MODELLING THE DRYING KINETICS OF MICROWAVE DRYING OF COCONUT CHIPS

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Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science

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Abstract

Drying of coconut chips has been of interest for research due to the commercial value of coconut oil and desiccated coconut. More recently the industry has called for cost effective solutions for the drying unit operation of coconut chips used in the production of virgin coconut oil and desiccated coconut. This study was carried out to identify the parameters on which microwave assisted coconut drying kinetics were impacted and a mathematical model was developed to predict the microwave assisted drying behaviour of coconut chips. Drying time of coconut was found to depend on the microwave power and the mass loading when external parameters such as air velocity, air humidity, and shape factors of the coconut chips were kept constant. The drying behaviour was accurately predicted by several thin layer drying models and the Page model was selected due to its accuracy and simplicity. A new model was proposed to represent the parameters of the Page model as a function of microwave power. The proposed new model is given by, $MR = exp(\, a.exp\left(\frac{M}{P}\right).t^{(c.P+0.6)})$ where, a = -0.07 min^{-1}, M=37.29 Js^{-1} and c = 0.0007 sJ^{-1}. Parameter *t* (time) needs to be substituted in minutes and *P* (power) in watts (W).

Moreover, the impact of mass loading was found to be effective only when the ratio of microwave power to mass loading (MPML) factor exceeded a value of about 3.7 Wg^{-1}. Under this condition, the diffusivity per unit of microwave power was found as 1.31×10^{-11} $m^2s^{-1}W^{-1}$. A sharp decrease in the drying rate was observed when the moisture content approached approximately 30 % (w/w dry basis), indicative of changing from the removal of free moisture to removal of bound moisture. The quality of the desiccated coconut and virgin coconut oil were analysed based on the standards stipulated by the Sri Lanka Standards Institute and Coconut Development Authority. A process development road map was proposed based on the drying kinetics, rehydration ratio, cooling time and maximum temperature to meet the quality requirements.

Keywords: Model for drying, Desiccated coconut, Microwave drying kinetics, Drying rate, Drying technology

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"*It is the supreme art of the teacher to awaken joy in creative expression and knowledge"*

– Albert Einstein

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NOMENCLATURE

Symbol/ Abbreviation	Description
$P_{v,s}$	Water vapour pressure at the surface
$P_{v,a}$	Water vapour pressure of the ambient
P_v	Vapour pressure
T	Temperature
DR	Rate of drying (min^{-1})
MR	Moisture ratio

m	Mass of wet solid (g)
A	Surface area of solid perpendicular to airflow direction (m^2)
X	Moisture content (w/w dry basis)
t	Time (minutes)
V_p	Velocity of propagation
ε'	Dielectric constant
C	Speed of light in air
ε"	Dielectric loss factor
V	Volume
S	Shrinkage
P	Microwave power (W)
D_{eff}	Effective Diffusivity
MPML	Microwave power per mass loading (Wg^{-1})
DC	Desiccated Coconut
VCO	Virgin Coconut Oil