamineus*) Leaves

ABSTRACT

O. stamineus or locally known as misai kucing is a Malaysian herbal plant, popular as a traditional medicine especially in the Southeast Asian region. It is believed to treat urinary tract diseases, kidney stones and many other human illnesses. Since this herb is stored and consumed in its dried form, knowledge of thin layer drying characteristics is important. The thin layer drying characteristics studies included moisture sorption behavior, drying kinetics and effects of drying conditions on final quality of *O. stamineus* leaves. Adequate knowledge of the drying characteristics provides appropriate final samples moisture content, thus decreases drying time, mass losses, risk of quality degradation, and reduces energy consumptions. In this work, the moisture sorption behavior was studied by developing moisture sorption isotherms at temperatures of 5 ^{o}C and ambient (about 30 ^{o}C) and at 5 levels of relative humidity ranging from 11.3 % to 75.7 % by a static gravimetric method. The thin layer drying characteristics of *O. stamineus* were evaluated at temperatures of 30, 40 and 50 ^{o}C and at air velocities of 0.8 and 1.3 m/s using a fabricated laboratory scale hot air dryer. A mathematical modeling was performed using a statistical software package to compare experimental data with predicted data for both moisture sorption isotherms and drying kinetics. Five widely used moisture sorption models, namely Oswin, Peleg, Guggenheim-Anderson-de-Boer (GAB), Brunauer, Emmett, & Teller (BET) and Chung & Pfost models and seven widely used thin layer drying models, namely Lewis, Page, Modified Page, Handerson & Pabis, Midili & Kucuk, Two Term Exponential and Wang & Singh were chosen. Color quality, total phenolic content and biomarker compounds (i.e. RA, SEN and TMF) concentration were determined to represent the final dried leaves quality. The moisture sorption isotherms of *O. stamineus* were found to be of Type III isotherm (J-shaped).The comparison between the experimental data and the predicted data of the moisture sorption isotherms was found to be closely followed the Peleg model, whereas, the thin layer drying kinetics closed to the Midili & Kucuk model. The thin layer drying of *O. stamineus* leaves took place in a falling rate period only. The drying time reduced as the air temperature increased, thus increased the drying rate. The air velocity showed no significant effect of the drying rate for the drying conditions. All the drying treatments showed a significant effect on the color quality, total phenolic content, RA, SEN and TMF concentrations of the dried *O. stamineus* leaves ($P<0.05$). The color quality, total phenolic content and RA concentration reduced at increasing of the air temperatures. However, the SEN and TMF concentrations depicted the highest values in samples dried at 40 ^{o}C. As a conclusion, drying conditions of 40 ^{o}C and 0.8m/s is suggested as optimum conditions for the drying of *O. stamineus* leaves. It is also recommended that for the future works, the studies could be extended to the effects of internal drying conditions such as products' temperature, moisture content and structures on the drying characteristics of *O. stamineus* leaves.