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Thin Layer Peach Drying in Solar Tunnel Drier

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Abstract

This study presents performance of the solar tunnel dryer for drying of peach samples. The solar tunnel dryer consists of a flat plate solar collector, a drying tunnel, a solar cell module and a small axial fan. It has been constructed at the Department of Agricultural Machinery and Technologies Engineering at Isparta University of Applied Sciences. During the drying process, solar irradiation, drying air temperature, relative humidity, and air velocity were measured constantly in different parts of the dryer. At same time, mass loss of the peach samples was measured during the drying period at one-hour interval. In this study, the color measurements fresh and dried products were determined at the beginning and end of experiment. The fresh peach samples were sorted, graded, washed by tap water and then sliced manually as half-moon without peeling before pretreatment. Sun drying behavior of sliced peach samples pretreated with 1% sodium metabisulfit, 1% ascorbic acid and non-pretreated was investigated. The drying characteristic curves were evaluated against ten mathematical models. Results showed that the Midilli *et al.* model was found to be the best descriptive model for solar tunnel drying of thin layer peach.

Keywords Drying characteristics · Peach · Solar tunnel dryer · Mathematical modelling

Trocknung von Pfirsichen in solarem Tunneltrockner

Schlüsselwörter Trocknungseigenschaften · Pfirsich · Solarer Tunneltrockner · Mathematische Modellierung

Introduction

Peach is originated in China and were introduced to Persia and Mediterranean region along the Silk Road before Christian times (Zhu and Shen 2014). The annual World production of peaches and nectarines was 21.64 mio. t in 2013. China (6.51 mio. t), Italy (1.57 mio. t) and USA (1.28 mio. t) are the main producers of peach and nectarines. Turkey produced about 0.64 mio. t in 2013 (FAOSTAT 2016). Peaches

can provide high nutrition, proteins, energy, minerals and vitamins (Sablani 2006). They are grown for table purposes and processing. It can be consumed fresh and in other forms such as juice, jam, jelly, fruit sauces, candy bars, fruit leather, in yoghurt and bakery products (Kingsly et al. 2009; Johnson and Mukhaini 2016).

Fruits are seasonal and generally available during a particular season of the year. Especially peach fruit is highly perishable, difficult to store and transport, thus, they must be preserved in any form (Kingsly et al. 2007). The drying process is a simple way of preservation consist of removing water vapour from the product and reduces water activity to prevent deterioration (Sunthonvit et al. 2007; Doymaz 2014). It is also important for the dried fruit that, it has to be shelf-stable, microbiologically safe without any degradation of physical, chemical, microbial and nutritional quality properties (Sablani 2006; Bauman et al. 2005). They are generally dried in halves, slices or cubes (Kingsly et al. 2009).

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Natural sun drying exposes the product to the direct solar radiation and convective power of the natural wind. Although it is the oldest, cheapest and the most popular method still applied, the quality depends on the weather conditions. So, it has some disadvantages like spoilage because of rain, wind, moist and dust and attack of human, insects, birds and animals. In addition, loss of vitamins, nutrients and unacceptable colour changes due to direct exposure to ultraviolet rays results in post-harvest losses. This process is labour intensive, long time consuming, undesirable drying rate and require large area (Janjai et al. 2009; Demir and Sacilik 2010; Patil and Gawande 2016; Hossain and Bala 2007; Talbot et al. 2016). Industrial drying is highly energy intensive and also expensive method. So, solar drying seems to be the best alternative method when we consider the drawbacks of natural sun and industrial drying (Nabnean et al. 2016). Solar drying is environmentally friendly, effective, sustainable, economically viable, requiring no electricity and no skilled man power method and provides employment in rural areas during off-season in the developing countries. It also reduces the dependence to fossil fuels and its negative effect to the environment (Labed et al. 2016; Varalakshmi 2016; Nabnean et al. 2016). In order to limit global warming, a global action agreement was signed by 195 countries in December 2015 in Paris Climate Conference to avoid climate change below 2 °C. So, solar drying will also help to achieve this target (Maragkaki et al. 2016). In solar drying, the moisture of the product is removed by solar heated air about the temperature of 50 to 60 °C under controlled temperature conditions and moisture removing rate in clean, hygienic and sanitary conditions to national and international standards (Kumar et al. 2016; Labed et al. 2016).

There are different sizes and designs of solar dryers depending on the requirements. Solar dryers are classified according to the air movement mode, solar contributions, air direction movements, type of the drying materials and insulation of the system (Kumar et al. 2016). Well-designed solar dryer may provide a much-needed suitable substitute for drying of some of the agricultural products in developing countries (Kant et al. 2016). In general, active solar dryers are better than passive ones in terms of controlling the drying process (Tiwari et al. 2016; Patil and Gawande 2016).

The solar tunnel dryer can be operated by photovoltaic power-driven fan to remove the moisture to the ambient conditions. This type dryer is used for drying of many types of different agricultural products such as fruits, vegetables, cereals, grains, legumes, oil seeds, spices and even fish and meat (Bala et al. 2003; Schirmer et al. 1996; Sacilik et al. 2006; Munir et al. 2013).

The main objective of this study is to evaluate the solar tunnel dryer for thin layer drying of peaches. In addition, the effect of pre-treatment of two different solutions on drying characteristics were determined. The best describing mathematical thin layer drying model to experimental data is determined by comparing 10 different models.

Material and Methods

A homogeneously sized peach samples were used in this study as an experimental material. Fresh peaches (*Lycopersicum esculentum Mill. Cv. Rio Grande*) were purchased from the local supermarket in same brand name to provide the consistency of results for the experiments in Isparta, Turkey and kept in refrigerator at +4 °C prior to use. The fresh peach samples were sorted, graded, washed by tap water and then sliced manually as half moon without peeling before pre-treatment.

Peach slices were immersed in 1% sodium metabisulfite and 1% ascorbic acid solution for 3 min. These pre-treated drying processes was compared with un-treated peach slices. Applying this solution prior to drying process of peach slices is useful to inactivate the bacteria contamination (DiPersio et al. 2004).

A solar tunnel dryer designed and constructed at Department of Agricultural Machinery and Technologies Engineering at Isparta University of Applied Sciences, Isparta, Turkey, was used in this study (Fig. 1). It consists of a flat plate solar collector, a drying tunnel, a solar cell module, and a small axial fan. All units are mounted on metal frame. The black painted bottom of solar collector has hexagonal channels and is directly connected to drying tunnel. The collector is coated with a transparent polycarbonate sheet. The dryer is equipped with a 150 W solar cell module for moving the air with a fan. The collector area is 2 m length and 1.9 m width. The drying tunnel area is twice the area of collector. The dryer is oriented in east-west direction,

Fig. 1 The experimental solar tunnel dryer

Table 1 Mathematical models tested for the moisture ratio values of the peach samples

No	Model name	Model Equation	References
1	Diffusion approach	$MR = a \exp(-k\,t) + (1-a) \exp(-k\,b\,t)$	Kayisoglu and Ertekin (2011)
2	Henderson and Pabis	$MR = a \exp(-k\,t)$	Tunde-Akintunde (2011)
3	Logarithmic	$MR = a \exp(-k\,t) + c$	Ho and Li (2013)
4	Midilli *et al*	$MR = a \exp(-kt^m) + b\,t$	Midilli et al. (2002)
5	Newton	$MR = \exp(-kt)$	Ertekin and Heybeli (2014)
6	Page	$MR = \exp(-kt^n)$	Akpinar (2011)
7	Two term	$MR = a \exp(-k_0 t) + b \exp(-k_1 t)$	Demir and Sacilik (2010)
8	Two term exponential	$MR = a \exp(-kt) + (1-a)*\exp(-m*k*x)$	Ertekin and Firat (2017)
9	Verma *et al*	$MR = a \exp(-kt) + (1-a) \exp(-gt)$	Varun and Naveen (2014)
10	Wang and Singh	$MR = 1 + at + bt^2$	Vijayan et al. (2016)

south-facing and its drying tunnel is not shaded between 9:00 am and 5:00 pm.

About 600 ± 5 g samples of peach slices were placed into trays in one layer in the drying tunnel for each experiment. Drying process started after completion of the loading at 9:00 am and was paused at 5:00 pm. Weight loss of the peach slices in the solar tunnel drier was measured during the drying period at one-hour interval with a digital balance reading to 0.01 g (Sartorius GP3202, Germany). The sliced peach samples were kept in the solar tunnel drier in the environmental conditions after 5:00 pm during the night. The drying process was ended until no mass change occurred. Experiments were carried out on July 19–21, 2017. Solar radiation was measured hourly (09:00 am–17:00 pm) on a horizontal surface by pyranometer. Drying air temperature and relative humidity were measured by using K type thermocouples and DT-3 hygrometer, respectively, at the drying tunnel. Drying air velocity at the outlet of drying tunnel was measured by a hotwire anemometer.

Peach samples were subjected to the moisture analysis at the oven at the temperature of 105 °C for 24 h (Yagcıoglu 1999).

The moisture ratio (MR) was calculated based on moisture content at any time (t) of drying process (M_t), initial moisture content (M_0), and equilibrium moisture content (M_e);

$$MR = \frac{M_t - M_e}{M_0 - M_e} \tag{1}$$

All moisture contents were reported as wet basis (% w.b) and converted to the MR values. Simplification of MR in Eq. 1 as M/Mo was suggested by Sacilik 2007; Goyal et al. 2007; Montero et al. 2015 due to the continuous fluctuation of relative humidity of drying air under solar drying conditions.

A non-linear regression analysis (Sigma Plot 12.00) was applied to experimentally obtained MR values as a function of drying time using 10 different thin layer drying models given in Table 1. The constants (a, n, b, c, m, k and g) of these models tested in Table 1 were determined based on the non-linear regression analysis. The performance of models was evaluated by statistical values of determination coefficient (R^2), the standard error of estimate (SEE), and residual sum of square (RSS) (Dinani et al. 2014; Ertekin and Firat 2017; Aral and Bese 2016; Harchegani et al. 2016).

Colour Measurement

Sample colour was measured before and after drying process by using a Minolta Chroma CR-100 colour meter (Minolta Co., Osaka, Japan). Five random readings for each sample were recorded and the mean values of these parameters with standard deviation values were determined. The colour values were expressed as $L*$ (whiteness or brightness/darkness), $a*$ (redness/greenness) and $b*$ (yellowness/blueness) at any time, respectively. In addition, Chroma* (Eq. 2), Hue Angle (Eq. 3) and the total colour difference (Eq. 4) were calculated from the values for $L*$, $a*$, $b*$ and used to describe the colour change during drying. The saturation index or Chroma* indicates colour saturation and is proportional to its intensity. The Hue angle is another parameter frequently used to characterize colour in food products. An angle of 0º or 360º represents red hue, while angles of 90º, 180º and 270º represent yellow, green and blue hue, respectively. It has been extensively used in the evaluation of colour parameters in green vegetables, fruits and meats (Maskan 2001).

$$C^* = \sqrt{(a^{*2} + b^{*2})} \tag{2}$$
$$\alpha^* = \tan^{-1}(b^*/a^*) \tag{3}$$
$$\Delta E = \sqrt{(L_0 - L)^2 + (a_0 - a)^2 + (b_0 - b)^2} \tag{4}$$

Results and Discussion

Peaches were dried on July in 2017 by solar dryer. The weather was sunny and no rain was recorded during the ex-

Fig. 2 Change of air temperature and relative humidity as a function of time for solar drying of peach
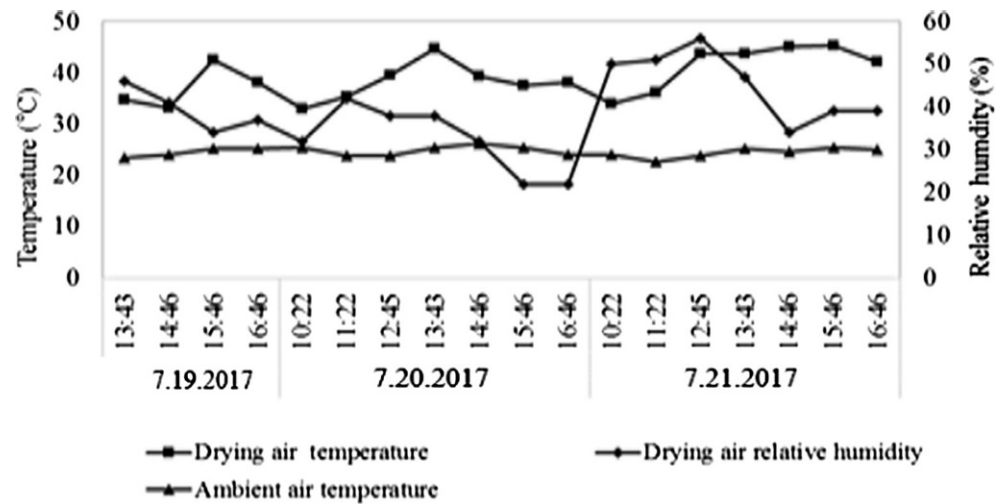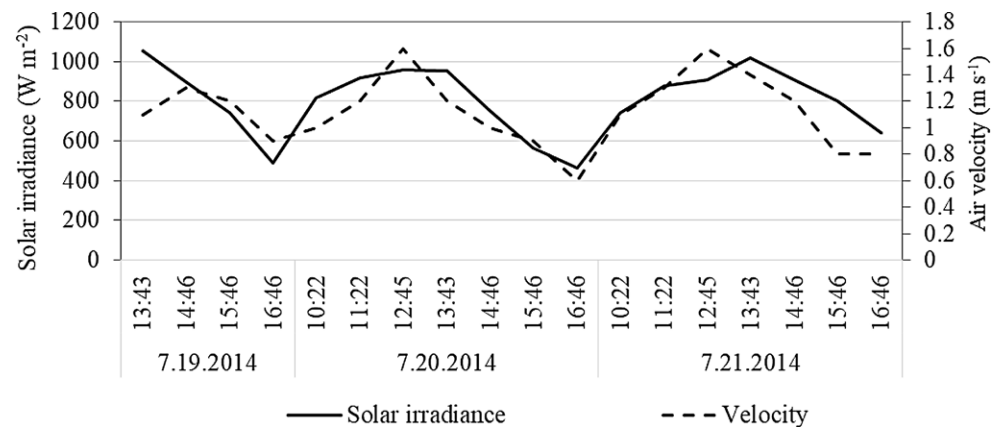

Fig. 3 Change of solar irradiance and air velocity of drying air at the outlet of drying tunnel as a function of time

periments. The pattern of ambient air temperature, drying air temperature and relative humidity is shown in Fig. 2. While drying air temperature changed between 33.4 and 60.4 °C, the relative humidity changed between 22 and 56% during the experiments. The changes during the drying period in solar irradiance and air velocity inside the solar tunnel dryer is given in Fig. 3. As can be seen from Fig. 3, the velocities obtained from fans peaked at approximately middle of the days and ranged between 0.6 and 1.6 m.s⁻¹. The fan, which was not controlled, was operated continuously as long as the solar cell module supplied power. The air velocities synchronized with air temperatures thereby modulating the drying temperature. In addition, more energy received by the collector at the high solar irradiance led to increase drying air temperature.

The air velocity changed as a function of solar irradiation, because of the dependence to the solar cell. The solar irradiance was between 462.8 and 1056.1 W.m⁻² and reached its highest values at the noon time.

The influence of pretreatment of thin layer sliced peaches on moisture content was investigated. The drying time

necessary for reduction of initial moisture content of 78.9–86.8% (w.b.) to the desired final moisture content of 12.42% (w.b.) for non-pretreated samples was found as *3900 min*, while drying time for sodium pretreated samples was *2640* and for ascorbic acid pretreated was *2940 min*. These results showed that pretreating peach slices reduced the drying time. The absence of lines in drying period in each day in Fig. 4 indicates the night periods.

In convective drying of peach, increasing drying air temperature from 50 to 70 °C decreased the drying time, but changing the drying air velocity 1.0 to 1.2 m.s⁻¹ has less effect than drying air temperature (Golisz et al. 2013). Increasing drying air temperature from 50 to 70 °C and velocity from 0.18 to 0.26 m.s⁻¹ decreased the drying time of 3 mm sliced peaches (Johnson and Mukhaini 2016). The drying time decreased by increasing drying air temperature and velocity, but decreasing slice thickness (Zhu and Shen 2014). Halved, peeled or unpeeled, blanched or unblanched peaches were dried at drying air temperature of 67 °C, relative humidity of 40% and air velocity of 4 m.s⁻¹. Drying process was faster for blanched fruits, while un-

Table 2 Results of nonlinear regression analysis of fitting the 10 drying models to the experimental data for solar tunnel drying of peach samples

Model No	Non-pretreated			Sodyum metabisulfite			Ascorbic acid		
	R^2	SEE	RSS	R^2	SEE	RSS	R^2	SEE	RSS
1	0.9801	0.0347	0.0192	0.9887	0.0307	0.0151	0.9912	0.0271	0.0117
2	0.9898	0.0241	0.0099	0.9890	0.0294	0.0147	0.9912	0.0262	0.0117
3	0.9944	0.0183	0.0054	0.9952	0.0201	0.0065	0.9942	0.0219	0.0077
4	0.9955	0.0173	0.0045	0.9960	0.0188	0.0053	0.9958	0.0211	0.0067
5	0.9801	0.0327	0.0192	0.9887	0.0289	0.0151	0.9912	0.0255	0.0117
6	0.9952	0.0166	0.0047	0.9911	0.0265	0.0119	0.9919	0.0251	0.0107
7	0.9945	0.0188	0.0053	0.9955	0.0200	0.0060	0.9944	0.0223	0.0075
8	0.9953	0.0168	0.0045	0.9953	0.0199	0.0063	0.9941	0.0222	0.0079
9	0.9953	0.0168	0.0045	0.9953	0.0199	0.0063	0.9941	0.0222	0.0079
10	0.9829	0.0311	0.0164	0.9832	0.0364	0.0225	0.9880	0.0307	0.0160

Table 3 Non-linear regression analysis results of semi-empirical Midilli et al. equation for solar tunnel drying of peach

Treatments	Constants	R^2	SEE ($\pm$)	RSS ($\pm$)
Non-pretreated	k = 0.9971 a = 0.0903 m = 0.7957 b = −0.0030	0.9958	0.0227	0.0046
Sodium	k = 0.9974 a = 0.0941 m = 0.7921 b = −0.0038	0.9967	0.210	0.0035
Ascorbic acid	k = 1.0000 a = 0.1568 m = 0.8603 b = −0.0036	0.9936	0.0401	0.0048

peeled halves dried in 1490 min, peeled halves dried in 1300 min. Increasing drying air velocity or fruit size and lowering drying air relative humidity influenced the drying rate. Drying time was lower at drying air velocity of 4 m.s⁻¹, relative humidity of 20% and small halves (58 mm) (Hansmann et al. 1998). While drying 3.5 mm sliced peaches at drying air temperature of 55 °C in cross-flow tunnel dryer the drying time was 240 min and 210 min for control and potassium metabisulfite or ascorbic acid applied samples, respectively. These values were 210 and 180 min at drying air temperature of 65 °C (Kingsley et al. (2007). Drying time was changed between 90 min (209 W) and 400 min (83 W) in infrared drying of peach slice of 0.5 cm (Doymaz 2014). Drying peaches by far infrared or microwave showed that, increasing power level decreased the drying time (Wang and Sheng 2006). In natural sun drying, peeled, divided into two halves non-pretreated peaches were dried in about 4 days (Toğrul and Toğrul 2007). Drying time in convective drying of peach slice at 5 mm in thickness, drying air temperature between 45 and 75 °C and constant drying air velocity of 2 m.s⁻¹ were investigated and results showed that while drying time was 600 min for citric acid pretreated samples, it was 765 min for non-pretreated samples at drying temperature of 45 °C (Doymaz and Bilici (2014).

In solar drying of peach, there was no constant rate drying period. So, diffusion is the most effective way of mass transfer. This result also found by many other researchers (Toğrul and Pehlivan 2004; Wang and Sheng 2006; Kingsly et al. 2007). Table 2 shows the outcomes of nonlinear regression analysis applied to the ten different drying models to the experimental data for non-pretreated, pretreated with

sodium metabisulphate and ascorbic acid with R^2, SEE, and RSS. The best model describing drying of peaches in given conditions was determined based on the highest value of R^2, with the lower value of SEE and RSS, which are evaluation criteria used to compare the statistical validity of the fit. The results showed that the R^2, SEE, and RSS values of nonlinear regression analysis ranged from 0.9801 to 0.9960, from 0.0166 to 0.0347, and from 0.0045 to 0.0192, respectively (Table 2). Furthermore, Midilli et al. model yielded the highest R^2 (0.9955, 0.9960, and 0.9958) for non-pretreated, pretreated with sodium metabisulfite and ascorbic acid, respectively, with the lowest SEE and RSS values (Table 2). At given conditions, this model was chosen as the best describing model based on evaluation criteria. Constants of the Midilli et al. model for the treatments were given in Table 3.

In convective drying, Lewis, Page, Henderson and Pabis, logarithmic and Midilli et al. models were evaluated and R^2, P (mean relative percent error), chi-square and RMSE values were found as 0.9981–0.9996, 4.1822–11.6361, 0.000036–0.000216 and 0.026130–0.055110 for Midilli et al. model, respectively (Doymaz and Bilici 2014). Thin layer drying process for drying air temperature between 50–70 °C and velocity between 0.18–0.26 m.s⁻¹ were described by Page model with R^2 of 0.948–0.993 (Johnson and Mukhaini 2016). The moisture ratio values were evaluated according to the statistical values of P (mean relative percent error), chi-square and RMSE at drying air temperature between 60 to 80 °C, velocity between 0.423 to 1.12 m.s⁻¹ and slice thickness between 2 to 4 mm for Newton, Page, Modified Page, logarithmic, Henderson and Pabis and

Fig. 4 Variation of moisture content with drying time for solar tunnel drying of peach
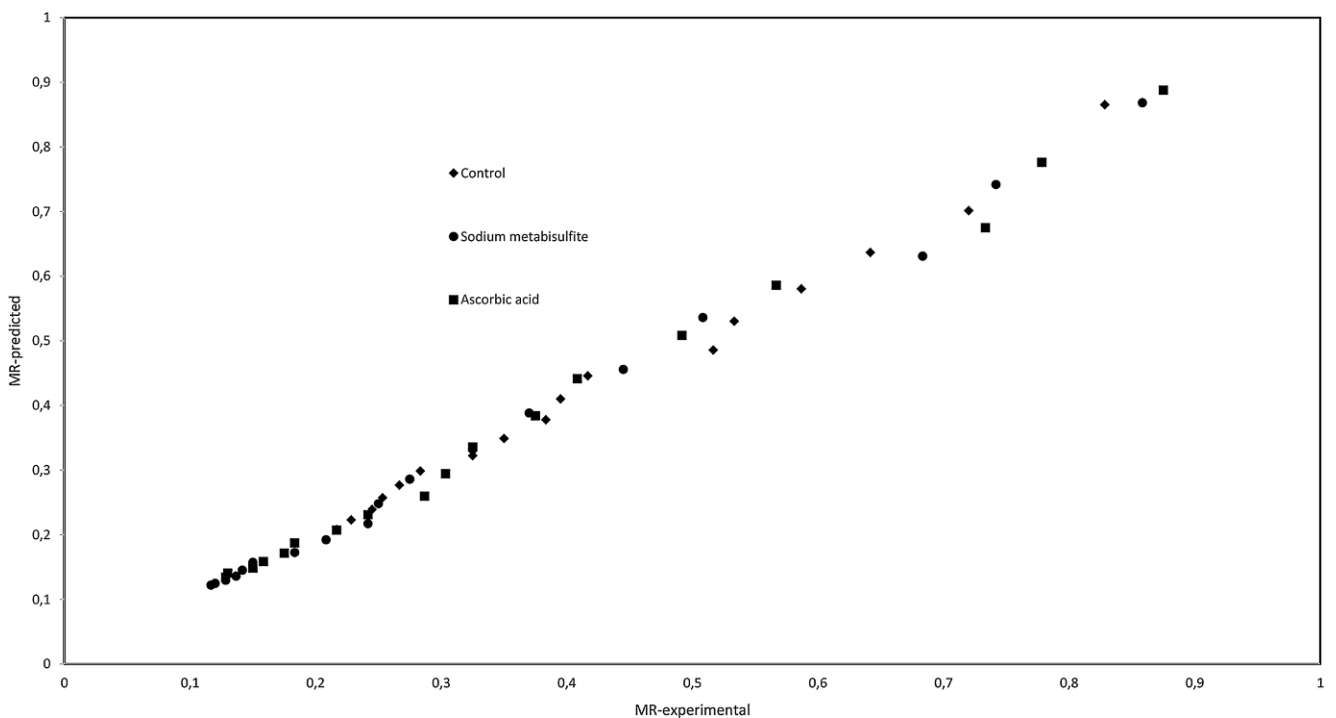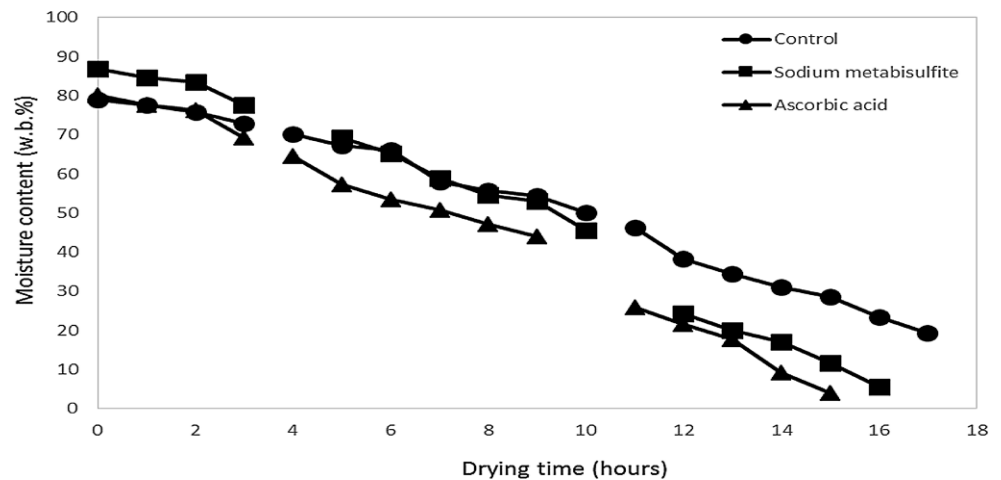

Fig. 5 Experimental and predicted moisture ratio values

Wang and Shengh models. According to the results, Page model for drying air temperature, Wang and Shengh model for drying air velocity and logarithmic model for slice thickness was found the best ones (Zhu and Shen 2014). Newton, Page, Modified Page, Henderson and Pabis, Logarithmic and Wang and Shengh models were evaluated for pretreated peach slices in convective drying. Logarithmic model was selected with R^2 of 0.9941–0.9995, chi-square of 0.00017–0.00240, RMSE of 0.010183–0.037055 and MBE of 0.000104–0.000515 (Kingsly et al. 2007). In natural sun drying, Newton, Page, Modified Page-I and II, Henderson and Pabis, Modified Henderson and Pabis, Logarithmic, Two term, Two Term Exponential, Wang and Shengh,

Approximation of Diffusion, Verma et al. models were compared with r, chi-square, MBE and RMSE. According to the results, Verma et al. model was found as the best suitable model with r of 0.9953, MBE of 0.0002, RMSE of 0.0247 and chi-square of 0.0006. The effect of ambient air temperature and relative humidity were shown in Verma et al. model coefficients with r of 0.9977, chi-square of 0.00031, MBE of 0.00011 and RMSE of 0.0173 (Toğrul and Pehlivan 2004). After pre-treatment with high pressure blanching, moisture ratio versus drying time changes were investigated by the Page, Modified Page, Henderson and Pabis, Logarithmic and Two Term models for convective drying. While the R^2 was higher, MBE, chi-square and

Table 4 Statistical analysis of colour tests for different applications

Applications	N	Mean	SEMean	StDev	CoefVar	Min	Max
L* value							
Ascorbic acid	5	62.388 b	0.894	2.000	3.21	60.480	65.360
Control	5	49.34 c	1.05	2.34	4.74	45.47	51.79
Non-pretreatment	5	22.02 d	2.95	6.60	29.99	15.85	33.08
Sodium metabisulfite	5	72.71 a	1.67	3.74	5.14	68.08	77.81
A* value							
Ascorbic acid	5	12.066 a	0.456	1.020	8.46	11.350	13.840
Control	5	4.844 b	0.251	0.561	11.59	4.240	5.640
Non-pretreatment	5	10.442 a	0.476	1.064	10.19	8.560	11.180
Sodium metabisulfite	5	3.85 b	1.45	3.25	84.42	1.08	9.26
b* value							
Ascorbic acid	5	24.73 b	1.42	3.19	12.88	21.27	28.90
Control	5	21.548 b	0.527	1.179	5.47	20.250	23.400
Non-pretreatment	5	7.07 c	1.94	4.34	61.42	4.40	14.79
Sodium metabisulfite	5	31.93 a	1.76	3.94	12.35	26.70	36.47
C* value							
C-Ascorbic acid	5	27.58 ab	1.17	2.61	9.47	25.26	31.09
Control	5	22.090 b	0.540	1.208	5.47	20.897	24.070
Non-pretreatment	5	12.91 c	1.44	3.22	24.91	9.62	18.30
Sodium metabisulfite	5	32.26 a	1.93	4.31	13.36	26.72	37.63
α value							
Ascorbic acid	5	63.71 b	1.96	4.37	6.86	56.95	68.39
Control	5	77.331 a	0.578	1.293	1.67	75.704	78.999
Non-pretreatment	5	31.92 c	5.52	12.34	38.65	25.18	53.94
Sodium metabisulfite	5	83.56 a	2.11	4.71	5.64	75.75	87.68
ΔE							
Ascorbic acid	5	15.51 b	1.03	2.30	14.80	13.15	18.83
Control	0	*	*	*	*	*	*
Non-pretreatment	5	33.05 a	4.31	9.64	29.16	18.58	45.54
Sodium metabisulfite	5	26.03 a	1.56	3.48	13.36	21.78	31.40

RMSE values were lower for Logarithmic model (Kingsly et al. 2009). 15 different thin layer drying models, i.e., Newton, Page, Henderson and Pabis, Logarithmic, Two Term, Two Term Exponential, Verma et al., Diffusion Approximation, Parabolic, Wang and Shengh, Midilli et al., Modified Midilli et al., Vega-Galvez-I, Vega-Lemus, Weibull, were evaluated for far infrared drying of peach slice. According to the results, Midilli et al. model was found as the most suitable model with r2 between 0.999–1.000, chi-square between 0.000011–0.000146, RMSE of 0.014858–0.026280 and P (mean relative percent error) between 1.4167–6.513 (Doymaz 2014). It can be seen from Fig. 5 that all moisture ratio values were bounded near to the straight line.

Colour Analysis

In the study, data were analyzed by one-way analysis of variance (One-way ANOVA). The Tukey Test was used to determine the differences between the means of the applications. As a result of the variance analysis on the data obtained for the L* values, the differences between the means of the applications were found statistically significant ($P < 0.01$). The results of the Tukey test are shown in Table 4. While the highest means of L* value was obtained with sodium methabisulfite application, the lowest means of L* was obtained in the non-pretreatment application. The result on a* value showed that, the differences between the means of the applications were statistically significant ($P < 0.01$). The difference between the means of non-pretreatment with ascorbic acid application was not statistically significant. Furthermore, the difference between control and sodium metabisulfite application was not statistically significant. However, ascorbic acid and non-pretreatment applications and control and sodium methabisulfite applications were different. The differences between the means of the applications were statistically significant ($P < 0.01$) in terms of b* value. There was no statistical significance

in the difference between the means of b* values of control and ascorbic acid application. However, ascorbic acid and control applications differed from the non-pretreatment and the sodium metabisulfite applications ($P < 0.05$). As a result of the variance analysis on the data obtained with respect to the C* value, the differences between the means of the applications were statistically significant ($P < 0.01$). While the highest mean of C* value was obtained from sodium metabisulfite application, the lowest mean of C* value was obtained from the non-pretreatment application. The difference in the means of C* value between control and ascorbic acid application and between the sodium metabisulfite and ascorbic acid application was not statistically significant. However, ascorbic acid and non-pretreatment application and furthermore, non-pretreatment and sodium metabisulfite applications were different. Results on α value revealed that, the differences between the means of the applications were statistically significant ($P < 0.01$). While the highest α mean value was obtained in sodium metabisulfite application, the lowest obtained in the non-pretreatment application. The difference between the means of α value of sodium metabisulfite and the control application was not statistically significant. However, control and sodium metabisulphite applications and ascorbic acid and non-pretreatment applications were different. As for ΔE, the differences between the means of the applications were statistically significant. While the differences between the means of non-pretreatment and sodium metabisulfite applications were statistically insignificant, these two applications differed statistically from ascorbic acid applications ($P < 20090.05$).

Conclusions

In this study, the solar tunnel dryer can be used for drying of peach under the climatic conditions of Isparta. During the experiment, relative humidity and temperature of drying air, solar irradiation, moisture reduction from peach samples, and color analysis were measured. The moisture content of peach samples was decreased in three days. The moisture content was reduced from 81.91% to 12.42% w.b. in 65 min for the non-pretreatment in solar tunnel dryer. Whereas the sodium metabisulfite and ascorbic acid applications took only 47 min and 49 min, respectively. In order to explain the drying behavior of peach fruits, ten different models were fitted to thin layer experimental data and compared according to their R^2, SEE and RSS. The all model tested, Midilli et al. Model was the best descriptive model for solar tunnel drying of thin layer peach. Color analysis emphasized that values of L* applied ascorbic acid peaches, are close to the L* values of fresh peaches. At the same time, samples with ascorbic acid for the b* values have been identified as the

samples closest to fresh examples. However, a* values of peach samples with sodium metabisulfite are closest fresh peach samples.

Conflict of interest S. Karaaslan, K. Ekinci, C. Ertekin and B.S. Kumbul declare that they have no competing interests.

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