Research Article

Drying Kinetics of Eggplant (*Solanum melongena*) in a Fluidized Bed Dryer: Experimental Evaluation and Modelling

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The drying kinetics of eggplant were studied experimentally in a laboratory-scale fluidized bed dryer. Experiments were conducted at drying temperatures of 60, 70, and 80°C and at constant air velocity of 3.10 ms⁻¹. The drying rate and moisture ratio were determined as a function of time. At any given temperature, only the falling rate period was observed during the drying process. Effective moisture diffusivity was in the range 2.667–4.311 × 10⁻⁸ m²/s while activation energy of 23.5 kJ mol⁻¹ was obtained from the Arrhenius equation. The experimental moisture ratio data was fitted to ten mathematical models. Statistical analysis showed that the by Demir et al. has the best fit quality. In terms of product quality, the dried samples had low rehydration ratio of 4.889. In addition, compared to direct sunlight drying, the dried product from the fluidized bed dryer exhibited better color quality.

1. Introduction

Drying, or dehydration, is an important industrial process that involves the removal of moisture from a wet solid by means of facilitated heat and mass transfer [1]. Dehydration is considered an important process in food process industries since it helps preserve food and improves food quality and hygienic conditions. This means that specific fruits and vegetables can be consumed throughout the year and acute shortages caused by the shift in agricultural seasons can be avoided [2]. Such an approach has been used for centuries by means of traditional sun-drying technique [3].

Dried fruits and vegetables are important for a number of reasons. For instance, apricots, raisins, dates, figs, and plums are consumed as dried fruits because they have nutritional benefits attributed to their low carbohydrate and fat content. In addition, dried vegetables such as onions and garlic are used mainly as flavor additives while other dried vegetables such as peas, carrots, celery, and corn are used as dried snacks [4]. Another important reason behind drying vegetables and fruits is to facilitate transportation and storage. Fresh raw fruits and vegetables are not easy

to transport. However, drying these agricultural products under appropriate conditions makes the transportation process significantly easier without losing a noticeable amount of contained vitamins [3]. Drying also prevents microbial contamination by reducing the water activity of the fresh agricultural commodities [5]. In the presence of moisture, pathogens can colonize the fruits and vegetables, producing mycotoxins that possess a health hazard to consumers [2]. Furthermore, under optimized drying conditions and temperature, drying can also enhance the product quality [5].

Fluidized bed dryers have been widely used for drying various agricultural products such as apple [6, 7], olive pomace [8], canola [9], soybeans [10], castor oil seeds [11], bird's eye chilli [12], red bell pepper [13], carrots [14], black tea [15], baker's yeast [16], coconut [17], and hazelnut [18]. Fluidized bed drying, a technique that was originally adapted for catalytic cracking of crude oil, offers several advantages over other types of drying such as solar drying, freeze drying, osmotic dehydration, spray drying, and vacuum drying [19, 20]. The main advantage is the thorough mixing of solids in this drying process which results in efficient mass and heat transfer, thus leading to rapid and economic drying [21–25].

Furthermore, inherent characteristics such as temperature uniformity and ease of control make fluidized bed dryers highly suitable for drying heat-sensitive products [22, 23, 25]. Also, fluidized bed dryers allow for easy handling and transport of the dried products which makes them appropriate for industrial purposes [19]. The main limitations of fluidized bed drying include loss of product qualities such as color, texture, flavor, and nutrients [3]. However, such drawbacks can be avoided by using appropriate drying conditions.

Studying the drying kinetics and the drying rate of agricultural products is important in order to minimize energy consumption and, accordingly, the cost of the drying process by determining the optimum drying conditions [26]. Several factors affect drying rate during the falling rate period such as air temperature and velocity and shape of the material to be dried. However, the temperature of the air is considered to be the most important factor affecting the drying process [27]. Drying rate increases significantly with an increase in hot air temperature which subsequently decreases the drying time [1, 28, 29]. However, it is crucial to optimize the temperature to attain maximum drying without cooking the foods or causing case hardening and shrinkage [30]. In addition, several studies have shown pretreatment to be another important factor in decreasing the drying time [31, 32]. Hot water blanching, pulsed electric field, and high-pressure treatment are among the existing methods of pretreatment that increase drying rate and improve the quality of the final dried product [32, 33]. Pretreatment of the sample also increases the brightness of the dried sample [1]. This is an important consideration since the color of the dried fruit or vegetable has a primary role in the consumer's perception [34].

To accurately predict the drying kinetics, several drying models have been developed and used taking into consideration the aforementioned factors. Most of these models are based on the principle that the moisture gradient is the driving force in the drying process and, therefore, these models use the temperature-dependent diffusion equations and first-order rate kinetics [35]. The reliability of such models in predicting the drying curves of different vegetables has been confirmed elsewhere in the literature [28, 36].

Eggplant (*Solanum melongena*) is an important agricultural product that is cultivated on a large scale in various countries. According to statistics by the Food and Agricultural Organization (FAO) of the United Nations, the total production of eggplants in the year 2013 was approximately 49.4 million tons [37]. Among all the eggplant-producing countries, Spain, Mexico, and Netherlands represent the top three exporters of eggplants [38]. Drying of eggplants is important for ensuring easy shipment and yearlong use in regions such as the Middle East and for use as an ingredient in soups and sauces [39]. Drying kinetics of eggplant have already been investigated using convective hot air dryer [1, 40], cabinet dryer [41], vacuum dryer [42], and ultrasonically assisted convective drying [43]. However, fluidized bed drying characteristics of eggplant are not reported in the literature. The aim of this study was to study the drying behavior and the drying kinetics of eggplant in a laboratory-scale fluidized bed dryer. The effect of hot air temperature

on drying rate and moisture ratio was investigated and the temperature-dependent effective moisture diffusivities were estimated using Fick's second law of diffusion. The experimental drying data was fitted to different mathematical models and, finally, rigorous statistical analysis was used to identify the best mathematical model.

2. Materials and Methods

2.1. Preparation of Eggplant Samples. The eggplants (*Solanum melongena* var. Black Enorma) used in this study were originally cultivated in Netherlands and obtained from a local supermarket in Sharjah, United Arab Emirates. After washing with tap water and allowing for stabilization at room temperature, the eggplants were peeled and then cut into 5.5 mm homogeneous cubes using a lab utility knife. The prepared samples were used for the drying experiments on the same day. The initial moisture content of the samples was obtained by averaging the initial moisture contents from all the experimental runs and was found to be 0.986 kg H₂O kg⁻¹ wet mass (98.6 wt.% water).

2.2. Drying Equipment and Procedure. Drying experiments were performed in a laboratory-scale batch fluidized bed dryer (Model: FT-31, Armfield, UK). The cabinet of this dryer consists of an inlet air filter, an electrical heater, a two-term (PI) temperature controller, a sequence timer, and a centrifugal air blower fan. The heater is a simple finned element with 2 kW power rating. The temperature controller can be used to set the hot air inlet temperature between 20 and 200°C with an offset of $\pm 1^\circ\text{C}$ over the entire operating range. The timer can be used for automatic drying cycles with duration up to 6 h. The dryer also allows for varying the air velocity by means of a blower speed control graduated from 1 to 10 corresponding to air velocities from 1.80 to 3.65 ms⁻¹. The drying chamber consists of a glass column, 16 cm in diameter and 25 cm in height, fitted with a filter bag over the top in order to retain the dried product. The base of the drying chamber consists of a nylon air distributor and stainless steel support gauze. The schematic diagram of the fluidized bed dryer is shown in Figure 1.

The samples were dried at hot air inlet temperatures of 60, 70, and 80°C. Exactly 14 g of freshly prepared eggplant sample was used for each experimental run. The mass was measured using a digital analytical balance (Model: WG5000, Adam Equipment, USA, accuracy of ± 0.1 g). The same balance was used to measure the mass of the empty drying chamber along with the filter bag. For each run, the bed was fluidized at constant air velocity of 3.10 ms⁻¹. The sample was placed in the drying chamber which was then covered with filter bag. The timer was set to 5 min. After every five minutes, the dryer switched off automatically and the total mass of the drying chamber, filter bag, and the sample was measured within 10–15 s. The drying process was then resumed. This procedure was repeated until the total mass of the drying chamber, filter bag, and the sample was constant; that is, the sample was completely dried. During the experiments, the ambient air temperature and the relative humidity varied in the ranges

FIGURE 1: Schematic diagram of the experimental fluidized bed dryer. (1) Drying cabinet with timer, temperature controller, and on/off controls. (2) Fluidized drying chamber. (3) Electrical heater. (4) Blower. (5) Drying cabinet base. (6) Drying chamber base with air distributor and support gauze. (7) Inlet air filter. (8) Filter bag.

22–23°C and 55–68%, respectively. The mass of eggplant sample at any time inside the drying chamber was calculated by subtracting the mass of the empty drying chamber along with the filter bag from the total mass of the drying chamber, filter bag, and the sample. Each drying experiment was replicated three times and the average kinetic data for the three trials along with the standard error has been reported.

2.3. Determination of Moisture Content and Moisture Ratio. The moisture content (X), expressed as $\text{kg H}_2\text{O kg}^{-1}$ dry mass, was calculated as a function of time using the following equation:

$$X = \frac{m_w}{m_{db}} = \frac{m_s - m_{db}}{m_{db}}, \quad (1)$$

where m_w is the mass of water in the sample at any time t , m_{db} is the mass of the dried sample, and m_s is the mass of the sample inside the drying chamber at time t .

The moisture ratio (MR) was then calculated by expressing the moisture content in the following dimensionless form:

$$\text{MR} = \frac{X - X_e}{X_0 - X_e}, \quad (2)$$

where X is the moisture content at any time t , X_0 is the initial moisture content, and X_e is the equilibrium content.

2.4. Determination of Drying Rate. The drying rate (DR) was expressed as the amount of moisture lost by the sample over time. Mathematically, it can be expressed in $\text{kg H}_2\text{O kg}^{-1}$ dry mass min^{-1} as follows:

$$\text{DR} = \frac{X_t - X_{t+dt}}{dt}, \quad (3)$$

where X_t is the moisture content at times t and $t + dt$, respectively, and dt is the drying time.

2.5. Rehydration Test. In order to assess the quality of the dried eggplant samples, the rehydration ratio was determined by placing a sample of the product dried at 80°C in a beaker of deionized water for 24 h. At the end of the test, excess water was drained and the mass of rehydrated sample was measured. The rehydration ratio (RR) was calculated as follows:

$$\text{RR} = \frac{m_r}{m_{db}}, \quad (4)$$

where m_r is the mass of the rehydrated eggplant sample and m_{db} is the mass of the dried sample used for rehydration.

Rehydration test was also performed by exposing another sample of the dried product to ambient moist air in the laboratory with relative humidity between 55 and 68%. The test duration was again 24 h.

2.6. Direct Sunlight Drying. For product quality comparisons, a fresh sample of eggplants was dried under direct sunlight. Exactly 14 g of fresh sample (5.5 mm cubes) was placed under direct sunlight in a glass container. The highest and lowest ambient temperatures observed were 46 and 44°C. Other observed climatic conditions were humidity of 16% and wind speed of 28 kmh^{-1} (West) [44].

2.7. Estimation of Effective Moisture Diffusivity. The effective moisture diffusivities at different temperatures were calculated by applying Fick's second law of diffusion. This law has been widely accepted to describe the falling rate period of different agricultural products [45]. The general solution to this law is given below [46]:

$$\text{MR} = \frac{8}{\pi^2} \sum_{n=0}^{\infty} \frac{1}{(2n+1)^2} e^{-(2n+1)^2 \pi^2 D_e t / 4L^2}, \quad (5)$$

where t is the drying time (s), D_e is the effective diffusivity (m^2/s), and L is half slab thickness of the eggplant cubes (m). Equation (5) is strictly true for cases where moisture movement is only by diffusion and external resistance is negligible. In addition, (5) assumes negligible shrinkage of the samples and constant diffusion coefficients and temperature [8].

For long periods of drying, (5) can be simplified by accounting only for the first term of the infinite series [8, 47]. This simplification results in the following equations:

$$\text{MR} = \frac{8}{\pi^2} e^{-\pi^2 D_e t / 4L^2}, \quad (6)$$

$$\ln(\text{MR}) = \ln\left(\frac{8}{\pi^2}\right) - \frac{\pi^2 D_e t}{4L^2}. \quad (7)$$

Equation (7) can be used to find the effective moisture diffusivity at any temperature from the slope of $\ln(\text{MR})$ versus the drying time t graph.

In order to describe the effect of temperature on the effective moisture diffusivity, the following Arrhenius-type equation was used [8, 13]:

$$D_e = D_0 e^{-E_a/RT}, \quad (8)$$

where D_0 is the preexponential factor or the diffusivity at infinite temperature (m^2/s), E_a is the activation energy (kJ mol^{-1}), R is the universal gas constant

($0.008314 \text{ kJ mol}^{-1} \text{ K}^{-1}$), and T is the absolute temperature (K).

2.8. Statistical Analysis of Drying Models. MS Excel was used to fit different mathematical models to the experiment moisture ratio data. In order to quantify the fit quality of the models, coefficient of determination (R^2), reduced sum square error (SSE), root mean square error (RMSE), and reduced Chi-square (χ^2) were calculated for different mathematical models using the following equations:

$$\begin{aligned} R^2 &= \left[\frac{n \sum_{i=1}^n \text{MR}_{e,i} \cdot \text{MR}_{m,i} - \sum_{i=1}^n \text{MR}_{e,i} \cdot \sum_{i=1}^n \text{MR}_{m,i}}{\sqrt{n \left(\sum_{i=1}^n \text{MR}_{e,i}^2 \right) - \left(\sum_{i=1}^n \text{MR}_{e,i} \right)^2} \sqrt{n \left(\sum_{i=1}^n \text{MR}_{m,i}^2 \right) - \left(\sum_{i=1}^n \text{MR}_{m,i} \right)^2}} \right]^2, \\ \text{SSE} &= \frac{\sum_{i=1}^n (\text{MR}_{e,i} - \text{MR}_{m,i})^2}{n}, \\ \text{RMSE} &= \sqrt{\frac{\sum_{i=1}^n (\text{MR}_{e,i} - \text{MR}_{m,i})^2}{n}}, \\ \chi^2 &= \frac{\sum_{i=1}^n (\text{MR}_{e,i} - \text{MR}_{m,i})^2}{n - c}, \end{aligned} \quad (9)$$

where $\text{MR}_{e,i}$ is the experimental moisture ratio, $\text{MR}_{m,i}$ is the moisture ratio predicted from the model equation, n is the number of data points, and c is the number of constants in the model equation.

3. Results and Discussion

3.1. Drying Rate. The drying rate (DR) curves as a function of time at drying temperatures of 60, 70, and 80°C along with the standard error bars are shown in Figure 2.

At any given temperature, the drying rate decreased with time due to decrease in moisture content of the eggplant samples. Lower moisture content resulted in less movement of water to the surface and, therefore, less evaporation from the surface with time. The initial drying rate was observed to be highest at 80°C and lowest at 60°C. This is because, for the same initial moisture content, higher air inlet temperature removed moisture at a faster rate. However, at later time instants, the drying rate at 60°C was higher than at 80°C since the moisture content in the sample was higher at 60°C compared to the moisture content at 80°C at the same time instant. The standard errors in Figure 2 are relatively small indicating good repeatability of the experiments.

3.2. Drying Curves. The drying curves (moisture ratio versus time) at drying temperatures of 60, 70, and 80°C along with the standard error bars are shown in Figure 3. The moisture ratio decreased with time at all drying temperatures. Similar trend was observed during drying of other food materials in fluidized bed [6–13, 48] and other types of dryers

[28, 49–55]. At any instant of time, moisture ratio was lower at higher drying temperature. Higher drying temperature also reduced the time for complete drying of the eggplant samples. Eggplant samples were completely dry after 30, 25, and 20 min at drying temperature of 60, 70, and 80°C, respectively. The equilibrium moisture content (X_e) was zero for all the experimental runs. In addition, the experiment had good repeatability as indicated by the low values of standard error in Figure 3.

As depicted in Figure 4, drying of eggplant in the fluidized bed dryer was described only by the falling rate period. The increasing and constant rate periods were not observed. This is due to the fact that the fresh eggplant samples were free of surface moisture. During the drying process, only the moisture within the eggplants moved to surface and was then evaporated resulting in the falling rate period. In fact, the drying of most food materials is defined only by the falling rate period [13].

3.3. Effective Moisture Diffusivity and Activation Energy. The effective moisture diffusivity values were calculated for temperatures of 60, 70, and 80°C by plotting (7) as shown in Figure 5. The diffusivity and R^2 values are tabulated in Table 1.

Compared to the previous studies on eggplant drying in other types of dryers [40, 41], higher moisture diffusivities were found in this study by using fluidized bed dryer and larger sample size. Effective moisture diffusivity values in the range $5.575\text{--}9.745 \times 10^{-10} \text{ m}^2/\text{s}$ have been reported for eggplant drying in a cabinet dryer [41] while effective moisture diffusivity values in the range $0.93\text{--}8.84 \times 10^{-10} \text{ m}^2/\text{s}$ have

FIGURE 2: Experimental drying rate (DR) of eggplant versus drying time in the fluidized bed dryer at drying temperatures of 60, 70, and 80°C. Air velocity kept constant at 3.10 ms^{-1} .

FIGURE 3: Experimental moisture ratio (MR) of eggplant versus drying time in the fluidized bed dryer at drying temperatures of 60, 70, and 80°C. Air velocity kept constant at 3.10 ms^{-1} .

been reported during convective drying within a temperature range of 50–80°C [40]. As tabulated in Table 1, the effective moisture diffusivities in this study were found to be in the range $2.667\text{--}4.311 \times 10^{-8} \text{ m}^2/\text{s}$ within the temperature range of 60–80°C.

Using (8), The plot of $\ln(D_e)$ versus $1/T$ exhibited a linear relationship (Figure 6) with a good fit quality ($R^2 = 0.9924$). The activation energy (E_a) and the preexponential factor (D_0) were found to be 23.5 kJ mol^{-1} and $1.322 \times 10^{-4} \text{ m}^2/\text{s}$, respectively.

FIGURE 4: Drying rate (DR) versus moisture ratio (MR) at drying temperatures of 60, 70, and 80°C. Air velocity kept constant at 3.10 ms^{-1} .

FIGURE 5: Experimental $\ln(\text{MR})$ versus drying time at temperatures of 60, 70, and 80°C.

TABLE 1: Effective moisture diffusivity (D_e) values at different drying temperatures.

Temperature, T ($^{\circ}\text{C}$)	Effective moisture diffusivity, D_e (m^2/s)	R^2
60	2.667×10^{-8}	0.9993
70	3.541×10^{-8}	0.9983
80	4.311×10^{-8}	0.9904

The effect of temperature on effective moisture diffusivity was, thus, given by the following equation:

$$D_e = 1.322 \times 10^{-4} e^{-2830.7/T}, \quad (10)$$

TABLE 2: Mathematical models used to describe the drying kinetics of eggplants [6].

Model number	Model equation	Model name	Reference
1	$MR = e^{-kt}$	Newton	[57]
2	$MR = a \cdot e^{-kt}$	Henderson and Pabis	[58]
3	$MR = a \cdot e^{-kt} + b$	Logarithmic	[59]
4	$MR = a \cdot e^{-k_1 t} + b \cdot e^{-k_2 t}$	Two-term	[60]
5	$MR = a \cdot e^{-kt} + (1 - a) \cdot e^{-akt}$	Two-term exponential	[61]
6	$MR = a \cdot e^{-kt} + (1 - a) \cdot e^{-bkt}$	Diffusion approach	[62]
7	$MR = e^{-kt^n}$	Page	[63]
8	$MR = e^{-(kt)^n}$	Modified Page	[64]
9	$MR = a \cdot e^{-(kt)^n}$	Ademiluyi et al.	[65]
10	$MR = a \cdot e^{-(kt)^n} + b$	Demir et al.	[56]

FIGURE 6: Linear relation between $\ln(D_e)$ and $1/T$ at temperatures dictated by the Arrhenius-type relationship.

where D_e has the unit m^2/s and T is the absolute temperature in K.

3.4. Mathematical Modelling and Statistical Analysis of Drying Curves. The experimental drying kinetic data at each temperature was fitted to the ten different models summarized in Table 2. All these models contain the moisture ratio (MR) as the dependent variable and drying time (t) as the independent variable. The models were fitted to the experimental moisture ratio data using nonlinear regression in MS Excel.

The values of model constants, coefficient of determination (R^2), reduced sum square error (SSE), root mean square error (RMSE), and reduced Chi-square (χ^2) are summarized for each drying temperature in Table 3. In order to select the best model, the simple criteria of highest R^2 and lowest SSE, RMSE, and χ^2 were used. All models fitted the experimental drying data very well with $R^2 \geq 0.9990$ and reasonably low values of SSE, RMSE, and χ^2 . However, the model by Demir et al. [56] described the drying data with highest R^2 and lowest SSE, RMSE, and χ^2 and, therefore, was selected as the best model to describe drying kinetics of eggplants in a fluidized bed dryer. Figure 7 shows a comparison between

FIGURE 7: Comparison of experimental and predicted moisture ratio for model by Demir et al. [56].

the experimental moisture ratio values and the moisture ratio predicted from the model of Demir et al. [56].

3.5. Rehydration Test Results. After 24 h of rehydration in deionized water, the eggplant samples were found to have a rehydration ratio (RR) of 4.889 as given by (4). Based on the rehydration ratio, the final moisture content after rehydration was $3.889 \text{ kg H}_2\text{O kg}^{-1}$ dry mass. Thus, the eggplant samples rehydrated partially and not completely to their initial moisture content. This indicates good quality of the dried eggplant product from the fluidized bed dryer. In case of rehydration on exposure to moist ambient air for 24 h, the rehydration ratio was found to be zero. This again indicates good quality of the dried product.

3.6. Comparison with Direct Sunlight Drying. In case of direct sunlight drying (temperature between 44 and 46°C), the sample was dry completely after 4 h. Compared to drying in fluidized bed dryer, direct sunlight drying took a longer period for complete drying. In addition, the color quality

TABLE 3: Results of mathematical modelling and statistical analysis of the experimental moisture ratio data.

T (°C)	Model name	Model constants	R^2	SSE	RMSE	χ^2
60	Newton	$k: 0.1376$	0.9993	7.959×10^{-5}	0.0089	9.285×10^{-5}
	Henderson and Pabis	$k: 0.1373; a: 0.9972$	0.9993	7.836×10^{-5}	0.0089	1.097×10^{-4}
	Logarithmic	$k: 0.1373; a: 0.9972; b: 0$	0.9993	7.836×10^{-5}	0.0089	1.371×10^{-4}
	Two-term	$k_1: 4.303; k_2: 0.1325; a: 0.0427; b: 0.9573$	0.9995	6.066×10^{-5}	0.0078	1.415×10^{-4}
	Two-term exponential	$k: 0.1509; a: 0.7271$	0.9993	7.624×10^{-5}	0.0087	1.067×10^{-4}
	Diffusion approach	$k: 1.849; a: 0.0427; b: 0.0716$	0.9995	6.066×10^{-5}	0.0078	1.061×10^{-4}
	Page	$k: 0.1471; n: 0.9708$	0.9995	6.669×10^{-5}	0.0082	9.336×10^{-5}
	Modified Page	$k: 0.1389; n: 0.9708$	0.9995	6.669×10^{-5}	0.0082	9.336×10^{-5}
	Ademiluyi et al.	$k: 0.1387; n: 0.9713; a: 0.9994$	0.9995	6.664×10^{-5}	0.0082	1.166×10^{-4}
70	Demir et al.	$k: 0.1301; n: 0.8906; a: 1.032; b: -0.0316$	0.9999	1.306×10^{-5}	0.0036	3.046×10^{-5}
	Newton	$k: 0.1715$	0.9993	1.116×10^{-4}	0.0106	1.339×10^{-5}
	Henderson and Pabis	$k: 0.1716; a: 1.001$	0.9993	1.114×10^{-4}	0.0105	1.672×10^{-4}
	Logarithmic	$k: 0.1716; a: 1.001; b: 0$	0.9993	1.114×10^{-4}	0.0105	2.229×10^{-4}
	Two-term	$k_1: 4.303; k_2: 0.1751; a: -0.0267; b: 1.027$	0.9999	1.076×10^{-4}	0.0104	3.226×10^{-4}
	Two-term exponential	$k: 0.1898; a: 1.372$	0.9993	9.403×10^{-5}	0.0097	1.410×10^{-4}
	Diffusion approach	$k: 2.125; a: -0.0267; b: 0.0823$	0.9993	1.075×10^{-4}	0.0104	2.151×10^{-4}
	Page	$k: 0.1597; n: 1.034$	0.9993	9.856×10^{-5}	0.0099	1.478×10^{-4}
	Modified Page	$k: 0.1696; n: 1.034$	0.9993	9.856×10^{-5}	0.0099	1.478×10^{-4}
80	Ademiluyi et al.	$k: 0.1695; n: 1.034; a: 0.9993$	0.9993	9.847×10^{-5}	0.0099	1.967×10^{-4}
	Demir et al.	$k: 0.1599; n: 0.9321; a: 1.032; b: -0.0326$	0.9999	1.876×10^{-5}	0.0043	5.627×10^{-5}
	Newton	$k: 0.1951$	0.9991	1.567×10^{-4}	0.0125	1.958×10^{-4}
	Henderson and Pabis	$k: 0.1952; a: 1.001$	0.9991	1.567×10^{-4}	0.0125	2.609×10^{-4}
	Logarithmic	$k: 0.1952; a: 1.001; b: 0$	0.9991	1.567×10^{-4}	0.0125	3.914×10^{-4}
	Two-term	$k_1: 4.303; k_2: 0.2002; a: -0.0348; b: 1.035$	0.9990	1.516×10^{-4}	0.0123	7.580×10^{-4}
	Two-term exponential	$k: 0.2167; a: 1.382$	0.9991	1.380×10^{-4}	0.0117	2.300×10^{-4}
	Diffusion approach	$k: 2.272; a: -0.0348; b: 0.0881$	0.9990	1.152×10^{-4}	0.0123	3.790×10^{-4}
	Page	$k: 0.1807; n: 1.039$	0.9991	1.142×10^{-4}	0.0119	2.366×10^{-4}
	Modified Page	$k: 0.1926; n: 1.039$	0.9991	1.142×10^{-4}	0.0119	2.366×10^{-4}
	Ademiluyi et al.	$k: 0.1925; n: 1.039; a: 0.9995$	0.9991	1.419×10^{-4}	0.0119	3.548×10^{-4}
	Demir et al.	$k: 0.1743; n: 0.8725; a: 1.057; b: -0.0575$	0.9999	1.794×10^{-5}	0.0042	8.971×10^{-5}

(a)

(b)

(c)

FIGURE 8: Comparison of color quality of (a) fresh eggplant sample, (b) dried product from fluidized bed dryer at 80°C, and (c) dried product from direct sunlight drying.

of the dried product was different for the two cases. Direct sunlight drying resulted in dried eggplant with a very poor color quality. This is due to high degree of burn caused by sunlight. Figure 8 shows a color comparison between the fresh eggplant sample and the dried samples from the fluidized bed dryer and direct sunlight drying.

As depicted in Figure 8, in terms of color quality, the product from the fluidized bed dryer was better when compared to the product from direct sunlight drying. In fact, fluidized bed dryer resulted in minimal color change of the product compared to the fresh eggplant sample.

4. Conclusion

In conclusion, drying of eggplants in the fluidized bed dryer was only described by the falling rate period. Both the drying rate and moisture ratio decreased with time. Higher drying temperature decreased the drying time and increased the effective moisture diffusivity. Although all the models considered fitted the experimental drying data very well, the model by Demir et al. showed the highest coefficient of determination and lowest values of reduced sum square error, root mean square error, and reduced Chi-square. Fluidized bed drying, therefore, provides a practical and feasible method for drying and preservation of eggplants while maintaining the qualitative characteristics such as low rehydration ratio and good color quality.

Conflict of Interests

The authors declare no conflict of interests.

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