DRYING KINEICS OF COIR PITH AND THE PERFORMANCE IN FLASH DRYING

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Degree of Master of Philosophy

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STATEMENT OF AUTHORSHIP

I do declare that this is my own work and this thesis does not incorporate any material previously submitted for a Degree or Diploma in any other University or Institute of higher learning to the best of my knowledge without due acknowledgement and I do believe it does not contain any material previously published or written by me or any other person except where the acknowledgement is made in the text.

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DEDICATION

Dedicated to my family members

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ABSTRACT

Drying and retting can be identified as the most important factors affecting the quality variations in dried coir pith which directly affects the final quality of compressed coir pith products. A pilot scale flash dryer was designed and fabricated to examine the effect of hot air temperature and velocity on the drying behavior of coir pith. Hot air drying was carried out to examine the drying kinetics by allowing the coir pith particles to fluidize and circulate inside the drying chamber. The physico-chemical properties of volume expansion ratio (VE), water retention capacity (WRC), bulk density, pH and electrical conductivity (EC) of compressed coir pith discs were measured. Scanning electron microscopy was used to analyze the microstructures of dried coir pith. The results were compared with the two other drying techniques namely sun drying and oven drying. The effect of time duration for retting and the method of retting the coconut husk were also examined.

The optimum temperature for coir pith drying was found to be 140 °C. The most suitable range of particle size and the range of moisture content in dried coir pith were identified as 0.5 – 6.3 mm and 12 - 23% (w/w, dry basis) respectively. The VE, WRC, pH and EC of coir pith dried in the flash dryer at the optimum temperature of 140 °C was found to be 5.01 ± 0.21, 4.02 ± 0.10 (w/w), 5.95 ± 0.08 and 330 ± 16 µs/cm respectively. These values were comparable with those of the sundried coir pith. Oven drying caused rupturing the cells and case hardening of coir pith. Similar effect was observed with temperatures > 140 °C for hot air drying and flash drying. VE and WRC of coco discs were found to increase significantly, pH to change marginally and EC to drop significantly with the increase of retting time.

The effective moisture diffusivity was found to increase from 1.18×10^{-8} to 1.37×10^{-8} m^2/s with the increase of hot air velocity from 1.4 to 2.5 m/s respectively. Correlation analysis and residual plots were used to determine the adequacy of existing mathematical models for describing the drying behavior of coir pith using hot air. A new mathematical model was proposed and it gave the best correlation between observed and predicted moisture ratio with high value of coefficient of determination (R^2) and lower values of root mean square error (RMSE), reduced chi-square ($\chi 2$) and mean relative deviation (E %). Wang and Singh model and Linear model were also found to be adequate for accurate prediction of drying behavior of coir pith. Since the experimental setup of this study closely simulated the particle motion and heat and mass transfer in flash drying due to induced fluidization and circulation, the new model has a great potential in designing and modeling of the flash drying of coir pith.

Key words**:** Coconut coir pith, Retting, flash drying, drying models, effective moisture diffusivity

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LIST OF ABBREVIATIONS

Abbreviations	Description	
a ,b, c, k, n	Constants in drying model	
a_2, b_2, c_2	Constants in drying model	
a_3, b_3, c_3	Constants in drying model	
BD	Bulk density of coir pith	(g/l)
BL	Breaking load	(N)
C	Calorific value of the kerosene	(kJ/l)
C/N	Carbon/Nitrogen	
CR	Compression ratio	
D_{eff}	Effective moisture diffusivity	(m^2/s)
DR	Instantaneous drying rate	(g water /g dry matter Per min)
E %	Percent mean relative deviation	
EC	Electrical conductivity	(µs/cm)
HAD	Hot air drying	
M	Moisture content at any time	(kg water/kg dry matter)
M_e	Equilibrium moisture content	(kg water/kg dry matter)
M_o	Initial moisture content	(kg water/kg dry matter)
MR	Moisture ratio	(kg water/kg dry matter)
$MR_{exp,i}$	i^{th} experimental moisture ratio	(kg water/kg dry matter)
$MR_{pre,i}$	i^{th} predicted moisture ratio	(kg water/kg dry matter)
M_t	Moisture content at time t	(kg water/kg dry matter)
M_{t+dt}	Moisture content at time t+dt	(kg water/kg dry matter)
n	Number of constants in the model	
N	Number of observations	
OD	Oven drying	
P	Particle size	(mm)
P_{bl}	Amount of energy consumed by the blower	(J)
r	Radius of sphere	(m)
R^2	Coefficient of determination	

RMSE	Root mean square error	
SD	Sun drying	
SEM	Scanning electron microscopy	
SMER	Specific moisture extraction rate	(kg/kWh)
t	Time	(min)
TS	Tensile Strength	(N/mm^2)
VE	Volume expansion ratio	
W	Amount of kerosene used by the blower	(L)
WRC	Water retention capacity	(kg water/kg dry solid)
χ^2	Reduced chi-square	

LIST OF APPENDICES