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Influence of pre-treatment on the drying process of apricots

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ABSTRACT- Drying has been used for the preservation of fruits since ancient times. Dried apricot reduces the damages, weight and volume losses, packaging space, storage and handling costs. In this paper, the effects of hot air dryer on an Iranian apricot cultivar "Noori" have been investigated. The experiment was conducted at three temperatures (30, 40 and 50^{o}C), three fruit thicknesses (5, 10 and 15 mm) and two pre-treatments (sulphur dioxide and water soluble sodium meta-bisulphite ($Na_2S_2O_5$)). Based on the analysis of variance, the effects of temperature, thickness, pre-treatment and their interactions on drying time were significant (P<1%). It was revealed that water soluble $Na_2S_2O_5$ reduced drying time more than sulphur dioxide. The data was fitted to eight different mathematical models. Page model was determined as the best one to explain thin layer drying of apricots by comparing the coefficient of correlation determination(R), chi-square (χ^2) and root mean square error (RMSE) between the observed and expected moisture ratios.

INTRODUCTION

Drying process is one of the best ways to preserve fruits like apricots. Suitable drying methods can reduce most of the product damages. During the drying process, water is removed from the product, thereby reducing the growth of microorganisms and unwanted chemical reactions, and helping to preserve the fruits for a longer time (Barbosa, 1996). Apricot (*Prunus armenical*) is not a climacteric fruit with high respiration and short ripening time. Dried apricot reduces the damages, weight and volume losses, packaging space, storage and handling costs. All leading apricot producers like Turkey, Iran and Australia apply the drying process on their apricot fruit (Bozkir, 2006).

Among the methods used to prevent or retard the deterioration of dried food products, treatment with chemical preservatives which protect them from unwanted chemical and microbiological reactions are highly recommended (Carcel et al., 2010). One of the most commonly used compounds is sulphur dioxide, applied as sodium or potassium meta-bisulphite (Rosello et al., 1993). Sulphur ting is an old and effective method to produce marketable and long-life dried apricot. Sulphur compounds have high water solubility with preventive role in the growth of molds and bacteria, disabling enzymatic and non-enzymatic reactions and preserving vitamin C and other oxidative sensitive compounds in food.

Many parameters are involved in the drying process including dryer temperature, primary moisture, material thickness and air velocity. The experiment was conducted under controlled conditions to predict the drying time and determine the moisture-time curve.

Many mathematical models of the drying kinetics have been investigated on food products. The first and best-known of the proposed models is Newton (Lewis, 1921). The Page model developed by Simal et al. (2005) presented the model of the kinetics for corn drying in 1941. Although this model is suitable for modelling the drying process of juicy fruits, it is unable to predict the drying process for moisture content of less than 15 per cent. The Handerson-Pabis's model was developed to dry fresh and half dry fruits (Karanthanos and Belessiotis, 1999). Approximation of diffusion model was invented for drying wheat in thin layer. Logarithmic model was used for modelling the drying process of laurel. Two-term model was presented for corn drying. Velma's model was introduced to dry rice (Verma, 1985).

Many mathematical modelling studies have been conducted on the thin layer drying processes of various vegetables and fruits such as apricot (Togrul and Pehlivan, 2003), mushrooms and parsley (Zecchi et al., 2011), mint, parsley and basil (Akpinar, 2006), washed apricot (Bozkir, 2005), eggplant (Brasiello et al., 2013) and pistachio (Midilli and Kucuk, 2003; Kashaninejad et al., 2007; Kouchakzadeh and Shafeei, 2010; Balbay et al., 2013). The objectives of this study are to investigate the effects of temperature and pre-treatment on the drying process and develop a mathematical model for the drying process of Noori variety of apricot. Although a number of researchers have previously investigated apricot drying using different drying methods, there was a lack of reports on the investigation of the effect of drying air temperature, pre treatment, slice thickness and their interaction on drying kinetics of this variety of apricot.

MATERIALS AND METHODS

Dryer, Measuring Tools, Pre-Treatments

The experiments were conducted using hot air dryer with adjustable drying temperature from 30 to 70°C. The main components of a dryer include centrifugal blower to supply air flow, air heating elements, dryer box and air temperature control system. Moreover, an electrical oven with accuracy of ± 1°C was used. Scale used for weighing samples was TD-4001 model (TASH Co., China) with accuracy of 0.1 gram.

To sulphur ate the samples with sulphur dioxide, smoke chamber containing 1.5 grams sulphur per kilogram of apricots was used. Fumigating lasted for 3 hours, and then samples were put in dryer. In another method, water soluble sulphide salts such as $Na_2S_2O_5$ and $K_2S_2O_5$ were used. To prepare the 1000 ppm of this solution, 1 g $Na_2S_2O_5$ w*as* added to 1 litter of water and then apricots were placed in this solution for 15 minutes.

Sample Preparation

Fresh Iranian apricots (Noori variety) were used for preparing samples needed. Dryer had been turned on for 15 minutes before starting experiments to achieve steady conditions. The moisture content was measured using AOAC (1980).In order to measure the moisture content of apricots based on AOAC (1980), samples were placed in the oven at 100°C for 3 to 4 hours. Three 50-gram samples were selected randomly and were placed in the oven. After the completion of the drying time, samples were weighed immediately. Moisture content based on dry weight (M_c) was calculated using equation (1):

$$M_c = \frac{m_1 - m_2}{m_2} \times 100 \quad (1)$$

wherem_1 is the initial mass of sample (g) and m_2 is the mass of sample after drying (g).

The experiments included three drying temperatures (30, 40 & 50°C), three apricot thicknesses (50, 10 & 15 mm) and two pre-treatments (sulphur dioxide and water soluble $Na_2S_2O_5$). The loss of sample weight was measured at various time intervals during the drying process. Ambient temperature and relative humidity of air were about 30°C and 25%, respectively.

Mathematical Modelling

The data on moisture ratio was used for modelling thin layer for drying apricot. Based on equation (2), the moisture ratio depends on the initial moisture (M_0), equilibrium moisture (M_e), and the moment moisture on the dry basis (M_t) (Doymaz, 2007).

$$MR = \frac{M_t - M_e}{M_0 - M_e} \quad (2)$$

For long-term drying, M_e values compared toM_0 values are very small so it is not required to measure the equilibrium moisture (Doymaz, 2007).

$$MR = \frac{M_t}{M_0} \quad (3)$$

For mathematical modelling, the thin layer drying equations in Table 1 were tested to select the best model for describing the drying curve equation of apricot during the drying process. The regression analysis was performed using MATLAB software. The correlation coefficient (R^2) was one of the criteria for selecting the best equation to describe the drying curve equation. Furthermore, the reduced χ^2 as the mean square of the deviations between the observed experimental and expected values for the models and root mean square error analysis (RMSE) were used to determine the goodness of fit. The higher values of the R^2 and the lower values of χ^2 and RMSElead to the better goodness of fit (Akpinar, Bicer&Midilli, 2003; Akpinar, Bicer &Yildiz, 2003; Midilli & Kucuk, 2003; Yaldiz & Ertekin, 2001). These can be calculated as:

$$R^2 = \frac{\sum_{i=1}^{n}(MR_i - MR_{pre,i}) . \sum_{i=1}^{n}(MR_i - MR_{exp.i})}{\sqrt{\left[\sum_{i=1}^{n}(MR_i - MR_{pre,i})^2\right] . \left[\sum_{i=1}^{n}(MR_i - MR_{exp,i})^2\right]}} \quad (4)$$

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

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

where $MR_{exp,i}$ is the *i*th experimentally observed moisture ratio, $MR_{pre,i}$ the *i*th expected moisture ratio, *N* the number of observations and *n* the number of constants.

Table 1. Mathematical models used to describe the drying be havior of apricots in thin layer

Model no	Model name	Equation	Refrence
1	Verma	*MR=aexp(-kt)+(1-a)exp(-gt)*	Verma et al. (1985)
2	Henderson and pabis	*MR= aexp (-kt)*	Henderson (1952)
3	Logarithmic	*MR= aexp (-kt)+c*	Togrul and Pehlivan (2003)
4	Two-term	*MR= aexp* $(-k_0t)$*+bexp* $(-k_1t)$	Henderson (1952)
5	Approximation of diffusion	*MR= aexp (-kt)+(1-a) exp (-kbt)*	Ertekin, and Yaldiz, (2004).
6	Page	*MR= exp* $(-kt^n)$	Simal et al. (2005)
7	Mofified Henderson and pabis	*MR= aexp (-kt)+bexp (-gt)+ cexp (-ht)*	Sharma et al. (2005)
8	Newton	*MR= exp (-kt)*	Ayensu (1997)

RESULTS AND DISCUSSION

The average initial moisture content of the samples on dry basis was 379%. Based on the analysis of variance, the effects of temperature, thickness and pre-treatment are significant at the level of 1%. Besides, interactions of pre-treatment and temperature, pre-treatment and thickness, temperature and thickness and pre-treatment, temperature and thickness are significant at this level (Table 2).

Duncan test was applied to compare the effects of main factors (temperature, thickness and pre-treatment) on the average drying time (Table 3).

Table 2. Results of the analysis of variance for drying time

Source of variation		Mean squares
Temperature	**2**	**14108.33 ****
Pre-treatment	**1**	**1182465.68 ****
thickness	**2**	**4576175.52 ****
Interaction of pre-treatment and thickness	**Degree of freedom 2**	**122662.16 ****
Interaction of pre-treatment and temperature	**2**	**152018.35 ****
Interaction of thickness and temperature	**4**	**1247209.17 ****
Interaction of pre-treatment, temperature and thickness		**Mean squares**
error	**2**	**14108.33 ****

**. Significant at 1% of probability level.

Drying time can be significantly increased by increasing thickness that causes resistance to remove moisture. This finding is in accordance with the results of Fernando et al. (2011). It was also revealed that water soluble $Na_2S_2O_5$ reduced drying time more than sulphur dioxide. The reason may be that theosmotic phenomena and subsequently the diffusion process enhance using the soluble. The effects of thickness on drying time in different pre-treatments are shown in Figs.1 and 2. According to these figures, drying time was decreased by increasing temperature with constant thickness. Similar results were reported by previous researchers too (Chen et al., 2015; Serement et al., 2016). Furthermore, drying time was increased by increasing thickness in constant temperature.

The models constants and their comparison criteria are given in Tabls 4,6. The results show that the values of R^2 ranged from 0.3865to 0.9999. It can be seen from Tabls 4,6 that the highest R^2 values were observed with the Page and the Logarithmic models. But the Page model presents lower $\chi 2$ and RMSE compared to the Logarithmic model. Therefore, the Page could be selected as the model to describe the drying be heavier of apricots.

Table 3. Comparison of the effect of the factors on average drying time

Source of variations			Drying time (min)
Pre-treatment	Thickness (mm)	Temperature (^oC)	
Water soluble sulphur	5	30	996
		40	378
		50	243
	10	30	1134
		40	546
		50	375
	15	30	2256
		40	1062
		50	541
Sulphur dioxide	5	30	978
		40	522
		50	306
	10	30	2184
		40	828
		50	390
	15	30	2802
		40	1206
		50	762

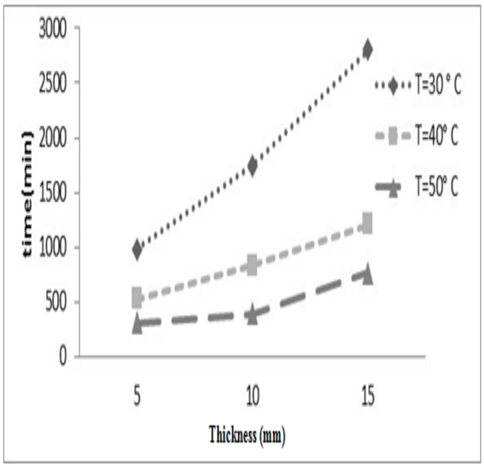

Fig.1. The effect of thickness on drying kinetics of apricot slices at different temperatures pre-treated with sulphur dioxide

The performance of the Page model is illustrated in Fig. 3. The experimental data are generally banded around the straight line, representing data found by computation, which indicates the suitability of the Page mathematical model in describing the drying be heavier of apricots.

Table 4. Modeling of moisture ratio according to drying time for apricot in 30℃.

Model	Parameters	thicknesses 5 mm Sulfur smoke	5 mm Solution of sodium meta bi sulfite	10 mm Sulfur smoke	10 mm Solution of sodium meta bi sulfite	15 mm Sulfur smoke	15 mm Solution of sodium meta bi sulfite
Two term	a	-0.037	10.21	1.07	1.575	1.025	14.94
	b	1.037	-9.176	-0.06973	-0.5735	-0.02535	-13.93
	k_0	4.339	0.06062	0.04425	0.109	0.03299	0.0654
	k_1	0.1022	0.05803	5.022	0.248	5.259	0.06814
	R^2	0.9895	0.9786	0.9837	0.9951	0.9762	0.9928
	χ^2	0.00156	0.00326	0.00184	0.0075	0.00213	0.000885
	RMSE	0.03946	0.05711	0.04295	0.02739	0.04613	0.02974
Modified Henderson and Pabis	a	0.07228	0.6232	-0.0225	0.9913	1.817	1.427
	b	1.165	-0.8334	1.07	-0.2018	-0.9719	0.6642
	c	-0.2374	1.21	0.1554	0.2105	0.1546	-1.427
	k	-0.00058	0.9854	3.311	0.09519	0.0472	0.7898
	g	0.1475	6.835	0.04425	5.721	0.09493	0.0258
	h	3.466	0.1083	1.738	0.09511	3.278	0.7911
	R^2	0.9956	0.9863	0.9837	0.9948	0.9872	0.871
	χ^2	0.00077	0.00232	0.00205	0.00884	0.00127	0.0173
	RMSE	0.02771	0.04818	0.04527	0.02973	0.03561	0.1315
Henderson and Pabis	a	1.004	1.048	1.024	1.052	1.01	1.038
	k	0.09897	0.09105	0.0422	0.08151	0.03237	0.04124
	R^2	0.9893	0.9761	0.9815	0.9850	0.9757	0.9846
	χ^2	0.00139	0.0033	0.0019	0.00207	0.00197	0.00176
	RMSE	0.0373	0.05747	0.04362	0.04553	0.04437	0.04199
Logarithmic	a	0.9689	1.068	1.341	1.099	1.661	1.327
	k	0.1122	0.08552	0.02451	0.07125	0.01439	0.02406
	c	0.4355	-0.02631	-0.3486	-0.05962	-0.6832	-0.3274
	R^2	0.992	0.9773	0.99934	0.9880	0.9875	0.9973
	χ^2	0.0111	0.0329	0.0071	0.0173	0.0106	0.0317
	RMSE	0.03332	0.05737	0.02666	0.0416	0.03262	0.01779
Newton	K	0.09857	0.08642	0.04112	0.077	0.03196	0.03945
	R^2	0.9893	0.9731	0.9803	0.9812	0.9754	0.9819
	χ^2	0.0013	0.00356	0.00194	0.00249	0.00191	0.00201
	RMSE	0.03624	0.05971	0.044	0.04987	0.04366	0.04485
Page	k	0.5452	0.04418	0.02072	0.03792	0.01936	0.01896
	n	2.907	1.278	1.212	1.277	1.15	1.225
	R^2	0.9957	0.9851	0.9894	0.9949	0.9807	0.9931
	χ^2	0.009125	0.000206	0.00011	0.0000699	0.000157	0.000079
	RMSE	0.312	0.04537	0.03304	0.02645	0.03961	0.02825
Approximation of diffusion	a	0.9999	1.254	-19.97	17.86	-7.008	-9.718
	b	-1.719	0.8968	0.9705	0.9676	-0.9301	0.9393
	k	0.1007	0.08406	0.07115	0.04462	0.05487	0.07079
	R^2	0.9937	0.9732	0.9901	0.9878	0.9822	0.9935
	χ^2	0.00102	0.0043	0.00118	0.00195	0.00167	0.000834
	RMSE	0.02969	0.06229	0.0327	0.04206	0.03891	0.02778
Verma et al.	a	0.9999	1.231	13.4	-0.5705	1.025	18.81
	k	0.10065	0.1097	0.06539	0.2495	0.03299	0.06963
	g	-1.175	6.1	0.06825	0.1089	4.241	0.07227
	R^2	0.9937	0.9862	0.9897	0.9951	0.9762	0.9933
	χ^2	0.000944	0.002098	0.00117	0.00075	0.00213	0.000823
	RMSE	0.02969	0.0447	0.0331	0.02673	0.04502	0.02815

Table 5. Modeling of moisture ratio according to drying time for apricot in 40℃.

Model	Parameters	Thicknesses 5 mm		10 mm		15 mm	
		Sulfur smoke	Solution of sodium meta bi sulfite	Sulfur smoke	Solution of sodium meta bi sulfite	Sulfur smoke	Solution of sodium meta bi sulfite
Two term	a	2.304	-7.085	0.5425	0.001856	6.655	-0.1661
	b	-1.309	8.104	0.4611	1.001	-5.662	1.166
	k_0	0.193	0.1455	0.1799	-0.1149	0.1152	4.875
	k_1	0.1911	0.1475	0.04807	0.2543	0.125	0.09734
	R^2	0.9907	0.9723	0.7236	0.9921	0.9868	0.9783
	χ^2	0.00199	0.004479	0.0525	0.00121	0.00198	0.00342
	RMSE	0.04462	0.06693	0.2292	0.03472	0.04448	0.05844
Modified Henderson and Pabis	a	1.0001	-17.47	0.3952	-0.2038	13.53	12.37
	b	1.024	0.6314	0.2494	-1.086	0.2749	-11.27
	c	-1.024	17.87	0.3884	2.291	-12.75	-0.08393
	k	-0.03818	0.07928	0.8431	0.235	0.05002	0.07989
	g	0.2057	0.2304	0.7822	0.3128	0.4083	0.07878
	h	-0.03553	0.07992	0.1294	0.2757	0.04934	1.601
	R^2	0.9964	0.9687	0.3865	0.9901	0.9649	0.9777
	χ^2	0.00103	0.0061	0.1425	0.00176	0.0061	0.003977
	RMSE	002966	0.07795	0.3775	0.04192	0.07833	0.06306
Henderson and Pabis	a	0.9947	1.017	0.9798	1.002	1.01	1.043
	k	0.196	0.1611	0.08832	0.2505	0.07858	0.08587
	R^2	0.9907	0.9721	0.717	0.9901	0.9839	0.9707
	χ^2	0.001591	0.00395	0.0455	0.00132	0.002105	0.004126
	RMSE	0.03989	0.06286	0.2133	0.03636	0.04588	0.06423
Logarithmic	a	0.9463	1.034	0.8864	0.9814	1.067	1.309
	k	0.232	0.1539	0.1244	0.2653	0.06786	0.0498
	c	0.0542	-0.02004	0.1149	0.02224	-0.06566	-0.3083
	R^2	0.9960	0.9728	0.7226	0.9916	0.9863	0.9912
	χ^2	0.000753	0.00411	0.0483	0.001194	0.00191	0.00131
	RMSE	0.02744	0.06414	0.2198	0.03455	0.04369	0.03617
Newton	K	0.197	0.1585	0.09027	0.2501	0.07783	0.08205
	R^2	0.9907	0.9717	0.7163	0.9901	0.9838	0.9678
	χ^2	0.00145	0.00377	0.0424	0.001245	0.0020	0.0043
	RMSE	0.03813	0.0143	0.2058	0.03528	0.04475	0.06561
Page	k	0.3037	0.09228	0.1443	0.2119	0.05622	0.03712
	n	0.7696	1.294	0.8175	1.102	1.119	1.312
	R^2	0.9950	0.9777	0.7225	0.9903	0.9861	0.9865
	χ^2	0.0008582	0.003155	0.0446	0.00129	0.00182	0.0019
	RMSE	0.0293	0.05617	0.2113	0.0359	0.04268	0.04359
Approximation of diffusion	a	0.9957	43.78	0.5461	0.9981	-8.168	-15.31
	b	-0.6409	0.9912	0.2684	-0.4503	0.9465	0.9551
	k	0.2121	0.1084	0.1771	0.2538	0.1212	0.1542
	R^2	0.9964	0.9734	0.7236	0.9921	0.9866	0.986
	χ^2	0.00088	0.00465	0.0578	0.0013	0.00216	0.00235
	RMSE	0.02616	0.06346	0.2195	0.03358	0.04329	0.04566
Verma	a	0.9957	-3.089	0.453	3.501	-6.838	-16.09
	k	0.2121	0.1032	0.04746	0.2318	0.1174	0.1499
	g	-0.1359	0.1146	0.177	0.225	0.1107	0.1437
	R^2	0.9964	0.9734	0.7236	0.9901	0.9865	0.9858
	χ^2	0.00077	0.00431	0.00525	0.001515	0.0020	0.00223
	RMSE	0.02616	0.06345	0.2195	0.0376	0.0434	0.04588

Table 6. Modeling of moisture ratio according to drying time for apricot in 50℃.

Model	Parameters	Thicknesses					
		5 mm		10 mm		15 mm	
		Sulfur smoke	Solution of sodium meta bi sulfite	Sulfur smoke	Solution of sodium meta bi sulfite	Sulfur smoke	Solution of sodium meta bi sulfite
Two term	a	0.432	0.2973	0.2338	0.3865	1.617	0.4786
	b	0.568	0.7027	0.7663	0.6196	-0.6164	0.5328
	k_0	0.1787	0.1642	0.08292	0.1592	0.1375	0.1429
	k_1	0.1978	0.9	0.5092	0.1592	0.1353	0.1429
	R^2	0.9998	0.9898	0.9995	0.9913	0.9867	0.9889
	χ^2	0.000022	0.00357	0.0001875	0.002604	0.003225	0.03314
	RMSE	0.004703	0.05971	0.01369	0.05103	0.05679	0.05756
Modified Henderson and Pabis	a	0.5443	0.2901	0.2384	1.973	-0.8129	1.096
	b	0.0499	0.4277	0.2127	-1.344	-1.435	1.116
	c	0.4058	0.2822	0.5489	0.3705	3.247	-1.213
	k	0.6807	0.903	0.08389	0.3192	0.7636	0.277
	g	0.9643	0.7524	0.9568	1.091	0.8481	0.2919
	h	0.1246	0.162	0.9352	0.3125	0.2151	1.036
	R^2	0.9979	0.9898	0.9995	0.996	0.9877	0.9987
	χ^2	0.00023	0.00594	0.000312	0.002007	0.00398	0.000649
	RMSE	0.00123	0.07709	0.01768	0.0448	0.06307	0.02548
Henderson and Pabis	a	1	1	0.9999	1.006	1.001	1.011
	k	0.1889	0.3949	0.1789	0.1592	0.1388	0.1429
	R^2	0.9698	0.9895	0.9991	0.9913	0.9867	0.9889
	χ^2	0.00001	0.00261	0.000231	0.00186	0.00258	0.00237
	RMSE	0.003326	0.05112	0.0152	0.04313	0.05079	0.04865
Logarithmic	a	0.9292	0.9874	0.9605	1.08	1.024	1.145
	k	0.6037	0.4117	0.2383	0.1343	0.1272	0.1066
	c	0.0708	0.0126	0.03949	-0.07963	-0.02354	-0.1454
	R^2	0.9999	0.9898	0.9995	0.996	0.9869	0.9987
	χ^2	0.00001	0.00297	0.000156	0.00100	0.00281	0.00031
	RMSE	0.00384	0.05451	0.0125	0.03167	0.05303	0.01775
Newton	K	0.1889	0.3949	0.1789	0.1582	0.1388	0.1412
	R^2	0.9999	0.9895	0.9991	0.9912	0.9867	0.9886
	χ^2	0.00000	0.00229	0.000202	0.00164	0.00234	0.00212
	RMSE	0.00297	0.04782	0.01422	0.04052	0.04843	0.04606
Page	k	0.8449	0.7645	0.7318	0.06952	0.04114	0.05168
	n	0.4329	0.5899	0.4816	1.478	1.441	1.565
	R^2	0.9908	0.9898	0.9995	0.996	0.9875	0.9987
	χ^2	0.00001	0.00255	0.000133	0.00086	0.00242	0.00027
	RMSE	0.00332	0.05046	0.01157	0.02932	0.04922	0.01643
Approximation of diffusion	a	0.2386	0.7592	0.7981	0.7693	1.061	-1.7
	b	0.4022	0.3201	0.1938	1	0.6316	0.2824
	k	0.4229	0.6676	0.3892	0.1582	0.134	1.15
	R^2	0.9999	0.9898	0.9995	0.9912	0.9867	0.9987
	χ^2	0.000424	0.00445	0.000234	0.00328	0.00366	0.00047
	RMSE	0.00384	0.05451	0.0125	0.1582	0.0534	0.01775
Verma	a	0.8315	0.6814	0.2365	2.529	1.72	2.707
	k	0.1775	1.241	0.08346	0.333	0.07897	0.325
	g	0.3274	0.1684	0.6126	1.091	0.1064	1.12
	R^2	0.9899	0.9898	0.9995	0.996	0.987	0.9987
	χ^2	0.000022	0.00356	0.000187	0.0012	0.00314	0.00037
	RMSE	0.00384	0.05451	0.0125	0.03167	0.05284	0.01775

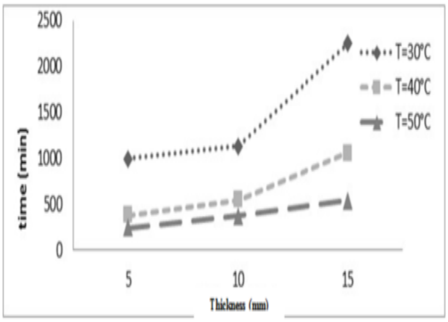

Fig. 2. The effect of thickness on drying kinetics of apricot slices at different temperatures pre-treated with water soluble $Na_2S_2O_5$

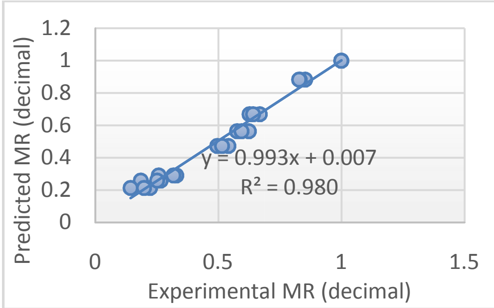

Fig. 3. Experimental and predicted moisture contents for Page model

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Appropriate temperature for drying apricot is determined.

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مدل پیج

چکیده- از دیرباز از خشک کردن برای نگهداری میوه ها استفاده می شده است. زردآلوی خشک خسارت، وزن و حجم تلفات، فضای بسته بندی، انبار داری و هزینه های حمل و نقل را کاهش می دهد. در این تحقیق، اثرات خشک کن هوای داغ بر میوه زردآلوی ایرانی رقم نوری، تجزیه و تحلیل شده است. این آزمایش در سه درجه حرارت (۳۰، ۴۰ و ۵۰ درجه سلسیوس)، سه ضخامت (۵، ۱۰ و ۱۵ میلی متر) و دو پیش تیمار (دی اکسید گوگرد و متا بی سولفیت سدیم محلول در آب) انجام شد. بر اساس تجزیه و تحلیل واریانس، اثرات دما، ضخامت، پیش تیمار و اثر متقابل این عوامل بر زمان خشک شدن محصول در سطح ۱٪ معنی دار بودند. مشخص شد که محلول متا بی سولفیت سدیم زمان خشک کردن را بیش از دی اکسید گوگرد کاهش می دهد. داده ها در هشت مدل مختلف ریاضی برازش داده شدند. مدل پیج به عنوان بهترین مدل برای توصیف خشک کردن لایه نازک زردآلو، با مقایسه تعیین ضریب همبستگی (R^2)، مجذور کای (χ^2) و ریشه میانگین مربع خطا (RMSE) بین نسبت رطوبت مشاهده شده و مقدار مورد انتظار آن، مشخص شد.