# DRYING BEHAVIOR AND SOME QUALITY PARAMETERS OF POTATO FINGER CHIPS USING INFRARED RADIATION

İ. DOYMAZ

*Department of Chemical Engineering, Yildiz Technical University, 34220 Esenler, Istanbul, TURKEY.*
*doymaz@yildiz.edu.tr*

***Abstract*— The effect of different infrared (IR) powers on drying of potato finger chips was investigated in infrared dryer. The potato finger chips dried at 38, 50, 62, 74 and 88 W infrared powers and constant slice thickness of 7 mm. Results showed that drying characteristics of potato chips were greatly influenced by infrared power. The experimental drying data were fitted to seven thin-layer drying models. The models were compared on coefficient of determination ($R^2$), reduced chi-square ($\chi^2$) and root mean square error (RMSE) values between experimental and predicted moisture ratios. The Midilli and Kucuk model was found to the best in predicting the drying kinetics of potato chips during infrared drying. The effective moisture diffusivity using the Fick's diffusion model varied from $1.82\times10^{-9}$ to $3.06\times10^{-9}$ m$^2$/s. It was found that the effective moisture diffusivity increased with increasing IR power. Activation energy was estimated by a modified Arrhenius type equation as 1.35 kW/kg. The results also showed that with increasing infrared power, rehydration capacity was decreased**.

***Keywords*— Activation energy; effective moisture diffusivity; infrared drying; mathematical modelling; potato finger chips**

## I. INTRODUCTION

As the fourth most important food crop in the world after maize, wheat and rice, potato (*Solanum tuberosum* L.) plays an important role in the human diet. Potato is a fat-free food containing, carbohydrate, protein, vitamins and minerals (Qiu *et al*., 2019). The annual world production of potatoes in 2019 was 370.4 million tons. Major producing countries are China, Indian, Russian Federation, Ukraine and United States of America. Potato production in Turkey was about 4.97 million tons in 2019 (FAO, 2020). A possible method of storing potatoes and avoiding further deterioration is by drying treatment of the product. Provides protection against both physicochemical and microbiological degradation reactions due to the reduction of water content in potatoes (Rosselló *et al*. 1992).

As a preservation method drying is a very important aspect of food processing. The main function of drying is to lower the water activity of the product and consequently, to inhibit the growth of microorganisms and decrease chemical reactions in order to prolong the shelf life of the product at room temperature (Hamrouni-Sellami *et al.*, 2013). Potato is commonly preserved by using the hot-air drying method both industrially and commercially. The hot-air drying method often leads to prolong drying time, high energy consumption, and reduced quality of final products especially at high drying temperatures (Onwude *et al.*, 2018). Therefore, instead of hot-air drying, more innovative drying methods should be used. One of these methods is infrared drying. Compared to traditional drying technology, infrared drying technology has the advantages of high energy efficiency, short drying time, uniform heating of materials, easy control of material temperature, good quality of the final products and low energy costs (Huang *et al.*, 2020).

Some agricultural products undergo some pre-treatments before drying. This is to prevent changes in the color and texture of the product. Besides, the pre-treatments increase the drying speed and consequently reduce the drying time. For this purpose, food products to be dried are treated with different solutions. Potassium hydroxide, potassium carbonate, potassium metabisulphate, methyl and ethyl ester emulsions, citric acid and ascorbic acid are the most common and commercially used some pretreatments (Dinrifo, 2012; Doymaz, 2012).

Several researches have studied the drying of potato slices such as convective (Chayjan, 2012; Dinrifo, 2012; Doymaz, 2012; Naderinezhad *et al.*, 2016), microwave (Song *et al*., 2009; Zhao *et al.*, 2016) and solar drying (Dhalsamant *et al*., 2017). However, some researches have been carried out on infrared or infrared-assisted drying of potato and other agricultural crops. Onwude *et al*. (2018) studied the mass and heat transfer characteristics of sweet potato slices during mid-infrared drying. Doymaz (2015) investigated the infrared drying of carrot and described the drying processes using empirical thin layer drying models. Doymaz (2017) studied the effect of different infrared power levels on the drying kinetics of eggplant slices and observed that an increased in power level resulted in a reduction in drying time. In another study, the drying characteristics, physico-chemical and functional properties of purple potato slices dried using different drying methods (vacuum freeze, hot-air and far-infrared heat-pump) were investigated by Qui *et al*. (2019). The main objectives of this study to: (1) investigate the effect of infrared power on drying, rehydration and color characteristics, and (2) compute effective moisture diffusivity and activation energy for potato finger chips.

## II. MATERIAL AND METHODS

### A. Material

Fresh potatoes (*Solanum tuberosum* L) were purchased from a local market in Istanbul, Turkey. Before drying process, the potato samples washed with water, peeled and then cut into 7 mm thick with cutting machine. Potato finger chips were divided into 2 sample lots before use. One lot of potato chips was soaked in an aqueous solution containing 1% citric acid (CA) for 2 min. The other lot was untreated (CONTROL).

The initial moisture content of potato chips slices was determined by using an oven at 105°C for 24 h. Triplicate samples were used for the determination of moisture content and the average values were reported as 74.30%, w.b. (2.892 kg water/kg dry matter, d.b.).

### B. Experimental procedure

Drying experiments were carried out in a moisture analyzer with one 250 W halogen lamp (Snijders Moisture Balance, Snijders b.v., Tilburg, Holland). Before infrared drying process, potato slices (approximately 35±0.5 g) were separated evenly and homogeneously over the pan. The drying experiments were performed at infrared power level varying from 38, 50, 62, 74 and 88 W, determined with a digital energy meter (PeakTech 9035, Germany). In addition, in order to observe the effect of the pretreatment solution, some finger potato slices were treated with citric acid solution and dried at 62 W IR power level. The power level was set in control unit of equipment. Weight loss of samples was recorded at regular intervals of 10 min during drying using a digital balance (model BB3000, Mettler-Toledo AG, Grefensee, Switzerland), which has 0-3000 g measurement range with reading accuracy of 0.1 g. Drying was stopped when the moisture content of samples were approximately 0.10±0.01 kg water /kg dry matter (d.b.). The dried product was cooled and packaged in low-density polyethylene bags then heat-sealed. The drying experiments were carried out in triplicate. Drying data were analysed using two-way analysis of variance at $p<0.05$.

### C. Moisture content

The moisture content of potato finger chips was calculated by the following equation:

$$M = \frac{W_i - W_d}{W_d} \tag{1}$$

where $M$ is the moisture content (kg water/kg dry matter), $W_i$ is the weight of sample (kg), and $W_d$ is the dry matter content of sample (kg).

### D. Drying rate

The drying rate ($DR$) of potato finger chips at a particular time period was calculated as follows:

$$DR = \frac{M_{t1} - M_{t2}}{t_2 - t_1} \tag{2}$$

where $t_1$ and $t_2$ are drying times (min); and $M_{t1}$ and $M_{t2}$ are the moisture contents (d.b.) at times $t_1$ and $t_2$ respectively.

### E. Mathematical modelling

The changes in the moisture content of potato chips as a function of drying time in the moisture ratio ($MR$) equation.

$$MR = \frac{M_t - M_e}{M_0 - M_e} \tag{3}$$

where $M_0$, $M_e$ and $M_t$ are the moisture content at initial, equilibrium and at any time $t$ (min) during drying pro cess, respectively, expressed as kg water/kg dry matter).

**Table 1.** Thin-layer drying models applied to the drying curves

| Model name | Model [(1)] |
|---|---|
| Lewis | $MR = \exp(-kt)$ |
| Henderson and Pabis | $MR = a\exp(-kt)$ |
| Logarithmic | $MR = a\exp(-kt) + c$ |
| Page | $MR = \exp(-kt^n)$ |
| Midilli and Kucuk | $MR = a\exp(-kt^n) + bt$ |
| Aghbashlo *et al.* | $MR = \exp\left(-\frac{k_1 t}{1 + k_2 t}\right)$ |
| Vega and Lemus | $MR = \exp(a + bt)^2$ |

(1) $a$, $b$, $c$, $k$, $k_1$, $k_2$ *and* $n$: constants and coefficients in drying models

However, the equilibrium moisture content ($M_e$) is relatively small compared with $M_0$, especially for infrared drying. So, Eq. (3) $MR$ can be simplified to $MR = M_t/M_0$ (Onwude *et al*., 2018).

### F. Data analysis

The MR data from drying of potato finger chips was fitted with seven thin-layer drying models (Table 1) typically used for the modeling of drying curves.

The data of MR were analyzed using Statistica 8.0.550 (StatSoft Inc., Tulsa, OK, USA) software package. The parameters of models were estimated using a non-linear regression procedure based on the Levenberg-Marquardt algorithm. The fitting quality of the experimental data to all models was evaluated using the coefficient of determination ($R^2$), reduced chi-square ($\chi^2$) and root mean square error ($RMSE$). Higher values of $R^2$ and lower $\chi^2$ and $RMSE$ indicate better goodness of fit (Naderinezhad *et al*., 2016). These parameters were calculated from the following formulas:

$$R^2 = 1 - \frac{\sum_{i=1}^{N}(MR_{pre,i} - MR_{exp,i})^2}{\sum_{i=1}^{N}(\overline{MR}_{pre} - MR_{exp,i})^2} \tag{4}$$

$$\chi^2 = \frac{\sum_{i=1}^{N}(MR_{exp,i} - MR_{pre,i})^2}{N - z} \tag{5}$$

$$RMSE = \left[\frac{1}{2}\sum_{i=1}^{N}(MR_{pre,i} - MR_{exp,i})^2\right]^{\frac{1}{2}} \tag{6}$$

where $MR_{exp,i}$ and $MR_{pre,i}$ are experimental and predicted dimensionless moisture ratios, respectively, $N$ is number of observations, and $z$ is number of constants.

### G. Calculation of effective moisture diffusivity

Fick's second law of diffusion equation, symbolized as a mass-diffusion equation for drying of agricultural products drying in a falling rate period, is shown in the following equation:

$$\frac{\partial M}{\partial t} = D_{eff}\nabla^2 M \tag{7}$$

Fick's second law of unsteady state diffusion given in Eq. (7) can be used to determine the moisture ratio in Eq. (8). The solution of diffusion equation for infinite slab given by Crank (1975), and supposed uniform initial moisture distribution, negligible external resistance, constant diffusivity and negligible shrinkage, is:

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

where $D_{eff}$ is the effective moisture diffusivity (m$^2$/s), $t$ is the time (s), $L$ is the half-thickness of samples (m) and $n$ is a positive integer. For longer drying periods, the above equation can be simplified to only first term of series, without much affecting the accuracy of the prediction.

$$MR = \frac{8}{\pi^2} exp\left(-\pi^2\frac{D_{eff}t}{4L^2}\right) \tag{9}$$

The Eq. (9) can be linearized by applying natural logarithmic at both sides as shown in Eq. (10), where the slope ($K$)

of the graph (ln $MR$ versus time) was used to determine the $D_{eff}$:

$$\ln(MR) = \ln\left(\frac{8}{\pi^2}\right) - \left(\pi^2 \frac{D_{eff}t}{4L^2}\right) \quad (10)$$

$$K = \frac{\pi^2 D_{eff}}{4L^2} \quad (11)$$

**H. Estimation of activation energy**

Activation energy ($E_a$) represents the minimum energy required for water molecules to migrate within the food during drying (Martynenko and Kudra, 2016). For the calculation of activation energy, modified form of Arrhenius equation shows the relationship between the effective moisture diffusivity and the infrared power to sample weight (Kayran and Doymaz, 2019).

$$D_{eff} = D_0 \exp\left(-\frac{E_a\, m}{p}\right) \quad (12)$$

where $D_0$ is the pre-exponential factor of Arrhenius equation ($m^2/s$), $E_a$ is the activation energy (W/kg), $p$ is the infrared power level (W), and $m$ is the sample weight (kg).

**I. Color**

The colors of the fresh and dried potato chips surface were analyzed by chroma meter (CR-400, Konica Minolta, Tokyo, Japan) at four different edge spots on the surface of each sample. The color values of the samples were expressed as $L$ (whiteness/darkness), $a$ (redness/ greenness), and $b$ (yellowness/blueness). The total color differences ($\Delta E$) and Chroma ($C$) calculated using Eqs. (13) and (14), respectively:

$$\Delta E = \sqrt{(L_0 - L)^2 + (a_0 - a)^2 + (b_0 - b)^2} \quad (13)$$

$$C = \sqrt{a^2 + b^2} \quad (14)$$

where $L_0$, $a_0$ and $b_0$ are the color values of fresh samples before drying.

**J. Rehydration**

Two grams of dried potato chips were soaked in 300 mL of distilled water at room temperature. After 6 h, the samples were removed from water, wiped with tissue paper, then drained and weighed. The rehydration was expressed by moisture content of the potato chips during rehydration process. Rehydration capacity ($RC$) of the potato chips was calculated as follow (Kutlu, 2021):

$$RC = \frac{W_1}{W_2} \quad (15)$$

where, $W_1$ is weight of rehydrated samples (g) and $W_2$ is weight dried samples (g). The experiments were replicated three times and the average values were calculated.

## III. RESULTS AND DISCUSSION

**A. Drying curves**

The plot of moisture content with drying time for infrared drying of potato chips is shown in Fig. 1.

The moisture content decreased exponentially with elapsed duration of drying and decreased faster at higher infrared powers in all cases, as expected. As can be seen, an increase in the infrared power decreased the moisture content due to increasing temperature. The drying time required reaching the final moisture content of samples were 160, 150, 140, 110 and 90 min at the infrared power levels of 38, 50, 62, 74 and 88 W, respectively. The average drying rate of samples increased about 1.78 times, respectively, as infrared power level increased from 38 W to 88 W. As expected at higher infrared power level the higher heat absorption resulted in higher product temperature, higher mass transfer driving force, faster drying rate and consequently lesser drying time (Onwude *et al.*, 2018; Doymaz, 2017).

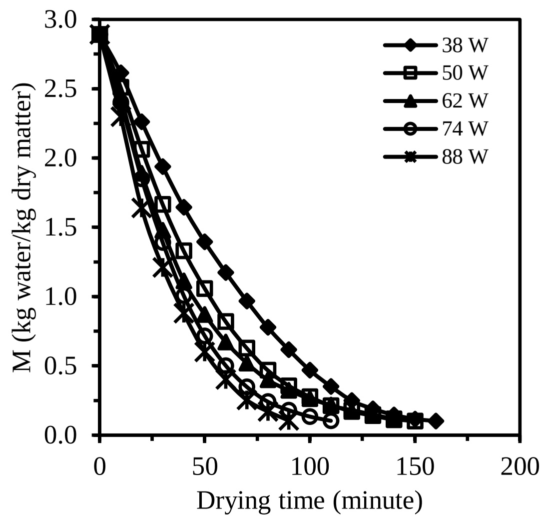


**Fig. 1.** Variations of moisture content with drying time of potato chips at different infrared powers

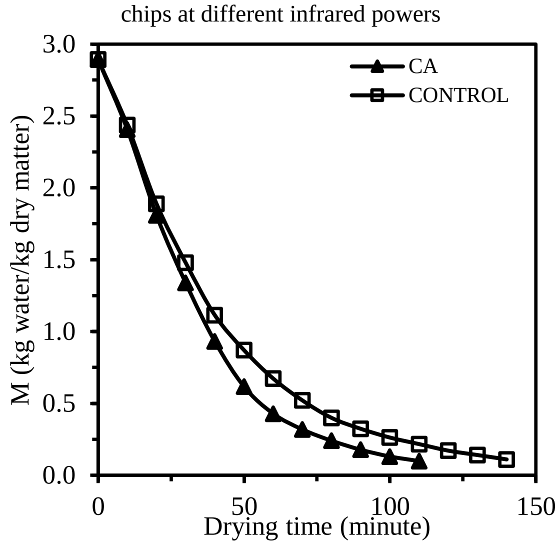


**Fig. 2.** Variations of moisture content with drying time of potato chips at 62 W.

**B. Influence of pre-treatment solution**

According to the results in Fig. 2, pre-treatment is very important parameter that affects the drying time.

The samples dipped in citric acid (CA) solution before drying process had a shorter drying time compared to Control samples. The reach a final water content (0.10 kg water/kg dry matter) in control samples, 140 min of drying at 62 W infrared power were needed, while potato chips pretreated with citric acid solution (CA code) reached this water content after 110 min. The difference in drying times was close to 27.27% for samples of CA

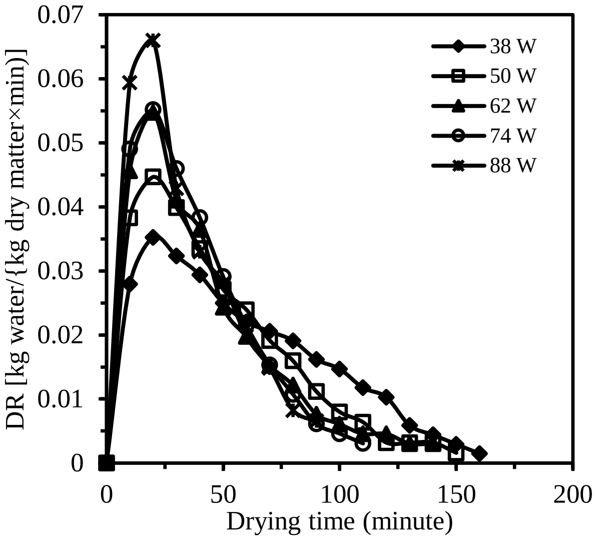


**Fig. 3.** Variations of drying rate as a function of moisture content for different infrared powers.

code. These results show that pre-treatment solution contributed to increase the permeability of the cell membranes of potato chips, leading to an increase in water diffusivity. This result observed was also reported in previous studies on potato drying (Dinrifo, 2012; Doymaz, 2012; Zhao *et al.*, 2016).

### C. Drying rate

The drying rate curves of potato chips are shown in Fig. 3. A constant-rate period was not observed in all cases. Examination in Fig. 3 reveals that, in general, two distinct periods are identifiable, namely warming-up (this too can be neglected) and falling-rate periods. This shows that diffusion is dominant physical mechanism governing moisture movement in the samples. Similar results have been reported by Dinrifo (2012) and Onwude *et al.* (2018).

A continuously decreasing of the drying rate decreasing moisture content can be seen in the Figure 3. In same time, the increase of drying rate is observed with the increase of infrared power. The drying rates were higher in the beginning of the process, and thereafter decreased with decrease of moisture content in the samples during drying process. The results were consistent with observations made by Hafezi *et al.* (2015) on drying of potato slices.

### D. Effective moisture diffusivity

The effective moisture diffusivity ($D_{eff}$) values for different infrared power levels, calculated from Eq. (11), are given in Fig. 4 and ranged from 1.82×10$^{-9}$ to 3.06×10$^{-9}$m$^2$/s.

The $D_{eff}$ values increased with increase in infrared power due to high mass transfer at high temperatures. Drying at 88 W had the highest value of effective moisture diffusivity and the lowest value was obtained for 38 W. Similar observation have been reported for agricultural products such as sweet potato (Onwude *et al.*, 2018), potato slices (Doymaz, 2012; Chayjan, 2012). The $D_{eff}$ values of the potato chips were within the general ranges of 10$^{-12}$ to 10$^{-8}$ m$^2$/s for biological materials (Zogzas *et al.*, 1996). The effect of infrared power on effective moisture diffusivity is defined by the following equation:

$$D_{eff} = 3 \times 10^{-10}p + 10^{-9} \quad (R^2 = 0.9744) \quad (16)$$

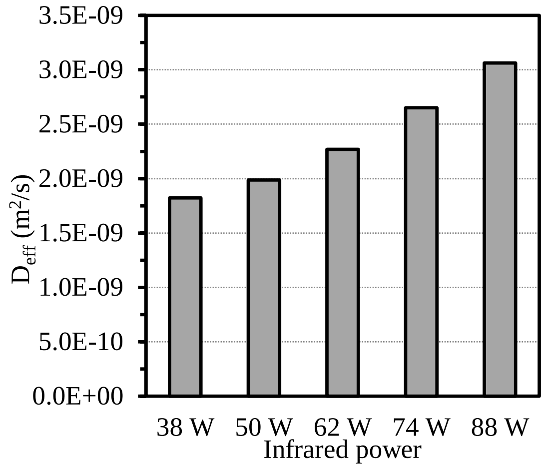


**Fig. 4.** Variation of effective moisture diffusivity with infrared powers.

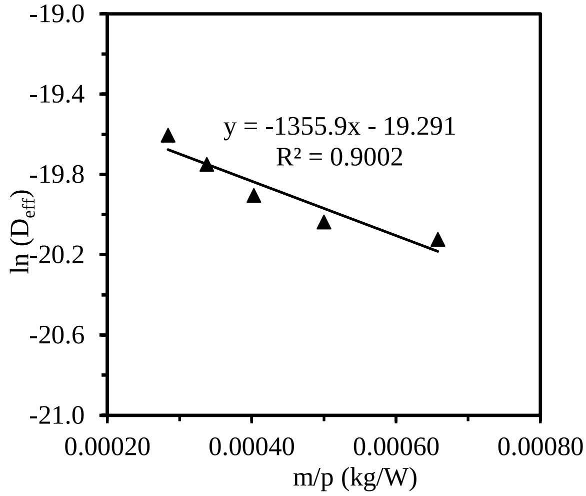


**Fig. 5.** Arrhenius-type relationship between effective moisture diffusivity and reciprocal absolute temperature.

### E. Activation energy

The activation energy can be determined from the slope of Arrhenius plot, $\ln(D_{eff})$ versus $m/p$ (Eq. 12). The ln ($D_{eff}$) as a function of the sample weight/infrared power level was plotted in Fig. 5. The slope of the line is ($-E_a$) and the intercept equals to $\ln(D_0)$.

The results show a linear relationship due to Arrhenius type dependence. Eq. (17) shows the effect of sample weight/power level on $D_{eff}$ of samples with the following coefficients:

$$D_{eff} = 4.18 \times 10^{-9} exp\left(-1355.9\frac{m}{p}\right) \quad (R^2 = 0.9002) \quad (17)$$

The estimated values of $D_0$ and $E_a$ from modified Arrhenius type exponential Eq. (17) were 4.18×10$^{-9}$ m$^2$/s and 1.35 kW/kg, respectively.

### F. Evaluation of the models

The moisture content data obtained at different infrared power levels were converted into the $MR$. Different mathematical models according to Table 1 were evaluated for predicting $MR$ variations of potato chips during the

**Table 2.** Statistical results of the thin-layer drying models.

| Power (W) | Model | $R^2$ | $\chi^2$ | $RMSE$ |
|---|---|---|---|---|
| 38 | Lewis | 0.9813 | 0.001904 | 0.156960 |
| | Henderson and Pabis | 0.9871 | 0.001401 | 0.130395 |
| | Logarithmic | 0.9972 | 0.000316 | 0.056751 |
| | Page | 0.9989 | 0.000116 | 0.036394 |
| | **Midilli and Kucuk** | **0.9994** | **0.000072** | **0.026477** |
| | Aghbashlo *et al.* | 0.9993 | 0.000075 | 0.023164 |
| | Vega and Lemus. | 0.9978 | 0.000230 | 0.044883 |
| 50 | Lewis | 0.9913 | 0.000854 | 0.095352 |
| | Henderson and Pabis | 0.9944 | 0.000594 | 0.078367 |
| | Logarithmic | 0.9966 | 0.000386 | 0.062011 |
| | Page | 0.9996 | 0.000036 | 0.017206 |
| | **Midilli and Kucuk** | **0.9999** | **0.000011** | **0.009919** |
| | Aghbashlo *et al.* | 0.9979 | 0.000215 | 0.044847 |
| | Vega and Lemus. | 0.9914 | 0.000912 | 0.095541 |
| 62 | Lewis | 0.9966 | 0.000319 | 0.044203 |
| | Henderson and Pabis | 0.9977 | 0.000226 | 0.040545 |
| | Logarithmic | 0.9978 | 0.000238 | 0.042782 |
| | Page | 0.9987 | 0.000126 | 0.032565 |
| | **Midilli and Kucuk** | **0.9996** | **0.000041** | **0.016617** |
| | Aghbashlo *et al.* | 0.9976 | 0.000242 | 0.043571 |
| | Vega and Lemus. | 0.9818 | 0.001848 | 0.138140 |
| 74 | Lewis | 0.9890 | 0.001188 | 0.096288 |
| | Henderson and Pabis | 0.9921 | 0.000937 | 0.086931 |
| | Logarithmic | 0.9959 | 0.000540 | 0.062277 |
| | Page | 0.9998 | 0.000022 | 0.011751 |
| | **Midilli and Kucuk** | **0.9999** | **0.000003** | **0.004541** |
| | Aghbashlo *et al.* | 0.9979 | 0.000250 | 0.039811 |
| | Vega and Lemus. | 0.9930 | 0.000828 | 0.77648 |
| 88 W | Lewis | 0.9926 | 0.000813 | 0.071469 |
| | Henderson and Pabis | 0.9943 | 0.000702 | 0.068268 |
| | Logarithmic | 0.9983 | 0.000231 | 0.030203 |
| | Page | 0.9995 | 0.000061 | 0.016847 |
| | **Midilli and Kucuk** | **0.9996** | **0.000060** | **0.014027** |
| | Aghbashlo *et al.* | 0.9990 | 0.000113 | 0.018772 |
| | Vega and Lemus. | 0.9929 | 0.000875 | 0.075470 |

drying process. Results of the statistical computing are shown in Table 2. The $R^2$ values for all models were above 0.98. Among the thin-layer drying models, the Midilli and Kucuk model represented the drying kinetics of potato chips with high $R^2$ values and low $\chi^2$ and *RMSE* values for all power levels (Table 2). It is clear that, the $R^2$, $\chi^2$ and *RMSE* values of this model were varied between 0.9994 and 0.9999, 0.000003 and 0.000072, 0.004541 and 0.026477, respectively. Similar finding on the appropriateness of Midilli and Kucuk model in describing performance of potato has also been reported (Naderinezhad *et al.*, 2016; Qui *et al.*, 2019).

## G. Color parameters

Color is considered as the key quality index due to its relation with flavor and attraction. The color values of fresh potato chips were measured as $L$, $a$, and $b$ equal to 67.33, -7.19, and 32.76, respectively. Table 3 represents $L$, $a$, $b$, $\Delta E$, and $C$ values of dried potato chips. As shown in Table 3, the results obtained from color measurements of potato chips dried under various conditions showed that the infrared radiation power has a significant effect on the color of the potato chips.

After all drying processes, the dried samples had lower $L$ and $b$ values and higher $a$ values. If the color values of the fresh and dried samples are compared, a decrease in the $L$ and $b$ values of the dried samples, whereas an increase in the $a$ values was observed. According to the results presented in Table 3, $L$ values varied between 73.75 and 59.85 depending on the infrared power level. It has been stated that the variation in whiteness of dried samples can be taken as a measurement of browning. Under the same conditions, the $b$ values fell from 18.54 to 13.44. In contrast, $a$ values increased from -3.25 to 1.50. Infrared drying produced an increase in $a$ value compared to fresh potato, probably due to isomerization or the increase in the concentration of some types of red carotenoids as lycopene (which has an intensely red tonality) because of heat irradiated and reduction of moisture content. Similar opinion has been expressed by Vega-Galvez *et al.* (2021) before.

**Table 3.** Results of color values for dried potato chips

| IR power (W) | $L$ | $a$ | $b$ | $C$ | $\Delta E$ |
|---|---|---|---|---|---|
| 38 | 73.75±2.41 | -3.25±0.31 | 18.54±0.71 | 18.82±0.60 | 16.09±0.31 |
| 50 | 72.29±2.04 | -2.80±0.25 | 17.91±0.65 | 18.12±0.39 | 16.26±0.38 |
| 62 | 65.85±1.99 | -2.17±0.14 | 17.17±0.46 | 17.30±0.51 | 16.44±0.45 |
| 74 | 59.97±0.67 | -1.00±0.19 | 16.11±0.41 | 16.14±0.37 | 19.27±0.57 |
| 88 | 59.85±0.28 | 1.50±0.10 | 13.44±0.35 | 13.44±0.21 | 22.09±0.65 |

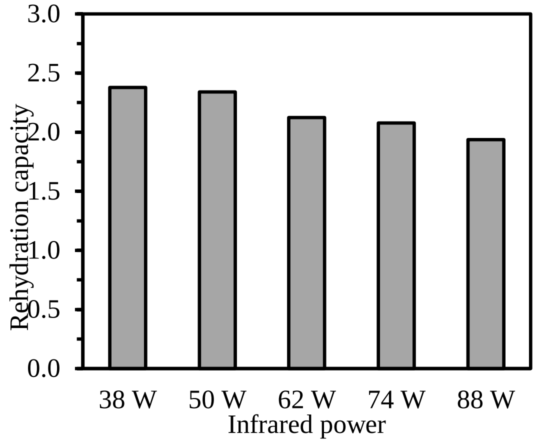


**Fig. 6.** Values of rehydration capacity of the potato chips dried at different infrared powers.

ΔE value is a useful tool to describe total color change after the drying process. With increasing in power of infrared from 50 to 88 W, $\Delta E$ was increased from 16.09 to 22.09. This is attributed to the process of Maillard browning reaction that might have occurred drying drying process. The chroma values were decreased 18.82 to 13.44 when infrared power increased from 50 to 88 W, and showed a decrease during drying process. The obtained values for chroma show the saturation degree of color and are corresponding to the color strength (Aidani *et al.* 2017).

## H. Rehydration capacity

Rehydration capacity is one of the physical properties most concerned (Huang *et al.*, 2021). Rehydration capacity provides information about the changes in physical and chemical properties of a dried sample attributed to drying and treatments preceding dehydration (Karacabey *et al.* 2016). To investigate the effect of drying conditions on final product quality, the values rehydration capacity of dried potato chips were calculated by using Eq. (15) and shown in Fig. 6.

As the infrared power increased, the rehydration capacity was found to be reduced. Thus in order to produce dried products with desirable rehydration capacity, very high infrared power during drying process should be avoided. Similar results were also presented in carrot slices (Doymaz, 2015) and pear (Antal *et al.*, 2017).

## IV. CONCLUSIONS

Drying characteristics of potato chips were investigated in an infrared dryer at different infrared powers. The drying of potato chips at each infrared power occurred in falling-rate period. The drying, color and rehydration characteristics were significantly influenced by infrared power. The drying time decreased with the increase in infrared power. The drying of potato chips exhibited lower drying times for pre-treated samples than for Control samples. The values of effective moisture diffusivity were varied between $1.82\times10^{-9}$ and $3.06\times10^{-9}$ $m^2/s$ for the range of infrared powers studies, between 38 W and 88 W. With the increase of power level, the effective moisture diffusivity increased. Activation energy was estimated by a modified Arrhenius type equation as 1.35 kW/kg. According to the results obtained in this study, it was determined that applying the pretreatment solution before drying and drying at low infrared powers is more suitable for the potato quality.

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