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Mathematical Modeling of Apricot Drying

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Abstract

Apricot is highly appreciated temperate fruit with taste, smell, visual and nutritional properties. Apricot fruits are mostly consumed as fresh but because of their perishable nature and short storage opportunity they are generally dried. Drying is apparently one of the oldest methods in food preservation technique, used by human and commonly used for preservation of fruits and vegetables. In this study, tray drying and also microwave pretreated tray drying were applied on apricot. The drying was performed at a constant air velocity of 0,5 m/s and temperature of 60°C. For microwave pretreated hot air drying, microwave was applied to apricot at 350 W power intensity and then samples were dried in tray dryer. Moisture content trends for both tray and microwave pretreated tray drying was the same, because of the studying constant temperature, as normal and similar to literature. The fit quality of 6 thin-layer drying models: Newton, Page, Logarithmic, Henderson and Pabis, Two Term and Wang and Sing were applied to the experimental data of apricot drying. Two term model was the best fitting model for tray dried apricot. For microwave pretreated tray dried apricot, best fitting models are Logarithmic and two term.

Keywords: apricot, drying, microwave, mathematical modeling

INTRODUCTION

Apricot is highly appreciated temperate fruit with taste, smell, visual and nutritional properties. It has been widely consumed for over years by various cultures. Apricot botanically named as Prunus armeniaca L. (Huang et al., 2013). Apricot has an important place in human nutrition because of not only the attractive color and taste but also the rich mineral and vitamin contents and antioxidant properties. Apricot fruits are mostly consumed as fresh but because of their perishable nature and short storage opportunity they are generally dried (Hacıseferoğulları et al, 2007).

Apricot has health benefit properties due to presence of bioactive compounds. Apricots are important essential nutrient sources for human such as minerals, vitamins like A, C, riboflavin, niacin, thiamine and pantothenic acid; fibers, bioactive phytochemicals, organic acids, phenolic compounds and carbohydrates (Orsat et al., 2007). Carotenoids, phenolics and antioxidants are important phytochemicals for their biological value. In the later years, interest in carotenoids and polyphenols of apricots has increasing for their antioxidant properties and ability to scramble towards chronic disease. Apricot contains high amount of carotenoids which contribute to fruit color, taste and nutritive value (Huang et al., 2013). In apricot 60-70% of the total carotenoids is represented as β-carotene (Sass-Kiss et al., 2005). Apricots are important source of phenolic compounds. They have antioxidant potential and act as anti-allergic, anti-microbial, anti-carcinogenic, anti-flammatory and anti-mutagenic role.

Drying is apparently one of the oldest methods in food preservation technique, used by human and commonly used for preservation of fruits and vegetables (Lewicki, 2006). Fresh fruits and vegetables are classified as highly perishable commodities because of the moisture content is more than 80%. Moisture in the foods is one of the important factor in microbiological deterioration and chemical and physical changes. For the dehydration of foods and bio-materials, there is a lot of processing technique. Each drying technique has specific effect on product by means of product functionality and quality. Over the years, a number of new and innovative drying methods have been developed.

Tray drying systems use trays to expose the food product to heated air in an enclosed space. In microwave drying electromagnetic energy with the frequency between 300 MHz and 300 GHz is used. It is demonstrated that using microwave energy for drying reduce the energy consumption. The microwave energy is an attractive thermal energy source by the reasons of reduced processing time and volumetric heating. For fully complete drying process microwave is recommended to combine with other drying techniques.

The drying kinetics of the product are the most important data required for the design and simulation of dryers and estimate the drying time. Thin layer drying equations are used to estimate the drying time for several products and also to generalize the drying curves. In food drying studies semi-theoretical and empirical models are widely used such as Newton, Page, Henderson and Pabis, Logarithmic, Two term and Wang and Sing (Table 1.).

Table 1. Thin layer models in food drying

Model Name	Model
Newton	$MR = \exp(-kt)$
Page	$MR = \exp(-kt^n)$
Henderson and pabis	$MR = a \exp(-kt)$
Logarithmic	$MR = a \exp(-kt) + c$
Two term	$MR = a \exp(-k_0 t) + b \exp(-k_1 t)$
Wang and Sing	$MR = 1 + at + bt^2$

In this study hot air and microwave pretreated hot air drying were applied on apricot and kinetic parameters were determined.

MATERIAL and METHODS

Apricot samples were obtained from traditional bazaar in Gaziantep. Apricot fruits were selected of nearly uniform size and maturity, free from diseases. All samples were brought to laboratory immediately and washed with distilled water for removal of dust and other pollutants. After washing, the excess water was dried on the drying paper.

The drying of apricot has been performed in a pilot plant tray drier (VOP 8 Tray Dryer, Armfield, UK). Apricot seeds were taken and all samples were cut into small pieces, and stored at -40°C. Samples stored at -40°C freezer were weighted nearly 200 g and placed to refrigerator for thawing. After 5 hours, samples put into special aluminium dish for tray dryer as a thin layer and replaced in the driers middle shelf. The drying was performed at a constant air velocity of 0,5 m/s and temperature of 60°C. Hot air flows parallel to the drying surface of the sample. Weight loss was recorded at 15 minutes interval by a digital balance connected to the dryer. Drying was continued until the moisture content of samples fall under 25%.

For microwave pretreated hot air drying frozen samples were thawed in refrigerator and nearly 200 g sample was put into squared glass dish and MW was applied for 1 minute at 350 W power intensity. After MW pretreatment, samples were dried in tray dryer in the same conditions with other samples, which dried only in hot air drying.

Six empirical and semi-theoretical models (Newton, Page, Henderson and Pabis, Logarithmic, Two term and Wang and Sing) were tested to fit the moisture ratio versus time. All data were analyzed by one-way analysis of variance (one-way ANOVA) to test for significant differences by using IBM SPSS Statistics 21. Differences among sample means were reported to be significant when $p<0.05$.

RESULTS and DISCUSSION

Drying Kinetics

The initial moisture contents of apricot was about 85 (wet basis). Drying of samples continued until the final moisture contents of about 25 % (by wet basis). Variations of the moisture contents of apricot samples with drying time in tray and MW pretreated tray drying are given in Figure 1. Moisture contents of all samples decreased with similar trends.

Moisture content trends for both tray and microwave pretreated tray drying was the same, because of the studying constant temperature, as normal and similar to literature (Marquez et al., 2006).

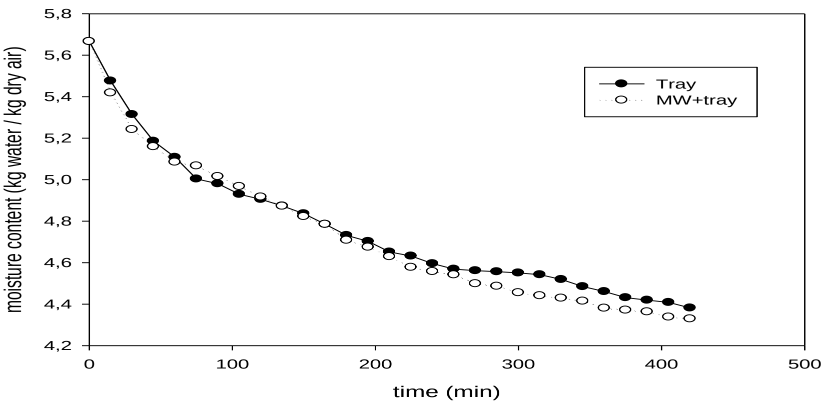

Figure 1. Variation of moisture content versus drying time of samples in tray and MW+tray drying

Modelling of Drying Curves

The moisture content data obtained from experimental drying were converted into moisture ratio (MR). Natural logarithm of moisture ratio plotting versus time (Figure 2). For apricot, only one falling rate period was observed. Then drying models was applied to the experimental data of apricot samples. The statistical values and constants of each model for all samples are shown in Table 2.

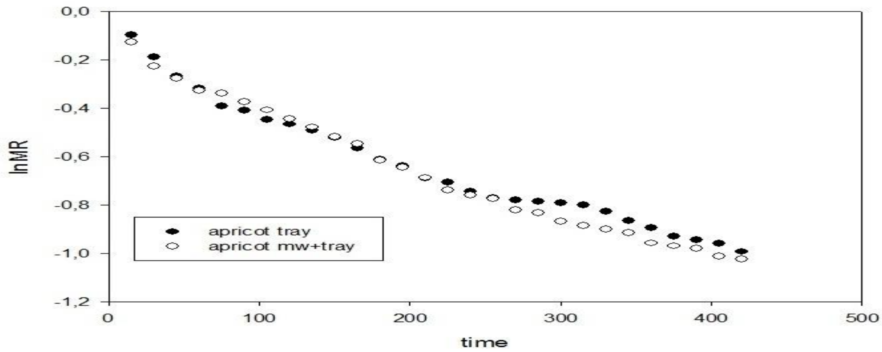

Figure 2. Natural logarithm of moisture ratio versus time graph for apricot

The coefficient of determination (R^2) was one of the primary criterions for selecting the best equation to define the drying curves of apricots and also root mean square error (RMSE) was used to determine the quality of the fit (Delgado et al, 2014).

Table 2. Thin Layer Model Fitting for apricot samples dried with tray and MW+tray drier

Sample	Model	R^2	RMSE	k	n	a	b	k_0	k_1	c
Apricot Tray	Newton	0.7634	0.0678	0.0030						
	Page	0.9926	0.0120	0.0278	0.5921					
	Handerson and Pabis	0.9546	0.0297	0.0021		0.8343				
	Logaritmic	0.9893	0.0144	0.0060		0.5739				0.3446
	Two Term	0.9950	0.0098			0.2809	0.7139	0.0215	0.0016	
	Wang and Sing	0.9029	0.0435			-0.0035	5.1481 E-006			
Apricot MW+Tray	Newton	0.8335	0.0596	0.0030						
	Page	0.9934	0.0119	0.0228	0.6336					
	Handerson and Pabis	0.9818	0.0197	0.0023		0.8462				
	Logaritmic	0.9945	0.0109	0.0044		0.6350				0.2577
	Two Term	0.9945	0.0109			.06350	0.2577	0.0044	4.1429 E-019	
	Wang and Sing	0.9228	0.0406			-0.0035	4.8732 E-006			

Two term model was the best fitting model for tray dried apricot. For mw+tray dried apricot best fitting models are Logarithmic and two term. The performance of the best models are illustrated in Figure 3. and Figure 4. The predicted data generally banded around the straight line which showed the suitability of mathematical model in describing drying behavior of apricots.

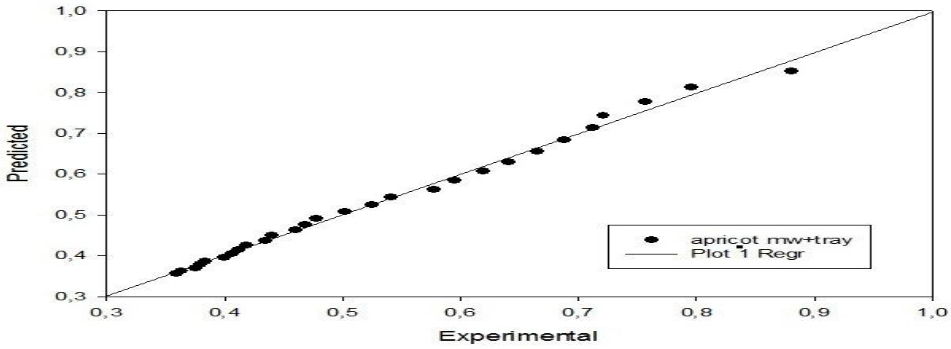

Figure 3. The performance of the logarithmic model for MW+tray dried apricot

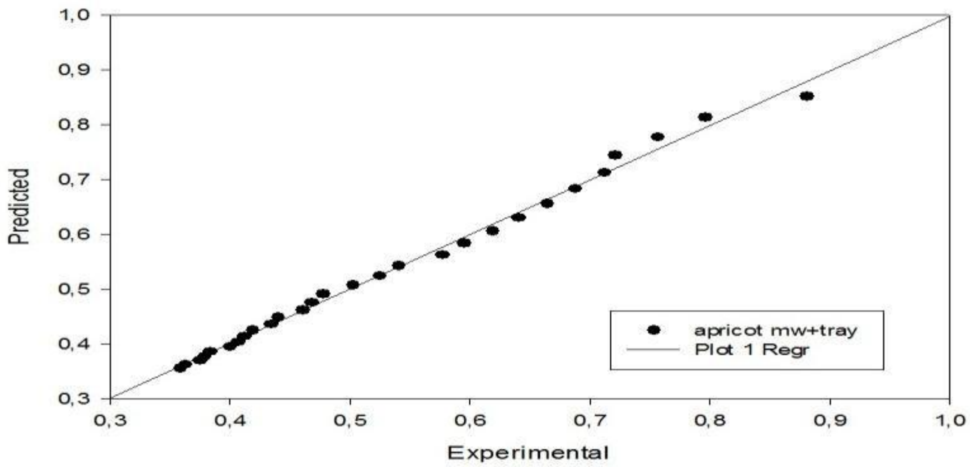

Figure 4. The performance of the two term model for MW+tray dried apricot

Toğrul and Pehlivan (2003) were studied about modeling of drying kinetics of single apricot. They described the logarithmic drying model is best for the drying behavior of single apricot (within 99.9%).

CONCLUSION

Hot air drying and microwave pretreated hot air drying were found to be suitable for drying of apricot. Drying curves for apricot samples only showed falling rate period. These results indicated that moisture movement mechanism in apricot could be by diffusion. The fit quality of 6 thin-layer drying models (Newton, Page, Logarithmic, Henderson and Pabis, Two Term and Wang and Sing) to experimental data were evaluated. Good results according to the coefficient of determination (R^2) and root mean square error (RMSE) were obtained with the Logarithmic and Two Term models.

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REFERENCES

Hacıseferoğulları, H., Gezer, İ., Özcan, M.M., Asma, B.M. (2007). Post harvest chemical and physical–mechanical properties of some apricot varieties cultivated in Turkey. Journal of Food Engineering. 79, 364–373.

Huang, W., Bi, X., Zhang, X., Liao, X., Hu, X., Wu, J. (2013). Comparative study of enzymes, phenolics, carotenoids and color of apricot nectars treated by high hydrostatic pressure and high temperature short time. Innovative Food Science and Emerging Technologies. 18, 74–82.

Lewicki, P.P. (2006). Design of hot air drying for beter foods. Trends in Food Science & Technology. 17, 153–163.

Marquez, C.A., Michelis, A.D., Giner, S.A. (2006). Drying kinetics of rose hip fruits (Rosa eglanteria L.). Journal of Food Engineering. 77, 566-574.

Orsat, V., Yang, W., Changrue, V., Raghavan, G.S.V. (2007). Microwave-assisted drying of Biomaterials. Trans IChemE, Part C, Food and Bioproducts Processing. 85, 255–263.

Sass-Kiss, A., Kiss, J., Milotay, P., Kerek, M.M., Toth-Markus, M. (2005). Differences in anthocyanin and carotenoid content of fruits and vegetables. Food Research International. 38, 1023–1029.

Toğrul, İ.T., Pehlivan, D. (2003). Modelling of drying kinetics of single apricot. Journal of Food Engineering. 58, 23–32.