EVALUATION OF MOISTURE DIFFUSIVITY IN COPRA AT DIFFERENT DRYING CONDITIONS

Agampodi Radeesha Laknath Mendis

(158033M)

Degree of Master of Science

Department of Chemical and Process Engineering

University of Moratuwa
Sri Lanka

December 2017

EVALUATION OF MOISTURE DIFFUSIVITY IN COPRA AT DIFFERENT DRYING CONDITIONS

A.R.L.Mendis

(158033M)

Thesis/Dissertation submitted in partial fulfillment of the requirements for the degree
Master of Science

Department of Chemical and Process Engineering

University of Moratuwa
Sri Lanka

December 2017

Declaration

I declare that this is my own work and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any University or other institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text”

Signature:………………………………… Date:……………………….

Copyright Statement

I hereby grant the University of Moratuwa the right to archive and to make available my thesis or dissertation in whole or part in the University Libraries in all forms of media, subject to the provisions of the current copyright act of Sri Lanka. I retrain all proprietary rights, such as patent rights. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation.

Signature:………………………………… Date:……………………….

I have supervised and accepted this thesis/dissertation for the award of the degree

Signature of the Supervisor:………………………. Date:……………………….

Dr. A.D.U.S. Amarasinghe
Senior Lecturer
Department of Chemical and Process Engineering
University of Moratuwa

Signature of the Co- Supervisor:………………………Date:……………………….

Dr. M. Narayana
Senior Lecturer
Department of Chemical and Process Engineering
University of Moratuwa

Abstract

Copra is one of the major traditional products processed from coconuts and is used primarily as a source of coconut oil. It is the kernel of coconut after reducing the moisture content from about 50% (dry basis) to about 6% (dry basis) by drying. Traditional drying processes are vastly used in manufacturing of copra and that has created many quality problems leading to hygienic and health issues which can be minimized by using controlled drying techniques. Controlled drying is also a primary requirement in producing edible copra and premium products like virgin coconut oil.

Accurate prediction of moisture diffusivity of porous materials like food under given conditions is important in analysing the drying process. In this study drying behaviour of copra was examined and two methods were suggested to predict the moisture diffusivity of copra. In the first method, the moisture diffusivity of copra was determined for the first and second falling rate periods. A critical moisture content of 30% (dry basis) was identified as the probable limit between the first and second falling rate periods. A computational fluid dynamic model was used to fine-tune the system parameters with experimental data and the effective moisture diffusivity values at 55 ºC for first and second falling rate periods were found to be 1.10×10^{-8} and 1.99×10^{-9} m^2s^{-1} respectively.

In the second method, moisture diffusivity of copra was found as a function of drying temperature and dry basis moisture content. Drying experiments were performed for seven different temperatures in the range of 45 – 75 ºC to obtain drying curves of copra. The moisture diffusivity was found to be an exponential function of moisture content where the model parameters were linearly varied with temperature. Further the volume shrinkage of copra was linearly correlated with moisture content. A three-dimensional numerical model was developed to predict the spatial distribution of moisture inside the copra using computational fluid dynamics (CFD) with OpenFOAM software. Results of the spatial moisture distribution were graphically presented. The results of simulation were in agreement with the experimental observations and the optimum temperature for drying of copra was found to be about 60 ºC for 20 hours of drying time.

Keywords: Copra drying, Moisture diffusivity, Numerical simulation

Acknowledgement

Completion of this thesis has been one of the most significant academic challenges I have ever had encounter. Without the support, patience and guidance of the following people, this task would not have been accomplished. It is to them that I owe my deepest gratitude.

I am really thankful to my main supervisor Dr.A.D.U.S.Amarasinghe and co-supervisor Dr.M.Narayana for giving me their fullest support from the beginning. Their advices and guidance were always helpful to me to complete this study. I am grateful to Dr P.G.Rathnasiri former Head of the Department of Chemical and Process Engineering for giving me the opportunity to do the M.Sc in the department. This research work was supported by University of Moratuwa Senate Research Grant Number SRC/LT/2015/10 and it was great financial encouragement for my research work.

I would like to express my deep gratitude to Mrs. Poorasinghe (Director Quality Assurance division of CDA) and Mr Ashoka Pushpakumara (Assistant Director Quality Assurance division of CDA) for giving me required information on the field of study.

Next, I must mention that support I received from my friends. Mr. Niranjan Fernando and Mr.Kasun Udana supported me much on finding required information in my research area. Mr. Kasun Anuranga, Ms Imalsha Abaysooriya, Mr. M. H. K. Chithalka, Mr. S. L. M. Mudalige, Mr. Kasun Samarasiri and Mr. Charith Bandara helped me much during experimental works. I place on record my sense of gratitude to them for their tremendous support which has offered me great convenience during my works.

I wish to express my thanks to the laboratory staff of Department of Chemical and Process Engineering, University of Moratuwa for their helps during my lab works. I would like to convey special thanks to the technical officers, Mr. Jayaweera and Miss. Dinooshi for their assistance during laboratory works.

Last but not least I wish to avail myself of this opportunity, express a sense of gratitude and love to my beloved parents and sisters for their manual support, strength, helps and for everything throughout my life.

Contents

List of Figures

List of Tables

Nomenclature

$C_{p,a}$	*Specific heat capacity of air*
D_{bin}	*water vapor diffusivity in dry air*
D_w	*Diffusion coefficient of water*
h_t	*Convective heat transfer coefficient*
I	*Evaporation rate*
J	*Volume shrinkage*
k_a	*Thermal Conductivity of air*
K_{evp}	*Evaporation rate constant*
K_m	*Convective mass transfer coefficient*
k_v	*Thermal Conductivity of vapor*
L	*Characteristic length*
n	*flux*
P	*Atmospheric pressure*
P_r	*Prandtl number*
P_{sat}	*Saturation vapor pressure*
R_e	*Reynolds number*
r	*Drying rate*
t	*time*
T_s	*Absolute temperature of solid phase*
U_a	*Velocity of air*
U_w	*Velocity of water*
V_0	*Initial volume*
V_t	*Volume at time t*
X	*Moisture content (%(w/w) Dry basis)*
X_e	*Equilibrium Moisture Content*
X_g	*Gas phase moisture*
X_0	*Initial Moisture Content (%(w/w) Dry basis)*
Greek letters	
ρ_a	*Density of air*
ρ_{amb}	*Ambient vapor density*
ρ_v	*Density of vapor*
$\rho_{v,eq}$	*Equilibrium vapor density*
ρ_w	*Density of water*
φ	*Porosity-function of moisture*
μ	*Viscosity of water*