Mathematical modelling of drying characteristics of blanched field pumpkin (*Cucurbita pepo* L) slices

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Abstract: Drying kinetics of blanched field pumpkin slices with slice thickness of 10, 20 and 30 mm were investigated at the temperatures of 60℃, 70℃, and 80℃. The velocity of convective cabinet dryer was kept constant at 1.5 m s^{-1}. Mass transfer during drying of field pumpkin slices was described using Fickian model of diffusion with the drying taking place in the falling rate period. The drying curves obtained were fit to different semi-theoretical and/or empirical thin layer drying models to determine the best-fit model for dehydration of blanched field pumpkin slices by a non-linear regression analysis. The goodness of fit of each model was evaluated using the coefficient determination (R^2), the reduced chi-square (χ^2), and the root mean square error (RMSE) between the predicted and experimental dimensionless moisture ratios. The effective moisture diffusivity (D_{eff}) of blanched field pumpkin slices increased from 1.17×10^{-9} to 6.75×10^{-9} m^2 s^{-1} with increase in drying air temperature and slice thickness. Temperature dependence of effective moisture diffusivity followed Arrhenius relationship and the activation energy of diffusion increased from 24.59 to 26.45 kJ mol^{-1}.

Keywords: field pumpkin, blanched, drying, diffusivity, activation energy

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1 Introduction

The use of solar energy is the oldest form of natural, atmospheric drying of grains, fruits and vegetables. The oldest form of sun drying was in an open space that is still in use in many states of Nigeria for drying of blanched field pumpkin. Dried field pumpkin slices are used to mimic meat in soups in some parts of south-western Nigeria. Field pumpkin is an annual crop of the family Cucurbitaceace which is used traditionally as food and medicine. Sun drying is associated with several problems aside from the fact that sunshine is unpredictable sometimes even during the dry season. Sun dried food products are often of low quality as a result of slow drying, insect damage, and contamination from air-borne dust (Ertekin and Yaldiz, 2004; Sankat and Mujaffar, 2004). A controlled environment is recommended in order to process a uniform dry product with high acceptability. Controlled drying is identified as an alternative to traditional sun drying method. Controlled drying system can either be by force or natural convection. Natural convection dryers rely on the movement of hot air through buoyancy while the forced convection dryers require electricity to drive the in-built fan.

Drying of food material involves simultaneous heat and mass transfer where water is transferred by diffusion from inside the food material to the air-food interface, and to the air stream by convection (Sobukola, 2009). The drying rate is influenced by the following factors: nature of the food material, initial moisture content, mass of the food material per unit exposed area, drying air temperatures, humidity of the drying chamber, and drying

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air velocity. Moisture removal processes and their dependence on these factors are expressed in terms of drying kinetics; hence, the determination of the drying rate is essential for the development of reliable process model (Kooli et al., 2007). By and large, the drying phenomena can be described using thin layer drying models mainly to estimate the drying time and moisture content of the food materials at any time after they are subjected to a known temperature and relative humidity. Recently, a number of studies have been reported on modelling and drying of food materials. Experimental studies conducted on thin layer drying process of various food products such as chilli (Hussain and Bala, 2002), red pepper (Akpinar et al., 2003), potato (Akpinar et al., 2003), carrot (Doymaz, 2004), eggplant (Ertekin and Yaldiz, 2004) and tomato (Sacilik et al., 2006) have been reported. Modelling is advantageous in the design of new or upgraded drying systems of the existing ones. Although considerable literature is available on drying kinetics of various food products using thin layer drying models, limited information exists on drying of field pumpkin slices. Modelling thin layer drying kinetics of blanched field pumpkin will go a long way in upgrading traditional sun drying system to a more efficient convective drying system. The objective of this study was to evaluate the effect of drying air temperature and slice thickness on the drying characteristics, and to choose suitable model that best describe drying behaviour of blanched field pumpkin slices using thin layer models.

2 Materials and methods

2.1 Materials

Field pumpkins (*Cucurbita pepo* L.) were purchased from a farmer in an open market in Igbesa Ogun State, Nigeria. Average moisture content, crude protein, ash content, and crude fibre of the field pumpkin were 89.37±0.12% (wet basis), 7.79±1.89%, 93.67±0.58%, and 15.17±1.61% respectively using AOAC (1990) method. Before the experiments, the pumpkin was washed, manually sliced into rectangular slabs with the dimensions of 50×20×10, 50×20×20 and 50×20×30 mm using very sharp knife. The slices were blanched at 90℃ for five minutes and cooled immediately in cold water (25℃) for five minutes to remove excess heat.

2.2 Drying procedure

Drying experiments were performed in convective tray dyer. The dryer was allowed to run for 30 minutes to enhance steady-state condition before the beginning of the experiment. Blanched pumpkin slabs were placed in a single layer on the perforated drying trays and drying of the samples were conducted at three drying air temperatures of 60℃, 70℃ and 80℃ with constant air velocity of 1.5 m s^{-1} (Falade and Abbo, 2007; Dinrifo, 2012). Moisture loss was measured gravimetrically at an interval of 10 minutes, for the first 30 minutes and subsequently at one hour intervals till constant moisture content was obtained. The drying experiments were conducted in triplicates.

2.3 Mathematical modelling of the drying curve

Thin layer drying models that describe the drying curves of agricultural produce mainly fall into three different classes, theoretical, semi-theoretical and empirical model. Theoretical model takes into account the internal resistance to moisture flux while semi-theoretical and empirical models consider external resistance to moisture flux between the product and the drying air. (Akpinar and Bicer, 2006). The selected mathematical models used in this study are identified in Table 1. In these models, MR is the dimensionless moisture ratio = $(M - M_e)/(M_o - M_e)$, where M is the instantaneous moisture content of blanched field pumpkin, M_o is the initial moisture content of blanched field pumpkin, and M_e is the equilibrium moisture content of blanched field pumpkin. The thin layer models (Table 1) were fit to find the best-suited model for describing the drying curve of blanched field pumpkin. Non-linear regression was used to obtain each constant of selected mathematical models using the following computer program Datafit 8.2 (Oakdale Engineering) and MATLAB 7.1 for selecting the best model for experimental data to describe the drying curves. The goodness of fit of the selected models was evaluated from the coefficient of determination (R^2), reduced chi-square (χ^2) as the mean square of the deviation between the experimental and predicted observations for the thin layer models and root mean square error (*RMSE*). The higher the values of R^2 (closeness to one), the lower values of χ^2 and *RSME* (closeness to zero) determines the goodness of fit (Gunhan et al., 2005; McMinn, 2006). These parameters can be described in the following equations:

$$R^2 = \frac{\sum_{i=1}^{n}(MR_{\exp,i} - MR_{pre,i})\sum_{i=1}^{n}(MR_{pre,i} - MR_{\exp,i})}{\sqrt{\left[\sum_{i=1}^{n}(MR_{\exp,i} - MR_{pre,i})\right]^2\left[\sum_{i=1}^{n}(MR_{pre,i} - MR_{\exp,i})^2\right]}} \quad (1)$$

$$\chi^2 = \frac{\sum_{i=1}^{n}(MR_{\exp,i} - MR_{pre,i})}{N - z} \quad (2)$$

$$RMSE = \left[\frac{1}{z}\sum_{i=1}^{n}(MR_{pre,i} - MR_{\exp,i})^2\right]^{\frac{1}{2}} \quad (3)$$

where, $MR_{exp,i}$ is the ith experimentally observed moisture ratio; $MR_{pre,i}$ is the ith predicted moisture ratio; N is the number of observations, and z is the number of constants in the models (Sobukola, 2009).

Table 1 Mathematical models used to describe the drying kinetics

No.	Model name	Model	References
1	Newton	$MR = \exp(-kt)$	Ayensu (1997)
2	Page	$MR = \exp(-kt^n)$	Agrawal and Singh (1977)
3	Modified Page I	$MR = \exp[-(kt)^n]$	Akpinar and Bicer (2006)
4	Henderson and Pabis	$MR = a\exp(-kt)$	Westerman et al. (1973)
5	Logarithmic	$MR = a\exp(-kt)+c$	Yagcioglu et al. (1999)
6	Wang and Singh	$MR = 1+at+bt^2$	Sacilik et al. (2006)
7	Two term	$MR = a\exp(-k_0t) + b\exp(-k_1t)$	Dandamrongrak et al. (2002)

3 Results and discussion

3.1 Drying curves

The effect of drying air temperatures at 1.5 m s^{-1} on the moisture profile of blanched field pumpkin slices is shown in Figures 1 and 2 respectively. Moisture ratio decreases continuously with the increase of drying time. This observation is in agreement with the previous studies reported by Akgun and Doymaz (2005); Falade et al. (2007); Sobukola (2009). There is an inverse relationship between drying air temperature and drying time. The time needed to reduce the moisture ratio of the samples to any given level was a function of drying air temperature, with the lowest time at 80℃ and highest at 60℃. The drying rates were also observed in the falling rate period in all drying conditions; therefore, higher drying time was required to remove moisture and this may be attributed to the slow diffusion process.

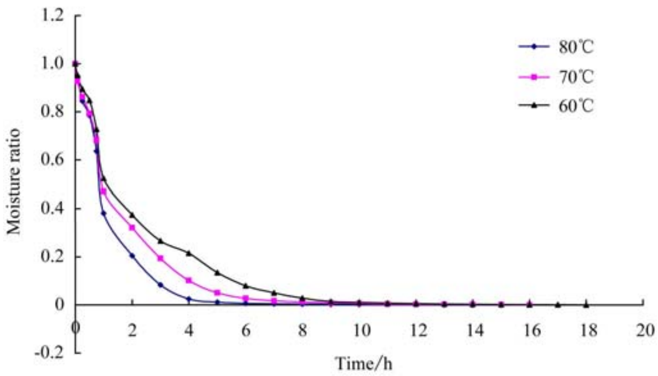

Figure 1 Effect of drying air temperature on moisture profile of 10 mm thick blanched pumpkin slab

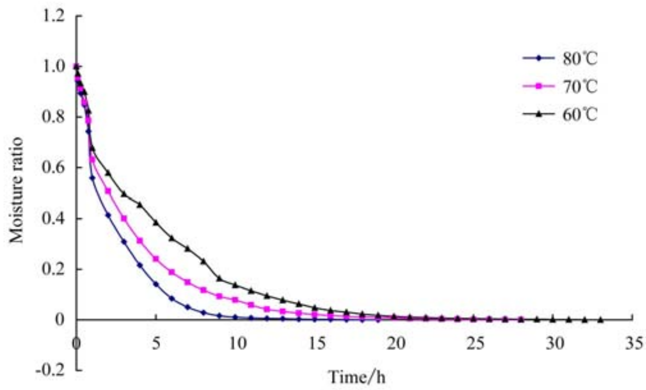

Figure 2 Effect of drying air temperature on moisture profile of 20 mm blanched pumpkin slab

The effect of slice thickness on the drying time of blanched field pumpkin slices at 70℃ is shown in Figure 3. From this figure, the increase in slice thickness significantly increased the drying time of the samples ($p < 0.05$). The drying time required to reduce moisture content of the samples to 11% dry basis increased from 13 hours to 33 hours as the slice thickness increases from 10 to 30 mm respectively under constant drying conditions. This observation is in agreement with previous studies reported by Ertekin and Yaldiz (2004) for eggplant; Falade et al. (2007) for yam slices; Nguyen and Price (2007) for banana slabs. However, increasing the thickness of the field pumpkin slices slowed the drying process, which means that thickness effects suppressed the surface area effect. This is in agreement with previous study reported by Uretir et al. (1996) on apple cubes. This buttresses the fact that drying operation is controlled by internal diffusion of moisture. The thickness of the samples through which moisture will diffuse is the moisture removal rate determining factor.

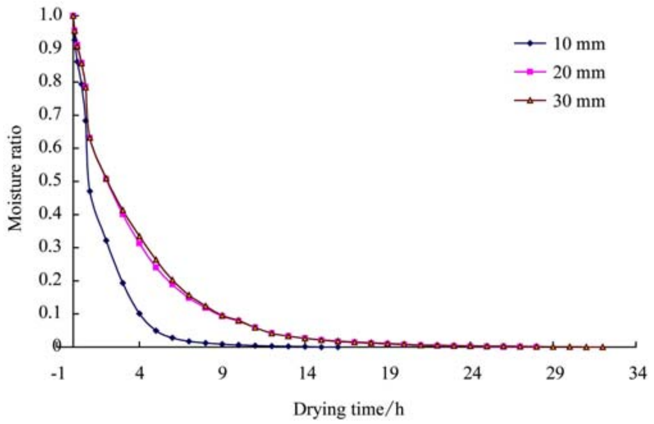

Figure 3 Effect of slice thickness on drying time of blanched filed pumpkin slices dried at 70℃

3.2 Determination of moisture diffusivity and activation energy

Drying of the most food materials occur in the falling rate period and moisture transfer during drying is controlled by internal diffusion (Falade et al., 2007; Babalis and Belessiotis, 2004; Doymaz and Pala, 2002). Fick's diffusion equation as shown in Equations (4) and (5), for an infinite slab, assuming unidimensional moisture transfer, no shrinkage, constant temperature, diffusivity coefficients and negligible external resistance has been widely used to describe the drying process during falling rate period for most biological material as follow:

$$MR = \frac{m_t - m_e}{m_o - m_e} = -a(kt) \tag{4}$$

$$MR = \frac{8}{\pi^2}\sum_{n=0}^{\infty}\frac{1}{(2n+1)^2}\exp\left(\frac{-(2n+1)^2\pi^2 D_m t}{4L^2}\right) \tag{5}$$

where, MR = moisture ratio, m_t = instantaneous moisture content, (kg water (kg dry matter)$^{-1}$); m_e = equilibrium moisture content (kg water (kg dry matter)$^{-1}$); m_o = initial moisture content (kg water (kg dry matter)$^{-1}$); L is the half-thickness of the pumpkin slices (m) and D_m is the moisture diffusivity. The linear solution of Equation (5) is obtained by assuming that the first term of the series is significant (Sobukola, 2009). Taking natural logarithm of Equation (5):

$$\ln MR = \ln\frac{8}{\pi^2} - \left(\frac{-\pi^2 D_m t}{4L^2}\right) \tag{6}$$

Moisture diffusivity (D_m) is determined by plotting natural logarithm of moisture ratio (ln MR) against time (t) to obtain a slope

$$slope = \frac{\pi^2 D_m}{4L^2} \tag{7}$$

The estimated values of D_m for different conditions are presented in Table 5. The effective moisture diffusivities of dried blanched filed pumpkin at 60℃ -80℃ varied in the range of 1.17×10^{-9} - 6.75×10^{-9} m^2 s^{-1}, but slightly higher than 3.88×10^{-10}, 6.58×10^{-10} and 9.38×10^{-10} m^{-2} s^{-1} at 50℃, 55℃ and 60℃ respectively for pumpkin slices reported by Doymaz (2007b). The difference between the values of this study and Doymaz (2007b) might be due to location and condition of growth, maturity, drying equipment, and other uncontrolled parameters. These values are within the general range of 10^{-11} – 10^{-6} m^{-2} s^{-1} by Zogzas et al. (1996) for food materials. Falade et al. (2007) also reported the effective moisture diffusivity (D_m) of pretreated yam slices. As expected the values of effective moisture diffusivity (D_m) increased with the increasing drying air temperature. An increase in effective moisture diffusivity (D_m) was also noticed at the same drying air temperature. At 60℃, D_m increased from 1.17×10^{-9} to 1.33×10^{-9} and to 1.58×10^{-9} m^{-2} s^{-1} with the increasing slice thickness from 10 to 30 mm. Graphically, if moisture diffusivity is plotted against slice thickness, it is expected that when thickness increases, slope will decrease while effective moisture diffusivity (D_m) will assume to be the same. This deviation from Fick's second law of diffusion which predicts that drying rate will vary inversely with the square of the slice thickness (L) may be attributed to external mass transfer resistance.

The effect of temperature was expressed by the Arrhenius equation, where the natural logarithm of effective diffusivity exhibited a linear behaviour against reciprocal of the absolute temperature of the drying air (Doymaz, 2007a):

$$D_m = D_o \exp - \frac{E_a}{RT_{abs}} \tag{8}$$

where, D_0 is the pre–exponential factor of the Arrhenius equation ($m^2\ s^{-1}$); E_a is the activation energy (kJ mol^{-1}); T_{abs} is absolute temperature (K); and R is the universal gas of constant (8.3143 J mol^{-1} K^{-1}). Linearising Equation (8) by taking natural logarithms of both sides;

$$\ln D_m = \ln D_o - \frac{E_a}{RT_{abs}} \tag{9}$$

Activation energy for drying was calculated from the $Slope = \frac{E_a}{R}$ with high correlation coefficients from 0.9892 to 0.9999 indicating a good fit (Table 5). The activation energy ranged from 24.59 to 26.45 kJ mol^{-1}. The activation energy obtained is comparable with those reported by Bon et al. (1997) for potato (27.8 kJ mol^{-1}); Simal et al. (1996) for green peas (28.4 kJ mol^{-1}); Doymaz (2004) for carrot (28.36 kJ mol^{-1}); Falade et al. (2007) for water yam (25.26 – 46.46 kJ mol^{-1}); Guine et al. (2011) for *Cucurbita maxima* (33.74 kJ mol^{-1}), but lower than Doymaz (2007b) for pumpkin (78.93 kJ mol^{-1}). This may be attributed to heterogeneous composition and nature of biological material as a result of growing conditions, variety and maturity.

Table 5 Effective moisture diffusivities and activation energy of diffusion for various slice thickness of blanched field pumpkin

Slice thickness /mm	Temperature /℃	$D_{eff.}$/$m^2\ s^{-1}$ $\times 10^{-9}$	E_a /kJ mol^{-1})	R^2
10	60	1.17	24.59	0.9985
	70	2.33		
	80	4.70		
20	60	1.33	26.17	0.9912
	70	2.69		
	80	5.82		
30	60	1.58	26.45	0.9964
	70	4.67		
	80	6.75		

3.3 Modelling of the thin layer drying characteristics

Experimental results of moisture ratio with drying time were fit for seven drying models namely Newton, Page, Modified Page, Henderson and Pabis, Logarithmic, Wang and Singh, and two terms for expressing drying characteristics of blanched field pumpkin slices dried by convective tray dryer and the statistical evaluation of the models using three criteria are presented in the Tables 2, 3 and 4. Following Akpinar (2006), the quality of fit of various models was evaluated using R^2, reduced χ^2 and *RMSE* values. The results presented in the tables showed that Wang and Singh model has the least coefficient of determination from the statistical analysis. Logarithmic model was found to describe the drying characteristics better when compared with other six models used in this study. This is in agreement with a previous study reported by Doymaz (2007b) for pumpkin slices. From the tables, apart from Wang and Singh model, the other tested models namely Newton, Page, Modified Page, Henderson and Pabis, Logarithmic, and two terms also described the drying characteristics of blanched field pumpkin slices reasonably well. Validation of selected model was confirmed by comparing the predicted moisture ratio with the experimental moisture ratio at different drying air temperatures. A good agreement was observed between experimental moisture ratio and predicted moisture ratio values, as they both laid around straight line for Logarithmic model as shown in Figure 4. This suggests that the Logarithmic model can be used to explain drying behaviour of blanched field pumpkin. Linear regression was employed to obtain values of drying rate constants (k) for different temperatures. Tables 2 – 4 showed that drying rate constants increase with increase in drying air temperature. An increase in rate constant with increasing drying air temperature has been reported for the drying of red chillies (Kaleemullah and Kailappan, 2006). However, drying rate constant is found to decrease with increasing slice thickness of the blanched field pumpkin for all the selected models, which is in agreement with Yusheng and Poulsen (1988) who reported a decrease in drying rate

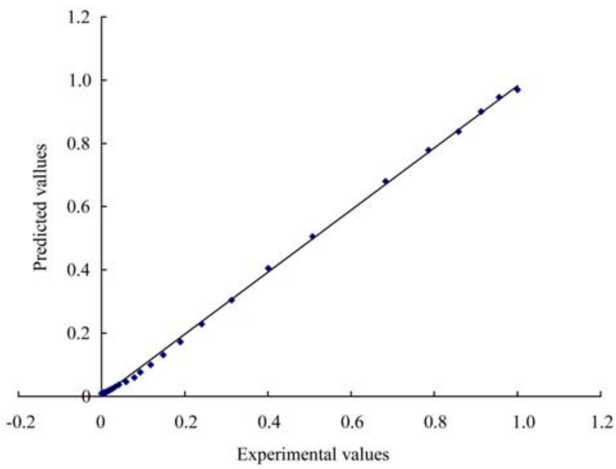

Figure 4 Experimental moisture ratio with predicted moisture ratio from Logarithmic model

constant with increasing potato slab thickness. This can be attributed to internal diffusion because during falling rate moisture must diffuse through the thickness if drying takes place on a face of the slab.

Table 2 Values of the drying constants and coefficients of mathematical models through non-linear regression analysis method for blanched field pumpkin slices (10 mm thickness)

Model	Temperature/℃	Model constants		R^2	χ^2	*RMSE*
Newton	60	k = 0.454312		0.9930	1.078 E-03	0.0215
	70	k = 0.582730		0.9950	9.472 E-03	0.0054
	80	k = 0.749215		0.9907	4.367 E-03	0.0086
Page	60	k = 0.476718	n = 0.937481	0.9933	1.007 E-03	0.0217
	70	k = 0.584536	n = 0.992985	0.9953	8.974 E-03	0.0546
	80	k = 0.737796	n = 1.192645	0.9936	8.717 E-03	0.0087
Modified Page	60	k = 0.453739	n = 0.937481	0.9936	1.007 E-03	0.0254
	70	k = 0.582325	n = 0.992985	0.9950	8.974 E-03	0.0221
	80	k = 0.774940	n = 1.192646	0.9936	8.717 E-03	0.0066
Henderson & Pabis	60	k = 0.448711	a = 0.992040	0.9927	8.549 E-03	0.0074
	70	k = 0.579041	a = 0.995926	0.9953	7.627 E-03	0.0426
	80	k = 0.782958	a = 1.030461	0.9915	7.627 E-03	0.0467
Logarithmic	60	k = 0.456717 c = 5.11E-03	a = 0.988854	0.9971	2.118 E-04	0.0012
	70	k = 0.582064 c = 1.69E-03	a = 0.994777	0.9953	5.937 E-04	0.0034
	80	k = 0.776354 c = 3.38E-03	a = 1.033052	0.9966	8.959E-04	0.0019
Wang & Singh	60	a = -0.19011	b = 8.035E-03	0.8595	8.688E-03	0.1334
	70	a = -0.22148	b = 1.071E-03	0.8234	1.202E-03	0.0897
	80	a = -0.24676	b = 1.300E-03	0.7565	1.593E-03	0.1569
Two Term	60	k_o = - k_1 = -	b = - a = -	-	-	-
	70	k_o = 0.60534 k_1 = 0.36429	b = 7.9343758 a = 0.9181986	0.9953	9.776E-03	0.0098
	80	k_o = - k_1 = -	b = - a = -	-	-	-

Table 3 Values of the drying constants and coefficients of mathematical models through non-linear regression analysis method for blanched field pumpkin slices (20 mm thickness)

Model	Temperature/℃	Model constants		R^2	χ^2	*RMSE*
Newton	60	k = 0.205749		0.9911	6.068E-03	0.0761
	70	k = 0.299338		0.9941	1.468E-03	0.0376
	80	k = 0.422488		0.9952	4.633E-03	0.0210
Page	60	k = 0.268129	n = 0.8700778	0.9947	1.068E-03	0.0098
	70	k = 0.358066	n = 0.8652157	0.9938	8.974E-03	0.0029
	80	k = 0.441359	n = 0.9512712	0.9957	8.717E-03	0.0288
Modified Page	60	k = 0.213390	n = 0.8700778	0.9947	1.007E-03	0.0981
	70	k = 0.358066	n = 0.8652158	0.9932	8.974E-03	0.0129
	80	k = 0.423250	n = 0.9512711	0.9957	8.717E-03	0.0288
Henderson & Pabis	60	k = 0.195210	a = 0.9575657	0.9933	8.549E-03	0.0690
	70	k = 0.284939	a = 0.9655231	0.9956	7.627E-03	0.08541
	80	k = 0.414757	a = 0.9875408	0.9954	2.782E-03	0.0163
Logarithmic	60	k = 0.194381 c = 1.193E-03	a = 0.9583264	0.9983	7.014E-05	0.0032
	70	k = 0.294939 c = 9.1998E-03	a = 0.9599621	0.9969	6.418E-04	0.0048
	80	k = 0.415013 c = 1.8291E-04	a = 0.9874215	0.9974	8.813E-05	0.0019

Model	Temperature/℃	Model constants		R^2	χ^2	*RMSE*
Wang & Singh	60	a = -9.9407E-02	b = 2.2506E-03	0.8815	5.731E-03	0.4040
	70	a = -1.2210E-02	b = 3.3335E-03	0.8248	8.907E-03	0.9230
	80	a = -0.1806E-02	b = 7.2423E-03	0.8685	8.837E-03	0.6471
Two Term	60	k_o = 1.598253 k_1 = 0.175612	b = 0.85747854 a = 0.15388722	0.9861	5.635E-03	0.0093
	70	k_o = 1.017838 k_1 = 0.233321	b = 0.76543623 a = 0.23878462	0.9881	1.105E-03	0.0902
	80	k_o = 1.256258 k_1 = 0.381318	b = 0.11243398 a = 0.88913071	0.9958	1.233E-03	0.0812

Table 4 Values of the drying constants and coefficients of mathematical models through non-linear regression analysis method for blanched field pumpkin slices (30 mm thickness)

Model	Temperature/℃	Model constants		R^2	χ^2	*RMSE*
Newton	60	k = 0.203703		0.9919	4.367E-03	0.2044
	70	k = 0.288942		0.9937	3.136E-03	0.1732
	80	k = 0.385666		0.9899	6.038E-03	0.0239
Page	60	k = 0.256385	n = 0.8748328	0.9949	1.506E-03	0.0379
	70	k = 0.352927	n = 0.8559847	0.9977	4.214E-03	0.0207
	80	k = 0.426836	n = 0.9020008	0.9916	1.696E-03	0.0040
Modified Page	60	k = 0.211018	n = 0.8748329	0.9949	1.506E-03	0.0037
	70	k = 0.352927	n = 0.8559847	0.9977	4.214E-04	0.0200
	80	k = 0.426836	n = 0.9020000	0.9916	1.696E-03	0.0408
Henderson & Pabis	60	k = 0.193295	a = 0.9596315	0.9939	1.596E-07	0.3907
	70	k = 0.272940	a = 0.9596315	0.9954	4.938E-07	0.0687
	80	k = 0.371911	a = 0.9756658	0.9904	1.934E-08	0.0136
Logarithmic	60	k = 0.192766 c = 7.607E-04	a = 0.9577971	0.9969	2.388E-12	0.0002
	70	k = 0.567922 c = 6.652E-03	a = 0.9627371	0.9971	1.696E-07	0.0046
	80	k = 0.373773 c = 1.412E-03	a = 0.9747753	0.9969	4.696E-23	0.0097
Wang & Singh	60	a = -8.80E-02	b = 1.728E-02	0.8304	1.593E-04	0.1234
	70	a = 1.091E-01	b = 2.471E-03	0.7841	1.027E-04	0.1198
	80	a = 1.520E-01	b = 5.090E-03	0.8269	4.696E-03	0.0902
Two Term	60	k_o = 1.754112 k_1 = 0.175984	a = 0.1411843 b = 0.8688639	0.9963	1.092E-06	0.0000571
	70	k_o = 1.258258 k_1 = 0.230985	a = 0.8005953 a = 0.2033549	0.9981	1.0715E-06	0.00010124
	80	k_o = 1.502648 k_1 = 0.322208	a = 0.8333818 b = 0.1762040	0.9922	9.774E-05	0.0099128

4 Conclusions

The drying characteristics of the blanched field pumpkin were studied in a convective hot air dryer as single layer with the thickness of 10, 20 and 30 mm at the drying air temperatures of 60℃, 70℃ and 80℃. The moisture ratio, drying rate, drying rate constants, and moisture diffusivities were affected by drying air temperature and slice thickness. The effective moisture diffusivities, drying rates, rate constants and activation energy for moisture removal increased with increase in drying temperature. Increasing slice thickness caused decrease in drying rate constants and increase in moisture diffusivities. The Logarithmic model gave the highest values for the coefficient of determination (R^2) and the lowest values of reduced chi-square (χ^2), and a lower root means square error analysis (*RMSE*) among the seven models was considered the best model for describing the drying behaviour of blanched field pumpkin slices. Effective moisture diffusivity values varied from 1.17×10^{-9} to 6.75×10^{-9} m^2 s^{-1}. The activation energy was found to range from 24.59 to 26.45 kJ mol^{-1} as slice thickness increased from 10 to 30 mm.

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