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MATHEMATICAL MODEL OF THIN LAYER DRYING OF GANODERMA LUCIDUM BY RADIO FREQUENCY ASSISTED HEAT PUMP DRYING

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ABSTRACT

This study determined the most appropriate thin layer drying model, the effective moisture diffusivity and the activation energy of moisture within Ganoderma lucidum in radio frequency (RF) assisted heat pump drying method. The thin layer drying experiments were conducted with input drying parameters such as: drying temperature of 40, 45 and 50°C and RF power of 0.65, 1.3 and 1.95 kW. In order to select a suitable form of drying curve, seven different thin layer drying models (Lewis, Page, Modified Page, Henderson and Pabis, Verma, Midilli, and Wang and Singh) were fitted to the experimental data. The Verma model was the most adequate model for describing the thin layer drying of Ganoderma lucidum. The average effective moisture diffusivity values varied from 2.34×10^{-9} to 3.54×10^{-9} m^2/s. The activation energy values varied from 18.27 to 19.61 kJ/mol over the proposed range of drying temperature and RF power.

Keywords: *Effective moisture diffusivity, activation energy, drying temperature, RF power*.

1. INTRODUCTION

Ganoderma lucidum is a medicinal herb that contains various precious bioactive ingredients as: Polysaccharides, Betaglucan, Germani, acid ganoderic, acid anodermic, acid oleic, ganodersteron, ganoderans, beta-D-glucan. Ganoderma lucidum. Ganoderma lucidum is considered as a precious medicine with the effect of protecting the liver, detoxifying, strengthening the immune system and brain, improving the mind, regulating the blood pressure, reducing the blood sugar, preventing and anti-cancer, and increasing longevity [Perumal, 2009].

Fresh Ganoderma lucidum has a relatively high moisture content of 3 (d.b) and can be spoilt easily by microbiological activity after harvest. Drying is one of the most common techniques used to reduce microbiological activity. The stability of moist materials is improved when the moisture content of drying material decreased to a required value after drying (Torki *et al.*, 2015). The drying process is mainly divided into two drying periods as: the constant rate and the falling rate period (Nidhal, 2018). During the constant rate period, a high drying rate is almost constant and there is a gradual and relatively small increase in the product temperature. Most of heat absorbed by material is used for vaporization. The falling rate period occurs at a low moisture content of material, and the drying rate continuously decreases until the moisture content of material reaches the equilibrium moisture content. The mechanism of a drying process is very complex, in which heat and mass transfer processes occur simultaneously within the material, and between the surface of the material and the surrounding media (Waheed and Komolafe, 2019; Araya and Ratti, 2009).

Dehydration kinetics plays an important role in designing and optimizing a drying system (Abhishek *et al.*, 2018). The dehydration kinetics of a drying process can be analyzed and identified by three categories: theoretical, empirical and semi-theoretical drying model. The semi-theoretical models can be used to predict a drying process in falling rate period of dehydration in order to determine the effective moisture diffusivity and the activation energy of moisture within drying material basing on the Fick's law of mass diffusion (Doymaz, 2006). The effective moisture diffusivity and the activation energy of moisture within drying material are necessary parameters in design, analysis and optimization of drying process (Aghbashlo *et al.*, 2008). Many models have been used to describe the drying process. In which, the semi- empirical and empirical thin layer drying models were the most widely used.

There were numerous studies of thin layer drying experiment to determine the effective moisture diffusivity and activation energy of moisture within material. Bhattacharya *et al.*, (2015) studied thin layer modeling of convective and microwave-convective drying of oyster mushroom. The result showed that when the temperature increased in range of 50 - 70°C, the average effective moisture diffusivity increased from 2.87×10^{-8} to 3.17×10^{-8} m^2/s, the activation energy value was 21.998 kJ/mol corresponding to convective drying only. The average effective moisture diffusivity increased from 11.09×10^{-8} to 12.39×10^{-8} m^2/s and the activation energy value was 17.126 kJ/mol corresponding to microwave-convective drying. Ali *et al.*, (2016) determined the effective moisture diffusivity of chamomile leaves by experimental thin layer drying of chamomile leaves in microwave-convective drying. The result showed that increasing the microwave power from 200 to 900 W, the average effective moisture diffusivity increased from 4.46×10^{-8} to 39.63×10^{-8} m^2/s. Waheed and Komolafe (2019) studied the drying kinetics of three varieties of cocoa beans at drying temperature of 40, 50 and 60°C and the result showed that the effective diffusivities of cocoa beans varieties in range between 9.9269×10^{-11} and 4.4671 x 10×10^{-10} m^2/s and the activation energy was 23.61 kJ/mol. Abhishek *et al.*, (2019) carried out the experimental convective hot air drying of radish at temperature of 30, 40 and 50°C. The result showed that the moisture effective moisture diffusivity of radish increased from 3.3×10^{-8} to 5.55×10^{-8} m^2/min according to increase in drying temperature and the

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activation energy value was 18.49 kJ/mol. Abhishek *et al.*, (2020) conducted the experimental convective hot air thin layer drying of beetroot to evaluate the effect of air temperature on drying kinetics. In which, the effective moisture diffusivity of material increased with an increase in drying temperature. The average effective moisture diffusivity was 3.11×10^{-8}, 3.89×10^{-8}, 4.03×10^{-8} and 5.48×10^{-8} m^2/min at drying temperature of 70, 75, 80 and 85°C and the activation energy for moisture diffusion was 35.59 kJ/mol. Soner *et al.*, (2020) studied the drying kinetics of apple with hot air, microwave and ultrasonic power. The result showed that the moisture effective diffusivity of material increased significantly when hot air combined with microwave or ultrasonic power. At temperature of 50°C, the moisture effective diffusivity was 3.115×10^{-10} m^2/s corresponding to hot air drying and the moisture effective diffusivity for microwave assistance at power of 120, 350 and 600 W obtained the value of 3.451×10^{-10}, 5.489×10^{-10} and 9.765×10^{-10} m^2/s. The moisture effective diffusivity for ultrasonic power assistance of 50 and 100 W obtained 3.845×10^{-10} and 6.753×10^{-10} m^2/s.

Radio frequency heating was an effective heating technique with high and uniform heating rate basing on volumetric heating mechanism. In which, the heat generation was due to ionic conduction and dipolar rotation within the material under a high voltage RF alternating electromagnetic field (Yuxiao and Shaojin, 2021). RF heating has been applied widely in food processing and agricultural products treatment because of emergent advantages. Wenjie *et al.,* (2020) studied the RF assisted hot air drying of in-shell hazel nut in order to achieve a higher drying efficiency and lower shell cracks. Chen *et al.,* (2021) studied hot-air assisted RF drying of hazelnuts and the result showed that the drying time was shortened and the product quality was improved comparing to hot air drying. Yuxiao and Shaojin (2021) studied the simultaneous hot-air assisted RF drying of in-shell walnuts and the results showed that the heating rate was high, the drying time was shortened and the crack of dried products was reduced. Wenjun *et al.,* (2021) conducted the hot-air assisted RF drying of in-shell hazel nuts for the higher heating rate and drying rate and the better quality of dried product comparing to hot air drying. Chenchen *et al.,* (2021) conducted the drying of carrot with hot air drying and RF assisted hot air drying. The combined drying method could shorten the drying time by 30% and maintain heat sensitive ingredient in carrot well.

The drying technique using RF heating can improve the heating rate, drying rate and quality of drying products with higher content of heat sensitive ingredients retention. RF assisted heat pump drying can be considered as a suitable drying method for Ganoderma lucidum. In which, the drying rate and quality of Ganoderma lucidum would be improved, especially in the precious bioactive ingredients retention. There had not been any previous studies about the drying kinetics of RF assisted heat pump drying of Ganoderma lucidum. The objective of this study was to determine the most appropriate thin layer drying model, the effective moisture diffusivity and the activation energy of moisture within Ganoderma lucidum by RF assisted heat pump drying method

2. MATERIALS AND METHODS

2.1 Material

Ganoderma lucidum used for the experimental thin layer drying was red Ganoderma lucidum (*Ganoderma boninense*). The fresh Ganoderma lucidum had a moisture content of 3 (d.b), diameter of 12 cm and average thickness of 1.5 cm. Ganoderma lucidum samples were cleaned with dry tissues

2.2 Experimental Method

The experimental thin layer drying was conducted under controlled temperature and RF power. The model for RF assisted heat pump drying of Ganoderma lucidum was given in Fig. 1. The dryer included a RF generator operating with the frequency of 27 MHz and the maximum capacity of 5 kW and a heat pump operating the maximum capacity of 0.85 kW (Nguyen *et al.*, 2018). The Ganoderma lucidum samples were placed on a plastic mesh grid drying tray which was placed between two RF electrodes in a drying chamber. The RF electrodes were separated with distance of 150 mm by Teflon plastic bars.

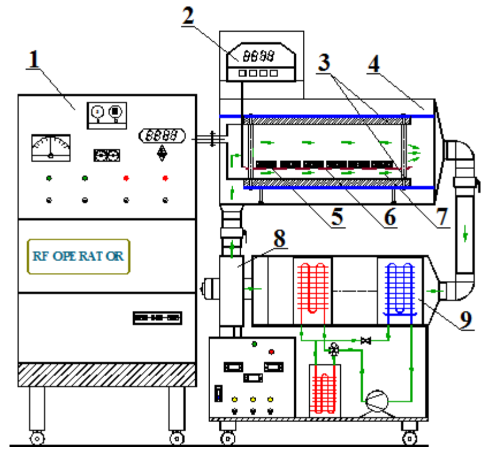

Fig. 1 The RF assisted heat pump dryer model

In which, 1. RF generator; 2. electronic scale; 3. RF electrodes, 4. drying chamber, 5. Ganoderma lucidum samples, 6. drying tray, 7. drying air direction, 8. air pump, 9. heat pump.

The input drying parameters were drying air temperature of 40, 45 and 50°C, drying air velocity of 1.2 m/s, RF power of 0.65, 1.3 and 1.95 kW.

The initial moisture content of the Ganoderma lucidum was determined by a moisture analyzer (FD660, maximum analyzed sample weight: 80 ± 0.005 g, analyzed moisture range: 0 - 100 ± 0.01%).

An electronic scale (B07TVMY9JL, maximum measurement value of 5000 ± 0.01 g) was used to weigh Ganoderma lucidum samples during the drying process. The electronic scale was installed and directly connected to drying tray to measure the carrot weigh regularly every 5 minutes. Each experiment was conducted until the drying material achieved the moisture content of 0.15 (d.b) and completed in triplicates.

2.3 Mathematical Modeling

Drying models that were used for nonlinear analysis to fit experimental data were presented in Table 1 (Bruce, 1985; Page, 1949; Overhults *et al.,* 1973; Henderson and Pabis, 1961; Wang and Singh, 1978; Verma *et al.,* 1985; Midilli *et al.,* 2002).

Table 1 Selected thin-layer drying models.

Model name	*Thin layer drying model*	*References*
Lewis	MR = exp(-k.t)	Bruce (1985)
Page	MR = exp(-k.t^n)	Page (1949)
Modified Page	MR = $\exp(-k.t)^n$	Overhults *et al.*, (1973)
Henderson and Pabis	MR = a.exp(-k.t)	Henderson and Pabis (1961)
Wang and Singh	MR = 1 + a.t + b.t^2	Wang and Singh (1978)
Verma	MR = a.exp(-k.t) + (1-a). exp(-g.t)	Verma *et al.,* (1985)
Midilli	MR = a.exp(-k.t^n) + b.t	Midilli *et al.,* (2002)

where: MR is Moisture ratio; t is drying time; a, b, k, n, and g are coefficients

Moisture content of the material samples in kinetic study is calculated on dry basis and the time is calculated on second.

Moisture ratio (MR) is calculated as Eq. (1).

$$\mathrm{MR} = \frac{M - M_e}{M_i - M_e} \qquad (1)$$

where: M (d.b) is moisture content of material at the time τ; M_e (d.b) is equilibrium moisture content of material; M_i (d.b) is initial moisture content of material.

Drying rate (DR) is calculated by Eq. (2).

$$DR = \frac{M_\tau - M_{(\tau+d\tau)}}{d\tau} \quad (2)$$

where: $M_{(\tau+d\tau)}$ is moisture content at time "τ + dτ", M_τ is moisture content at time "τ" and dτ is the time difference.

The experimental MR values were regressed along with drying time (τ) by nonlinear analysis by SPSS V8 software, 2021. In order to determine the quality of fit to experimental data, three statistical parameters as standard error of estimate (SEE), the residual sum of squares (RSS) and the quadratic regression coefficient (R^2) are evaluated. The higher the value of R^2 and the lower the value of SEE and RSS were used as the criteria for better goodness-of-fit corresponding to each thin layer drying model in Table 1. The nonlinear analysis by SPSS software is presented particularly such as: the experimental MR values vs drying time (τ) are declared in database of SPSS software. SPSS software is used for automatic non-linear analysis of the experimental data (MR vs τ) corresponding to each thin layer drying model in Table 1 in order to get the statistical parameters (SEE, RSS, R^2), which are key goodness-of-fit measures for regression analysis.

The parameters as SEE and RSS are defined as:

$$SEE = \sqrt{\frac{\sum_{i=1}^{n}(M-M_S)^2}{df}} \quad (3)$$

$$RSS = \sum_{i-1}^{n}(M-M_S)^2 \quad (4)$$

where: M_s is the simulated value of M, df is the degree of freedom and n is the number of data points.

Besides, the error of the recommended correlations was estimated by the Root mean square error (RMSE) and Mean absolute error (MAE), which were defined in Eq. (5) and Eq. (6).

$$RMSE = \left[\frac{1}{N}\sum_{i=1}^{N}\left(MR_{exp,i} - MR_{pre,i}\right)\right]^{0.5} \quad (5)$$

$$MAE = \frac{1}{N}\sum_{i=1}^{N}\left(\frac{|MR_{exp,i}-MR_{pre,i}|}{MR_{pre,i}}\right) \quad (6)$$

$MR_{exp,i}$ is the i[th] experimental moisture ratio, $MR_{pre,i}$ is the i[th] predicted moisture ratio based on the proposed thin layer drying model, N is the number of observations.

2.4 Determination of Effective Moisture Diffusivity and Activation Energy

Moisture diffusion within the material is considered as the dominant factor controlling moisture transfer from inside of the material to its surface (Beigi, 2016). One dimensional diffusion is considered and Fick's diffusion equation is used for the simple analysis of the only diffusion based thin layer drying equation (Demiray and Tulek, 2012).

An analytical solution of effective moisture diffusivity model can be done with the following assumptions:

- Initial moisture content is uniformly distributed throughout the mass of the material.
- Mass transfer is symmetrical with respect to the center of the slab.
- When drying begins, the surface moisture content instantaneously reaches equilibrium moisture content.
- Resistance to mass transfer at the surface is negligible compared to the internal resistance of the sample.
- Mass transfer is represented by a diffuse mechanism.
- The diffusion coefficient is constant and material shrinkage is negligible.

With the above assumptions, Eq. (7) is derived from the theoretical model that defines diffusivity for slab geometry (Alibas, 2014).

$$LnMR = Ln\frac{8}{\pi^2} - \left(\frac{\pi^2 D_{eff}}{4.L^2}\right).\tau \quad (7)$$

where: D_{eff}: effective moisture diffusivity within material (m^2/ s); L is the half slab thickness (m) and τ is the drying time (s).

The plot of LnMR against τ forms a straight line from which effective diffusivity (D_{eff}) can be calculated from its slope (X_1) as follows:

$$X_1 = -D_{eff}\left(\frac{\pi}{2L}\right)^2 \quad (8)$$

Activation energy is calculated by Arrhenius equation as Eq. (9).

$$D_{eff} = D_0 e^{\left(-\frac{E_a}{RT_a}\right)} \quad (9)$$

where: D_o (m^2/s) is the diffusivity constant, T_a (K) is the absolute air temperature, E_a (kJ/mol) is the activation energy and R is the universal gas constant (R = 8.3143 kJ/mol.K).

Taking log natural to the Eq. (9) to get Eq. (10).

$$LnD_{eff} = \left(-\frac{E_a}{R}\right)\frac{1}{T_a} + LnD_0 \quad (10)$$

Solve Eq. (10) for activation energy by plotting LnD_{eff} versus $1/T_a$ yields a straight line with slope (X_2) used for calculating activation energy.

$$X_2 = -\frac{E_a}{RT_a} \quad (11)$$

3. RESULTS AND DISCUSSIONS

3.1 Dehydration Kinetics

In thin layer RF assisted heat pump drying of Ganoderma lucidum, the change of moisture ratio corresponding to drying time was presented graphically in Fig. 2.

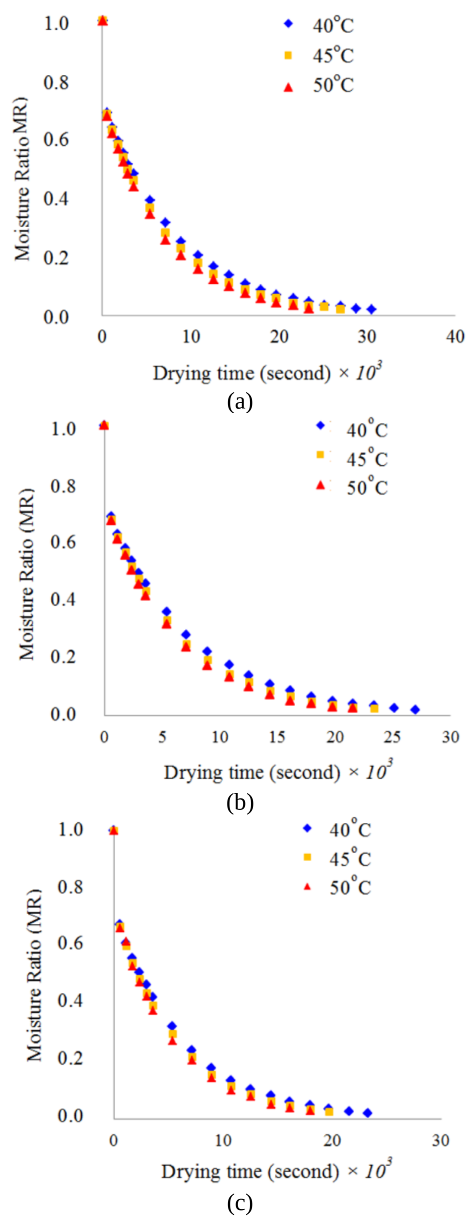

Fig. 2 MR versus drying time at RF power of 0.65 kW (a), 1.3 kW (b) and 1.95 kW (c).

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As shown in Fig. 2, the effect of temperature on all samples was almost similar. At the same RF power, as drying temperature increased, the moisture ratio increased. Besides, increasing RF power had a significant effect on moisture ratio, the moisture ratio was higher at higher RF power. At the drying temperature of 50°C and RF power of 1.95 kW, the drying time reduced by 10% and 21% in comparison with RF power of 1.3 and 0.65 kW. The similar transitions in drying time were shown at temperatures of 40 and 45°C. It can be explained by RF heating mechanism, in which, increasing the RF power increases RF energy absorption inside Ganoderma lucidum, and the heat generation within Ganoderma lucidum becomes faster and the moisture diffusion within Ganoderma lucidum occurs faster (Nguyen *et al.*, 2018). This shortened the drying time.

The characteristics of the drying process was exhibited by the plot of the drying rate versus moisture content, as shown in Fig. 3.

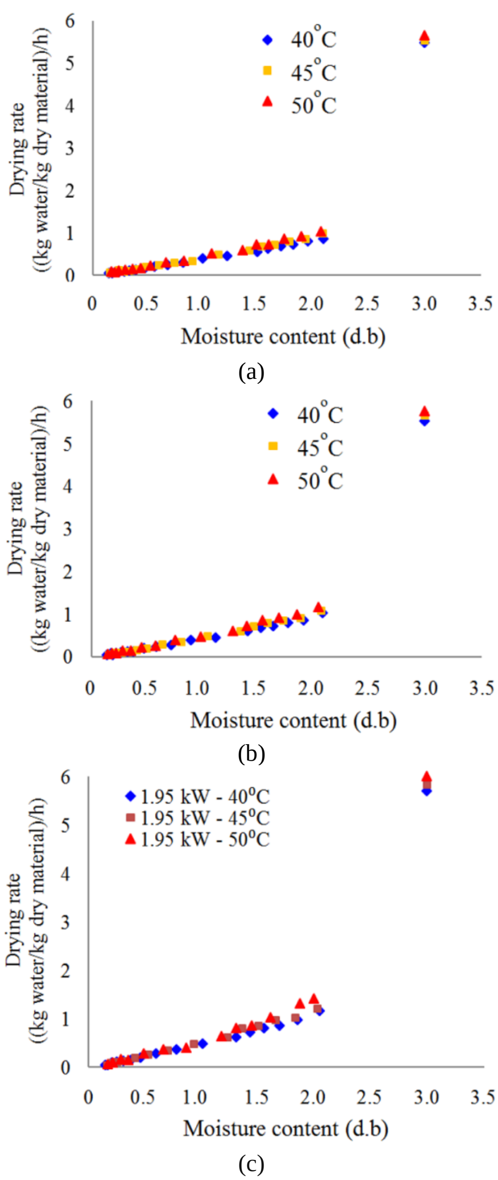

Fig. 3 Drying rate versus moisture content at RF power of 0.65 kW (a), 1.3 kW (b) and 1.95 kW (c)

Figure 3 showed that the drying rate was higher at first stage and decreased gradually when the moisture content of material decreased. The drying rate continuously decreased until the moisture content of material reached the equilibrium moisture content and the drying process ended. The drying rate obtained the higher value at higher drying temperature and higher RF power. The characteristics of drying rate versus moisture content was in agreement with the results of previous study (Manuel *et al.*, 2019).

In thin layer RF assisted heat pump drying of Ganoderma lucidum, the drying operations seemed occur in the falling rate period. The constant rate drying period was either absent or difficult to exhibit in thin layer drying process due to the very fast moisture removal from the surface of Ganoderma lucidum slices. The result was in agreement with the previous studies (Correia *et al.*, 2015; Abhishek *et al.*, 2019).

The nonlinear estimation analysis on SPSS software was conducted to determine the fitness of moisture rate versus drying time according to the selected thin layer drying models. The value of the statistical parameters was given in Table 2 (see Appendix).

As shown in Table 2, two parameters as SEE and RSS achieved the lowest value and the quadratic regression coefficient (R^2) achieved the highest value for Verma model at all values of temperature and RF power. The goodness of fit tests indicated that the Verma model gave the best fit to experimental data results, the coefficient values given by nonlinear estimation analysis as below:

$$a = 0.719 + 1.4\times10^{-5}\times t_a^2 + 0.006\times P^2 + 0.2\times10^{-3}\times t_a + 0.003\times P - 0.5\times10^{-3}\times t_a\times P \quad (13)$$

(R^2 = 0.983)

$$k = 0.1\times10^{-3} + 6.7\times10^{-8}\times t_a^2 + 3.9\times10^{-6}\times P^2 - 3\times10^{-6}\times t_a + 7.7\times10^{-6}\times P - 9.9\times10^{-22}\times t_a\times P \quad (14)$$

(R^2 = 0.980)

$$g = 0.04 + 1.1\times10^{-5}\times t_a^2 + 0.003\times P^2 - 0.9\times10^{-3}\times t_a - 0.014\times P - 4.8\times10^{-5}\times t_a\times P \quad (15)$$

(R^2 = 0.994)

In which, t_a (°C) is drying air temperature, P (kW) is capacity of RF operator.

The statistical analysis was conducted corresponding to the Verma model and experimental value of moisture ratio (MR vs τ), the statistical error of the recommended parameter was defined in Eq. (5) and Eq. (6) and given in Table 3. As shown in Table 3, the value of RMSE and MAE was relatively low. Thus, the analyzing results confirmed that The Verma model was found to be the suitable model for describing the thin layer drying of Ganoderma lucidum.

Table 3 The statistical error.

Thin layer drying model	*RMSE*	*MAE*
MR = a.exp(-k.t) + (1-a). exp(-g.t)	0.03	4.6%

3.2. Effective Moisture Diffusivity and Activation Energy

The value of effective moisture diffusivity (D_{eff}) and activation energy (E_a) were calculated from the slope of Eq. (8), and Eq. (10) and provided in Table 4.

Table 4 Values of effective moisture diffusivity and activation energy.

Parameters	*Temp (°C)*	*RF power (kW)*		
		0.65	*1.3*	*1.95*
Effective moisture diffusivity ($\times10^{-9}$ m²/s) **	40	2.34	2.58	2.85
	45	2.64	2.89	3.18
	50	2.95	3.24	3.54
Activation energy (kJ/mol)		19.61	19.07	18.27

*** Significant at the 0.001 probability level (P < 0.001)*

As shown in Table 4, the effective moisture diffusivity of Ganoderma lucidum increased when the drying temperature and RF power increased. It can be explained by the fact that increasing the drying temperature and RF power would increase heat exchange between material and drying air and the heat generation within the material due to RF heating. Thus, moisture diffusion within Ganoderma lucidum occurred faster. The effective moisture diffusivity of Ganoderma lucidum values were in range from 10^{-7} to 10^{-11} m²/s that was in range of moisture diffusion value proposed for food and vegetables (Bhattacharya *et al.*, 2015; Motevali *et al.*, 2016; Abhishek *et al.*, 2019; Abhishek *et al.*, 2020; Soner *et al.*, 2020).

When RF power increased, the activation energy of moisture within Ganoderma lucidum decreased. The activation energy obtained the value of 19.61, 19.07 and 18.27 kJ/mol corresponding to RF power of 0.65, 1.3 and 1.95 kW. The value of activation energy of the study was in the range of activation energy value proposed for food and vegetables (Bhattacharya *et al.*, 2015; Motevali *et al.*, 2016; Abhishek *et al.*, 2019; Abhishek *et al.*, 2020; Soner *et al.*, 2020). The results can be explained by the fact that when RF power increased, the water dipole molecules and free ions in Ganoderma lucidum would fluctuate faster, that made the linkage between water dipole molecules be broken more easily.

The values of effective moisture diffusivity values were fitted to Arrhenius equation as the function of temperature and the models were obtained as in Table 5.

Table 5 Effective moisture diffusivity model under different drying conditions.

RF power (kW)	*The effective moisture diffusivity model D_{eff} (m^2/s)*
0.65	$D_{\text{eff}} = 4.376 \times 10^{-6} \times Exp\left(-\frac{2358}{(t_a + 273.2)}\right)$
1.3	$D_{\text{eff}} = 3.935 \times 10^{-6} \times Exp\left(-\frac{2294}{(t_a + 273.2)}\right)$
1.95	$D_{\text{eff}} = 3.196 \times 10^{-6} \times Exp\left(-\frac{2198}{(t_a + 273.2)}\right)$

where: t_a (°C) is the drying temperature

4. CONCLUSION

Thin layer drying experiments were conducted to determine the characteristics of thin layer drying of Ganoderma lucidum by RF assisted heat pump drying. The drying rate increased when the drying temperature and RF power increased. The Verma model was found to be the most suitable model for describing the thin layer drying of Ganoderma lucidum. The effective moisture diffusivity and the activation energy of moisture within Ganoderma lucidum were determined. When the drying temperature increased from 40 to 50°C, the effective moisture diffusivity increased from 2.34×10^{-9} to 2.95×10^{-9} m^2/s, from 2.58×10^{-9} to 3.24×10^{-9} m^2/s, and from 2.85×10^{-9} to 3.54×10^{-9} m^2/s corresponding to RF power of 0.65, 1.3 and 1.95 kW. The activation energy decreased from 19.61 to 18.27 kJ/mol as RF power increased from 0.65 to 1.95 kW

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APPENDIX

Table 2 Statistical parameters value of nonlinear estimation analysis

Models	*Temperature* (ºC)	*RF power of 0.65* kW			*RF power of 1.3* kW			*RF power of 1.95* kW		
		R^2	*RSS*	*SEE*	R^2	*RSS*	*SEE*	R^2	*RSS*	*SEE*
Lewis	40	0.984	0.028	0.031	0.991	0.015	0.025	0.986	0.022	0.031
	45	0.988	0.019	0.028	0.991	0.014	0.025	0.990	0.015	0.027
	50	0.991	0.014	0.025	0.991	0.013	0.026	0.991	0.012	0.026
Page	40	0.995	0.009	0.018	0.997	0.005	0.014	0.994	0.009	0.020
	45	0.996	0.006	0.016	0.997	0.005	0.015	0.996	0.006	0.018
	50	0.996	0.006	0.017	0.996	0.005	0.016	0.997	0.004	0.015
Modified Page	40	0.984	0.028	0.032	0.991	0.015	0.025	0.986	0.022	0.032
	45	0.988	0.019	0.029	0.991	0.014	0.026	0.990	0.015	0.028
	50	0.991	0.014	0.025	0.991	0.013	0.026	0.991	0.012	0.026
Henderson and Pabis	40	0.992	0.013	0.022	0.995	0.008	0.019	0.992	0.012	0.024
	45	0.994	0.010	0.021	0.995	0.008	0.020	0.994	0.009	0.022
	50	0.995	0.008	0.020	0.994	0.008	0.021	0.995	0.007	0.021
Wang and Singh	40	0.899	0.180	0.082	0.919	0.139	0.076	0.914	0.134	0.078
	45	0.922	0.127	0.074	0.931	0.108	0.072	0.932	0.099	0.072
	50	0.933	0.106	0.071	0.932	0.099	0.072	0.934	0.089	0.072
Verma	40	0.999	0.002	0.008	0.999	0.002	0.008	0.999	0.002	0.010
	45	0.999	0.001	0.008	0.999	0.002	0.009	0.999	0.002	0.010
	50	0.999	0.002	0.011	0.999	0.002	0.010	0.999	0.001	0.008
Midilli	40	0.996	0.007	0.017	0.998	0.004	0.013	0.996	0.006	0.017
	45	0.997	0.004	0.014	0.998	0.003	0.013	0.998	0.003	0.014
	50	0.998	0.004	0.014	0.998	0.003	0.013	0.999	0.002	0.010