A Comparative Study on Diffusivity and Mass Transfer Coefficients of Mushrooms and Vegetables Dried in a Fluidized Bed Dryer Using ANN

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Extended Abstract :

Attempt has been made to study the diffusivity of mushroom and different vegetables (Radish, Tundli, Lady's finger and Barabatti one type of Beans) dried through a fluidized bed drier in the present study. Fick's diffusion equation for particles is used for calculation of effective moisture diffusivity as follows.

$$M_R = \frac{8}{\pi^2}\exp\left(\frac{-\Pi^2 D_{eff}\, t}{r^2}\right) \quad (1)$$

Where: D_{eff} is the effective diffusivity in $m^2\ s^{-1}$, t is the time of drying in seconds, and r is the slab thickness in centimeters.

The activation energy required for drying was calculated by using the Arrhenius equation.

$$\ln(D_{eff}) = \ln(D_o) - \frac{E_a}{R}\frac{1}{T} \quad (2)$$

Where: D_o is the constant (measured as intercept at y axis from the plot of D_{eff} vs E_a), E_a is the activation energy (kJ mol^{-1}), R is the universal gas constant (8.314 kJ mol^{-1} K^{-1}), T is the absolute temperature (^{0}K).

Diffusivity of different samples have been calculated by using above equation no. (1) and are shown in the following table-1.

Table - 1: Effective Diffusivity of Samples

Time, min	Effective Diffusivity of different samples, m^2/s					
	Mushroom	Potato	Tundli	Barbatti	Radish	Ladys finger
10	0.0016	7.801E-06	4.330E-05	2.809E-05	0.0010	0.0005
20	0.0007	2.404E-06	1.710E-05	9.393E-06	0.0004	0.0001
30	0.0004	9.156E-07	9.860E-06	4.386E-06	0.0002	9.008E-05
40	0.0003	4.261E-07	6.718E-06	2.232E-06	0.0001	4.799E-05
50	0.0002	2.324E-07	5.056E-06	1.118E-06	0.0001	2.537E-05

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Thus the expressions for the diffusivity of the samples were developed by correlating the observed diffusivity of the mushroom and different vegetables with the respective different system parameters on the basis of Regression analysis. Artificial Neural Network method was also used for the prediction of drying behaviors in terms of diffusivity. The sigmoidal function used for the neural network training in the present work is as follows.

$$f(x) = 2.0 \times \left(\frac{1}{1 + e^{-\lambda . x}} - 0.5\right) \quad (3)$$

(Where, λ is the slope parameter which determines the slopes of the activation function.)

A three layered feed forward back propagation Artificial Neural Network theory was also used to validate the developed correlations on the basis of regression analysis for the diffusivity of all the

samples. It is further observed that the RMS error for vegetables is almost negligible in comparison with the Mushrooms. RMS error for Mushrooms started at 0.35 and decreased to 0.17 which remained constant over 20000cycles.

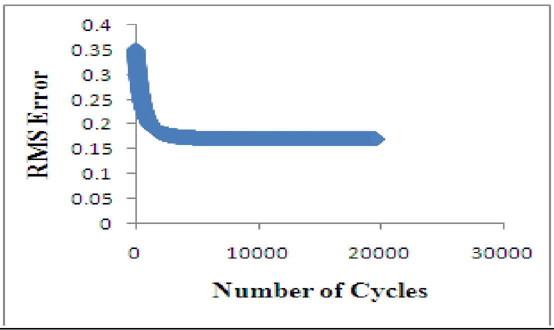

Fig -15: The RMS Error plot for mushroom

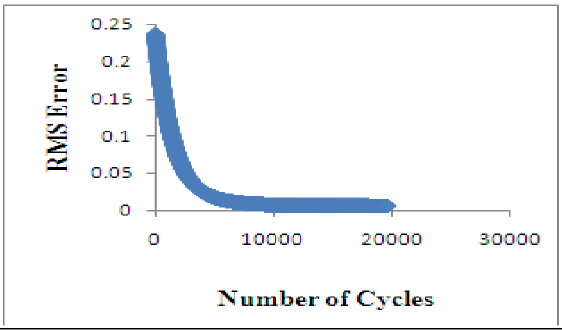

Fig -16: The RMS Error plot for vegetables

Fig.-1: RMS error plot for ANN learning

The general form of the correlations of diffusivity against the system parameters by both Regression analysis and ANN approaches for all the samples (i.e. for mushrooms and vegetables) are as follows.

$$D_{eff} = K' \times \left[(t)^a \times (\theta)^b \times (U_o)^c \times \left(\frac{L}{D}\right)^d \right]^n \qquad (4)$$

Where, n and K' are the overall exponent and coefficient of the correlation; a,b,c,d are the individual exponents of parameters.

The mass transfer coefficients for different samples subjected to fluidized bed drying have also been calculated and plotted against the temperature to get the mass transfer kinetic equations of different grains and vegetables which are listed in Table-2. The developed transfer coefficient equations for different samples are expressed in the following form.

$$K = A \times e^{B/\theta} \qquad (5)$$

where K is the mass transfer coefficient , θ is the temperature, A and B are coefficients.

Table-2: Mass transfer coefficient equations for different samples

Grains	Kinetic Equation	Vegetables	Kinetic Equation
Wheat	$K= 0.0034\ e^{107.74/\theta}$	Mushroom	$K= 0.0341\ e^{862.79/\theta}$
Mustard	$K= 0.0023\ e^{107.75/\theta}$	Tundli	$K= 0.0004\ e^{1093.4/\theta}$
Rice	$K= 0.0014\ e^{107.86/\theta}$	Potato	$K= 6E\text{-}07\ e^{2435.4/\theta}$
Moong	$K= 0.0012\ e^{108.24/\theta}$		

It is observed that increased flow rate of air increases the diffusivity of Mushroom whereas all other parameters have reverse effects on diffusivity of the samples. As a whole it is observed that the diffusivity of the samples increases with the increased variation of the system parameters for both the cases, i.e. for Mushroom and vegetables studied.

Activation energies for different samples are also calculated using the calculated values of diffusivity. It is observed that the activation energy increases with time for different vegetables whereas it decreases for Mushroom with increase in time.