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DRYING KINETIC OF FRESH AND OSMOTICALLY DEHYDRATED MUSHROOM (*AGARICUS BLAZEI*)

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ABSTRACT

*The aim of this study was to model the drying kinetics of fresh and osmotically pretreated mushroom slices (*Agaricus blazei*). Besides the effects of drying air temperature and air velocity, the effect of osmotic pretreatment on drying kinetics and color of dried mushrooms was also determined. The osmotic treatment was carried out at 20C with a 10% (w/w) salt solution, 80 rpm agitation and 60 min immersion time. The fresh and osmosed mushrooms were dried in a vertical bed dryer with forced airflow at different temperatures (40, 60 and 80C) and air velocities (1.0, 1.75 and 2.5 m/s). Drying curves obtained from the experimental data were fitted to the different thin layer-drying models (Fick's, Page's and logarithmic models). Drying rates of osmosed mushroom decreased due to the presence of infused solids. Increasing the drying temperature and air velocity caused shorter drying times. Osmotically pretreated mushroom presented lower luminosity values (L*) when compared with fresh mushroom, indicating that the osmotic dehydration was not efficient to prevent color loss. Temperature strongly affected the color parameters luminosity L* (or lightness) and chroma C* (or color intensity).*

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PRACTICAL APPLICATIONS

Biological materials are highly perishable due to their high moisture content. Therefore, these materials must be processed to improve their shelf life. Among the several methods employed for preservation, drying is a process in which the water activity of the food is reduced by the removal of water, minimizing chemical, enzymatic and microbiological reactions. Several pretreatments are commonly used to minimize adverse changes occurring during drying. Osmotic dehydration is used for the partial removal of water from the food by immersion in a hypertonic solution reducing the physical, chemical and biological changes during drying at higher temperatures. Thus, this study intends to contribute in understanding the behavior of undesirable color quality degradation during the process.

INTRODUCTION

Agaricus blazei is a Brazilian mushroom popularly known as the sun mushroom, and is frequently consumed as food due to its unique flavor, or as tea for its medicinal effect. This mushroom is used to fight physical and emotional stress, osteoporosis and ulcers, and for quality-of-life improvement in diabetic people, for cholesterol reduction and for the treatment of circulatory and digestive problems. In addition, it has shown antitumor activity (Niu *et al.* 2009), immunomodulation effect (Chan *et al.* 2007), antioxidant activity (Soares *et al.* 2009) and antimutagenic and anticlastogenic properties (Delmanto *et al.* 2001).

Due to their high moisture content, mushrooms are highly perishable as they start deterioration soon after harvest, with a shelf life of 1–2 days at room temperature. Therefore, fresh mushrooms are processed to increase their shelf life. Among the several methods employed for preservation, drying is a process in which the water activity of the food is reduced by the removal of water by vaporization or sublimation, minimizing enzymatic and microbiological reactions. Drying is a simultaneous heat and mass transfer process, accompanied by a phase change. The drying rate depends on factors that influence the transfer mechanisms, such as the vapor pressure of the material and drying air, temperature and air velocity, water diffusion in the material, thickness and surface exposed for drying (Van Arsdel 1973; Barbanti *et al.* 1994; Lewicki and Jakubczyk 2004).

Although air drying offers dehydrated products that can have an extended life of a year, the quality of a conventionally dried product is usually drastically reduced from that of the original foodstuff (Ratti 2001).

Several pretreatments are commonly used in order to minimize adverse changes occurring during drying. Osmotic dehydration is used for the partial

removal of water from food by immersion in a hypertonic solution, without a phase change that reduces the physical, chemical and biological changes during drying at higher temperatures (Kowalska and Lenart 2001). The osmotic dehydration of mushrooms (*Agaricus bisporus*) has been studied as a pretreatment for microwave drying by Torringa *et al.* (2001) and for air-convective drying by Shukla and Singh (2007).

The objective of the present study was to evaluate the influence of pretreatment (osmotic dehydration) and different drying conditions (air temperature varying between 40 and 80C and air velocity varying between 1.0 and 2.5 m/s) on the drying kinetic and on the color of the dried product.

Theory

A 2-L-thick infinite slab, having uniform initial water content and undergoing drying with constant conditions, can be described by Fick's unidirectional diffusion equation (Crank 1975):

$$\frac{\partial X}{\partial t} = \frac{\partial}{\partial z}\left(D_{\text{eff}} \frac{\partial X}{\partial z} \right) \tag{1}$$

where X is the moisture content (kg water/kg solids), t is the time (s), z is the coordinated direction and D_{eff} is the effective diffusivity of water (m^2/s).

Considering D_{eff} constant and using the following initial and boundary conditions:

(1) Uniform initial moisture content: $X(z,0) = X_0$;

(2) Symmetry of water concentration: $\left.\frac{\partial X(t)}{\partial z}\right|_{z=0} = 0$;

(3) Equilibrium content at surface: $X(L,t) = X_e$

and applying:

$$\overline{X(t)} = \frac{1}{L}\int_0^L X(z,t)\,dz \tag{2}$$

where $\overline{X(t)}$ is the average moisture content at instant t (kg water/kg solids) and L is the characteristic length, sample half-thickness (m).

Therefore, the solution as a series obtained for water transport in a semi-infinite plate, and negligible shrinkage, is:

$$MR = \frac{\overline{X(t)} - X_e}{X_0 - X_e} = \frac{8}{\pi^2}\sum_{i=0}^{\infty} \frac{1}{(2i+1)^2} \exp\left[-(2i+1)^2 \frac{\pi^2 D_{\text{eff}}}{4L^2} t \right] \tag{3}$$

where MR is the dimensionless moisture ratio, X_0 is the initial moisture content (kg water/kg solids) and X_e is the equilibrium moisture content (kg water/kg solids).

One of the most useful empirical models is Page's equation (Eq. 4), which is an empirical modification of the simple exponential model. This model has been widely utilized for drying of biological materials (El-aouar *et al.* 2003; Simal *et al.* 2005; Azoubel et al. 2009; Doymaz 2009).

$$MR = \exp\left(kt^b\right) \tag{4}$$

where k is the drying constant (1/s) and b is the Page's parameter.

Another model, which is widely used for thin layer-drying studies, is the logarithmic model. This model has produced good fits in predicting the drying of sucrose-osmosed tomato (Azoubel et al. 2009) and spinach leaves (Doymaz 2009):

$$MR = a\exp(-kt) + c \tag{5}$$

where c is constant.

MATERIALS AND METHODS

Material

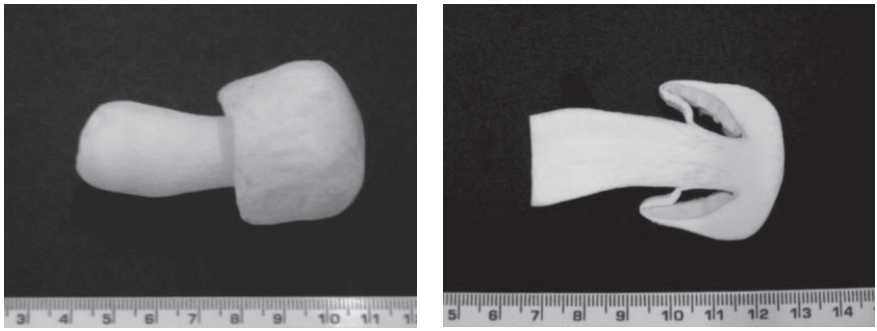
Fresh mushrooms (*A. blazei*), with an average initial moisture content of 88.7% (w/w) were supplied by the Group Agaricus of Piedade Industry, located in the city of Pilar do Sul, Brazil. The samples were visually sorted by color (light yellow) and size (average diameter of 3 cm and length of 5 cm) and longitudinally cut into slices 0.5 cm thick (Fig. 1) using a cutter designed for this purpose.

The main characteristics of the mushrooms, obtained according to AOAC (1995), are summarized in Table 1. The results were very close to those obtained by Mizuno *et al.* (1990), with the exception of the protein and carbohydrate contents. The pH and water activity values of the fresh mushrooms were 6.24 ± 0.01 and 0.995 ± 0.001, respectively.

The osmotic solution was prepared with distilled water and commercial sodium chloride.

Color Measurement

The color of the fresh, osmotically dehydrated and dried samples (with and without pre-treatment) was measured using the CIELAB color scale. The



a **b**

FIG. 1. (a) MUSHROOM (*AGARICUS BLAZEI*) AND (b) SLICED MUSHROOM

TABLE 1.
CHEMICAL COMPOSITION OF MUSHROOM

Analysis	Content*	Mizuno *et al.* (1990) (%)
Moisture (w.b., %)	88.7 ± 0.1	85–87
Carbohydrate (d.b., %)	51.5 ± 1.1	38–45
Proteins (d.b., %)	30.4 ± 0.9	40–45
Ash (d.b., %)	7.29 ± 0.1	5–7
Fibers (d.b., %)	6.76 ± 0.4	6–8
Fat (d.b., %)	4.1 ± 0.2	3–4

* Values represent means of three determinations ± standard deviations.
d.b., dry basis; w.b., wet basis.

parameters L^* (lightness), a^* (green–red coordinate) and b^* (blue–yellow coordinate) were obtained by using the Color Quest II colorimeter (Hunter Associates Laboratory, Inc., Reston, VA). Previously, the equipment was calibrated with a light trap (to simulate that all the light was absorbed by the sample) and a white reference tile. A quartz-halogen lamp as a source of illumination was used (D65 illuminant and 10° standard observer angles as the reference system). The color coordinators L^*, a^* and b^* values were determined and the chroma value (C^*) was calculated according to Eq. (6). L^* values (from 0 [black] to 100 [white]) represent luminosity, a^* values range from –60 (green) to 60 (red), b^* values range from –60 (blue) to 60 (yellow) and C^* values is regarded as the quantitative attribute of colorfulness. All the parameters were measured in triplicate.

$$C^* = \sqrt{\left(a^{*2} + b^{*2}\right)} \tag{6}$$

Osmotic Pretreatment

The samples were osmotically dehydrated in a NaCl solution (concentration of 10% w/w) at a temperature of 20C and 80 rpm agitation. The slices were placed in 250-mL beakers containing the osmotic solution, where the sample : solution ratio was 1:10, to avoid dilution of the solution during the process. The process conditions were based on the results to obtain maximum water loss and minimum solids gain observed by Torringa *et al.* (2001). The process was carried out in a shaker (Tecnal, model TE-421, Piracicaba, Brazil). After 60 min of experiment, dehydrated slices were lightly rinsed to remove any excess salt solution, drained and then placed on a preweighed drying tray in order to proceed to the drying process.

Air-Drying Experiments

A convective tray dryer was used in the experiments with fresh and osmotically dehydrated mushrooms slices. The tests were carried out at three air temperatures (40, 60 and 80C) and three air velocities (1.0, 1.75 and 2.5 m/s). The dryer system consisted of a vertical airflow through the trays and was arranged as a closed circuit. For the air heating, three electric resistances were used (two of 1600 W and one of 800 W), which could be worked independently, and manually set into operation by a digital thermostat. A thermohygrometer (model 635, Testo, Lenzkirch, Germany) was used to measure the dry-bulb temperature and the drying air humidity. A digital anemometer (Airflow Co., model LCS 600, Buckinghamshire, UK) was used to measure drying air velocity.

The sample was weighed using a semi-analytical balance with a resolution of 0.001 g. Weighing intervals of 15 min were used during the first hour of processing, 30 min for the next 2 h and then 1 h until the sample weight became constant. The equilibrium moisture content (X_e), which is shown in Table 2, was calculated according to Kurozawa *et al.* (2005). Samples had average initial moisture content (wet basis [w.b.]) of 88.7% for fresh and 80.7% for osmotically pretreated units. The sample moisture contents were gravimetrically determined using a vacuum oven at 100 mm Hg at 70C for 24 h (AOAC 1995).

Statistical Analysis

In order to obtain the model parameters, a nonlinear regression analysis was carried out using the Statistica 5.0 (Statsoft, Tulsa, OK) software package for Fick's, Page's and logarithmic models. The degree of fitness of each model was evaluated by the determination coefficient and root mean square error (RMSE):

TABLE 2.
RELATIVE HUMIDITY (RH) OF AIR DRYING AND EQUILIBRIUM MOISTURE CONTENT OF MUSHROOMS (X_e)

Temperature (C)	Air velocity (m/s)	RH (%)		X_e (kg water/kg solids)	
		Fresh	Osmotically dehydrated	Fresh	Osmotically dehydrated
40	1.75	32.7	31.3	0.0544	0.0566
60	1.75	14.1	14.2	0.0098	0.0089
80	1.75	10.4	10.4	0.0051	0.0042
	1.0	13.2	13.2	0.0086	0.0076
60	1.75	14.1	14.2	0.0098	0.0089
	2.5	14.5	14.5	0.0103	0.0093

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(V_E - V_P)^2} \quad (7)$$

where V_E is the experimental value, V_P is the predicted value and N is the population of experimental data.

The results of color of fresh, osmotically dehydrated and dried products obtained were analyzed by analysis of variance and Tukey's test, using the same software package.

RESULTS AND DISCUSSION

Air-Drying Kinetics and Mathematical Modeling

Figure 2 shows the influence of temperature (40, 60 and 80C) at constant air velocity (1.75 m/s) on drying kinetics of fresh and salt-osmosed mushrooms. As expected, air temperature affected drying kinetics curves, decreasing the drying time of samples. The drying time reduced from 360 to 90 min when the air temperature increased from 40 to 80C. However, high air temperatures, apart from obvious noneconomical reasons, may result in undesirable nutritional and textural quality degradation, such as case hardening (Karathanos and Belessiotis 1997). At higher air temperature, there is a bigger temperature gradient between the sample and the air drying, resulting in a greater heat transfer into the samples and, thus, higher evaporation rate. This behavior was more evident for fresh samples (Fig. 2a). However, for salt-osmosed mushroom, there is little effect of temperature on drying curves when the variable increased from 60 to 80C (Fig. 2b). This can be explained due to

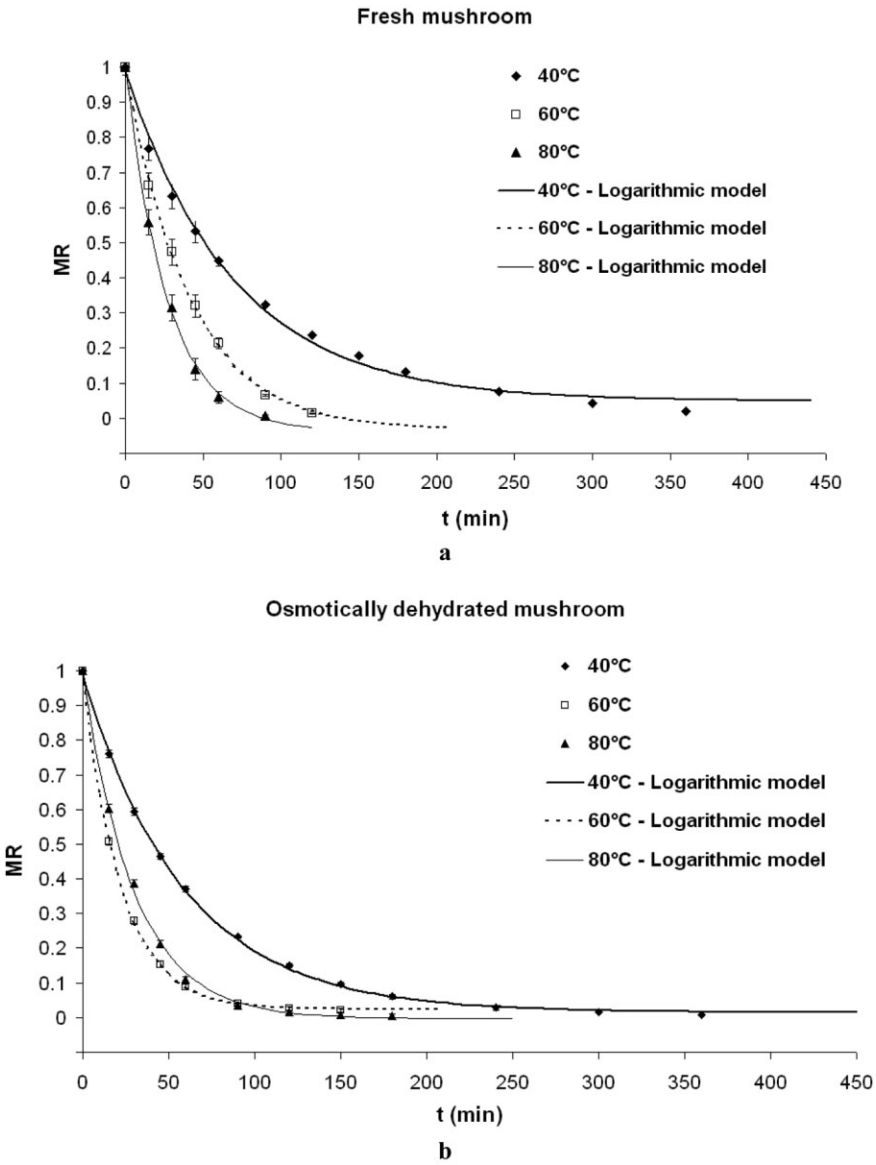


FIG. 2. EXPERIMENTAL AND PREDICTED DRYING CURVES (LOGARITHMIC MODEL) FOR (a) FRESH AND (b) OSMOTICALLY DEHYDRATED MUSHROOMS, AT DIFFERENT TEMPERATURES AND AIR VELOCITY OF 1.75 m/s
MR, moisture ratio.

a greater shrinkage and superficial hardening observed at higher temperature (80C) during drying of osmosed samples, which resulted in an increased internal resistance to mass transfer. Moreover, the solute uptake that occurs in the osmotic process contributed to the increase in internal resistance.

The effect of air velocity (1.0, 1.75 and 2.5 m/s) at constant temperature of 60C on drying kinetics curves of mushroom is shown in Fig. 3. There is an evident influence when air velocity increased from 1.0 to 1.75 m/s for fresh and osmotically dehydrated samples. However, for air velocities of 1.75 and 2.5 m/s, little difference between kinetics curves was observed. Thus, the effect of air velocity can be neglected for values higher 1.75 m/s. Some researches chose to neglect the effect of the air velocity concluding that the resistance to moisture movement from the surface to the drying medium is less important if compared to the internal resistance (Madamba *et al.* 1996). Krokida *et al.* (2003) evaluated the effect of several drying parameters, including air velocity, on the progress of the drying process of several vegetables. The influence of air velocity (1.5–2.6 m/s) on kinetics was low. According to the authors, the lower air velocity studied (1.5 m/s) was already considered relatively high, in which the diffusion of water prevails to the resistance. The influence of air velocity, in the range of 0.5–3.0 m/s, on drying kinetic of figs (*Ficus carica*) was evaluated by Babalis and Belessiotis (2004). The authors observed that for values above 2.0 m/s, the increase of the airflow velocity had no more significant effect on the drying rate, showing the predominance of internal mass transfer resistance over external resistance. Park *et al.* 2002, studying mint leaves drying, calculated the value of effective diffusivity as a function of sample temperature during drying, because on convective drying, effective diffusivities are obtained considering a negligible external resistance of mass transfer (corresponding to the boundary layer), although the effect of air velocity on heat transfer is relevant.

The experimental moisture ratios were fitted to the Fick's (for the first five terms of the series), Page's and logarithmic models to describe the drying kinetics of fresh and osmotically dehydrated mushrooms. Each model was tested for adequacy and goodness of fit by determining the coefficient R^2 and RMSE. These values and the parameter models obtained by nonlinear regression analysis are shown in Tables 3 and 4. The results showed that for the most of experimental drying, the logarithmic model presented a better fit than the other models, with lower values of RMSE and determination coefficients close to unit. In Figs. 2 and 3, the predicted and experimental moisture ratio values showed the suitability of the logarithmic model in describing the drying behavior of mushrooms.

Fick's model was used to obtain the effective diffusivities of water. However, according to Tables 3 and 4, this model did not give a good fit of the experimental data. This lack of fit occurred due to the fact that behavior of

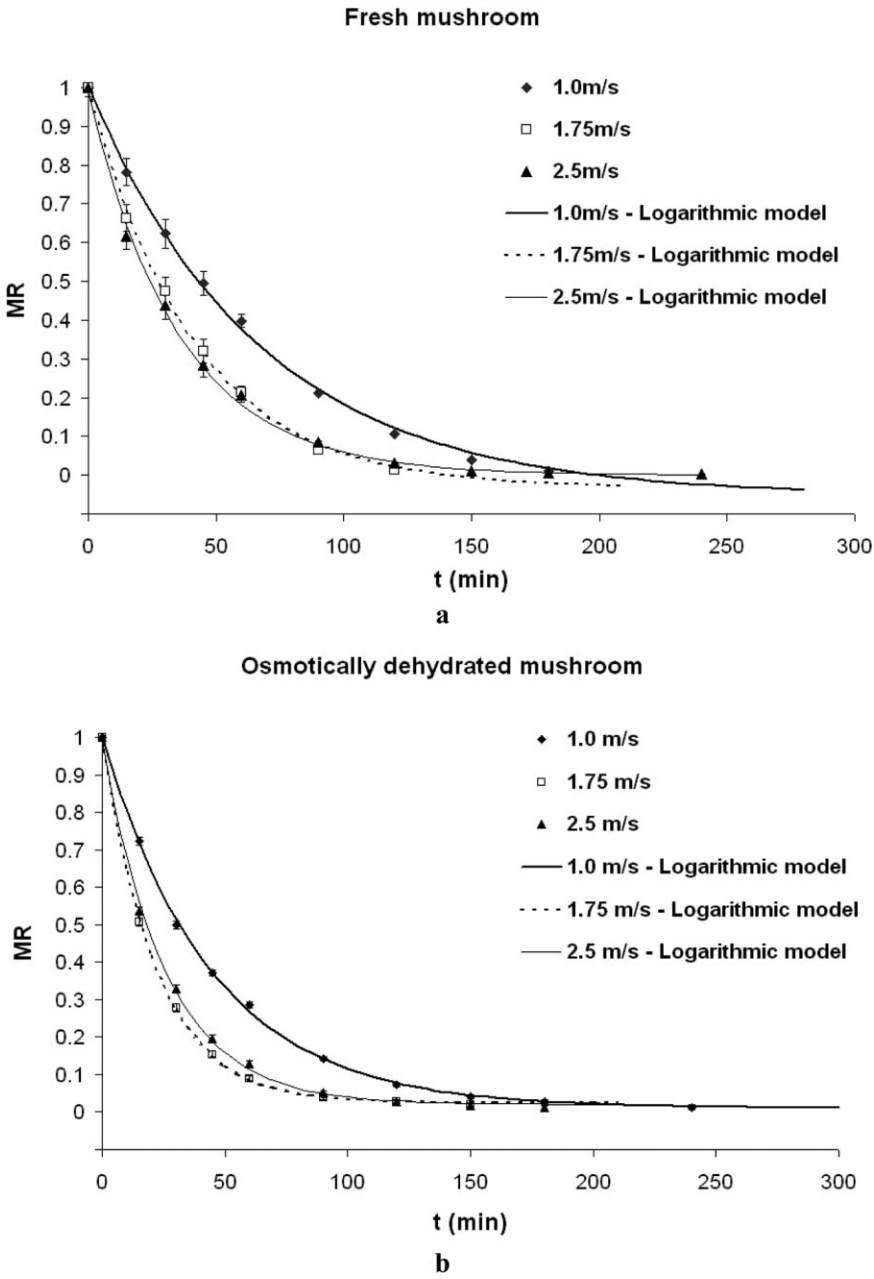


FIG. 3. EXPERIMENTAL AND PREDICTED DRYING CURVES (LOGARITHMIC MODEL) FOR (a) FRESH AND (b) OSMOTICALLY DEHYDRATED MUSHROOMS, AT DIFFERENT AIR VELOCITIES AND TEMPERATURE OF 60C
MR, moisture ratio.

TABLE 3.
ESTIMATED PARAMETER VALUES FOR THE FICK'S, PAGE'S AND LOGARITHMIC MODELS FOR FRESH MUSHROOM

Model	Temperature (C)	Air velocity (m/s)	Parameters			R^2	RMSE
			D_{eff} (m^2/s)				
Fick	40		4.14×10^{-10}			0.996	0.0189
	60	1.75	8.86×10^{-10}			0.981	0.0447
	80		14.28×10^{-10}			0.984	0.0435
		1.0	5.57×10^{-10}			0.964	0.0624
	60	1.75	8.86×10^{-10}			0.981	0.0447
		2.5	9.50×10^{-10}			0.995	0.0222
			K	b			
Page	40		8.78×10^{-4}	0.834		0.999	0.0043
	60	1.75	5.43×10^{-4}	0.972		0.996	0.0203
	80		6.42×10^{-4}	1.007		0.997	0.0182
		1.0	3.59×10^{-4}	0.968		0.991	0.0302
	60	1.75	5.43×10^{-4}	0.972		0.996	0.0203
		2.5	10.02×10^{-4}	0.902		0.999	0.0109
			a	K	c		
Logarithmic	40		0.939	2.39×10^{-4}	0.048	0.995	0.0207
	60	1.75	1.033	4.06×10^{-4}	–0.034	0.999	0.0115
	80		1.042	6.26×10^{-4}	–0.037	0.999	0.0110
		1.0	1.056	2.50×10^{-4}	–0.053	0.998	0.0127
	60	1.75	1.033	4.06×10^{-4}	–0.034	0.999	0.0115
		2.5	0.985	4.70×10^{-4}	0.003	0.998	0.0136

RMSE, root mean square error.

moisture transfer during drying of food generally does not satisfy the assumed simplifications in the solution of the 2nd Fick's law: the food product has a heterogeneous cellular structure; mass transfer is not unidirectional; diffusion can occur under several mechanisms; product temperature increases during drying process; and product shrinkage is observed, changing its dimensions (Romero-Peña and Kieckbusch 2003; Hassini *et al.* 2007; Rahman *et al.* 2009).

For a better visualization of drying behavior, the drying rates were calculated as a function of the moisture ratio, as shown in Figs. 4 and 5. Analyzing these figures, the drying rates were highest at the beginning of drying when moisture content was the greatest, with fresh mushrooms displaying the highest initial drying rates. The physical and chemical changes in the mushroom slices during osmotic dehydration caused differences in the drying rate in the subsequent air-drying process when compared to fresh sample. This observed differences between fresh and osmosed mushroom may

TABLE 4.
ESTIMATED PARAMETER VALUES FOR THE FICK'S, PAGE'S AND LOGARITHMIC MODELS FOR OSMOTICALLY DEHYDRATED MUSHROOM

Model	Temperature (C)	Air velocity (m/s)	Parameters			R^2	RMSE
			D_{eff} (m^2/s)				
Fick	40	1.75	5.44×10^{-10}			0.991	0.0292
	60		14.72×10^{-10}			0.996	0.0201
	80		11.66×10^{-10}			0.989	0.0344
	60	1.0	7.28×10^{-10}			0.988	0.0345
		1.75	14.72×10^{-10}			0.996	0.0201
		2.5	12.67×10^{-10}			0.997	0.0163
			K	b			
Page	40	1.75	7.32×10^{-4}	0.882		0.999	0.0079
	60		17.28×10^{-4}	0.881		0.999	0.0088
	80		5.58×10^{-4}	1.001		0.999	0.0117
	60	1.0	7.43×10^{-4}	0.911		0.998	0.0120
		1.75	17.28×10^{-4}	0.881		0.999	0.0088
		2.5	19.07×10^{-4}	0.852		0.999	0.0046
			a	K	c		
Logarithmic	40	1.75	0.976	2.85×10^{-4}	0.015	0.999	0.0069
	60		0.975	7.60×10^{-4}	0.024	0.999	0.0045
	80		1.008	5.64×10^{-4}	–0.004	0.999	0.0112
	60	1.0	0.993	3.75×10^{-4}	0.010	0.999	0.0081
		1.75	0.975	7.60×10^{-4}	0.024	0.999	0.0045
		2.5	0.971	6.50×10^{-4}	0.020	0.999	0.0112

RMSE, root mean square error.

be related to the solute uptake that occurred in the osmotic process which resulted in an increase in the internal resistance to mass transfer, as observed by Azoubel *et al.* (2009), Mandala *et al.* (2005) and El-aouar *et al.* (2003), working with cashew apple, apple and papaya.

Color

The color attributes of mushrooms were influenced by osmotic dehydration as shown in Figs. 6 and 7. Osmotically pretreated mushroom presented lower luminosity values (L^*) when compared with fresh mushroom. It is well known that the color parameter L^* is correlated with darkening in fruit and vegetable tissues due to enzymatic and nonenzymatic browning. High L^* values indicate more browning. These results indicate that the osmotic dehydration was not efficient in preventing color loss. Baroni (2004) obtained

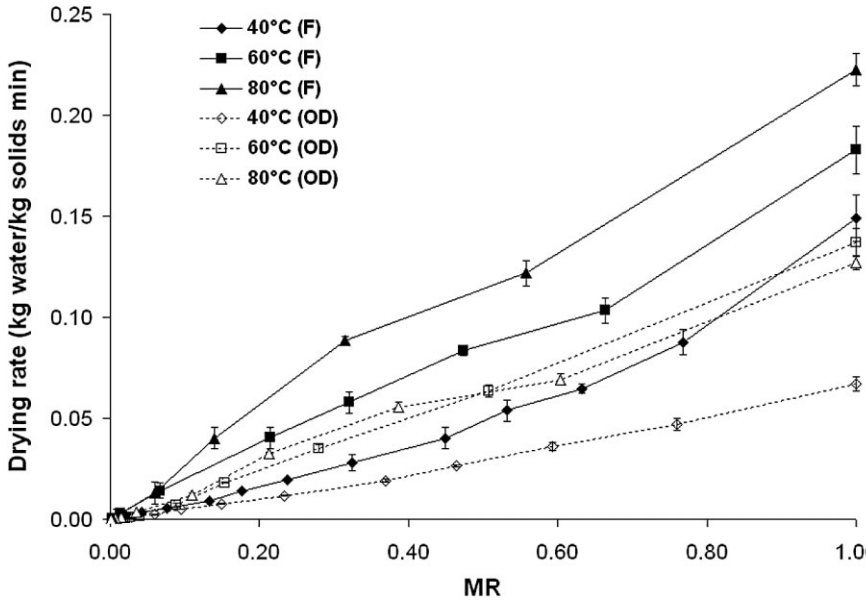


FIG. 4. EFFECT OF TEMPERATURE ON DRYING RATES CURVES FOR FRESH (F) AND OSMOTICALLY DEHYDRATED (OD) MUSHROOM AT AIR VELOCITY OF 1.75 m/s
MR, moisture ratio.

similar results, studying drying of osmotically dehydrated tomato using sodium chloride (10% w/w). The author suggested that the salt-impregnated samples presented a greater oxidation potential than the other samples. On the other hand, according to Zawistowski *et al.* (1991), the NaCl leads to the formation of a complex between the halide ions and copper in the polyphenol oxidase (enzyme presents on mushrooms that catalyzes browning reactions), inhibiting its action and, consequently, the product browning. However, Gómez-López (2002), evaluating the effect of NaCl on activity of polyphenol oxidase, concluded that the inhibitory effect was not satisfactory. Several works (Knapp 1965; Wong *et al.* 1971) have reported the effect of NaCl on polyphenol oxidase, in which a high inhibitor concentration was necessary to achieve inhibition. Therefore, sodium chloride was not totally effective in preventing mushroom darkening during the osmotic dehydration process.

Analyzing the chroma values (C^*) in Fig. 7, there was no significant difference between dried mushrooms with and without osmotic pretreatment. For samples that were not dried, osmosed mushrooms presented higher C^* value than fresh mushrooms, showing color intensification. The water loss, which occurred during osmotic dehydration, may have promoted mushroom pigment concentration, with color intensification.

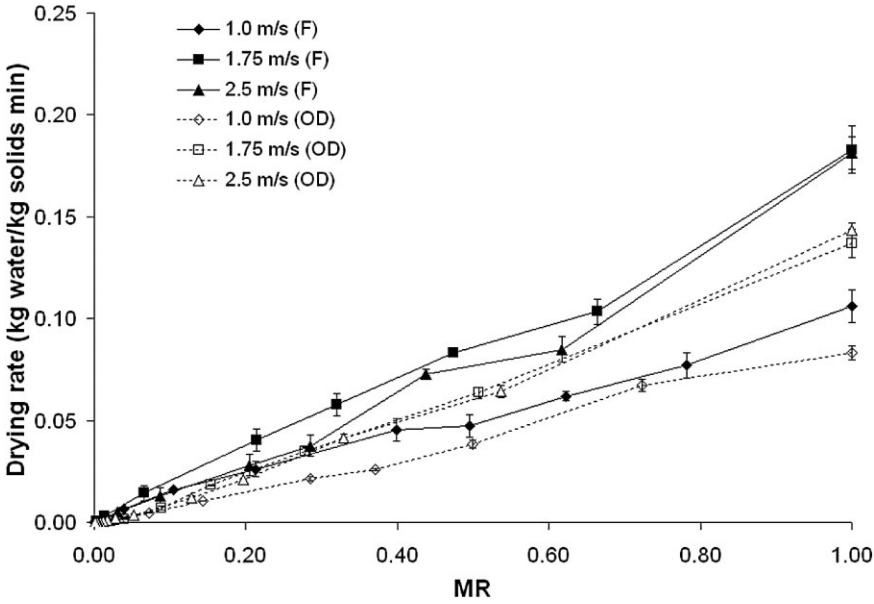


FIG. 5. EFFECT OF AIR VELOCITY ON DRYING RATES CURVES FOR FRESH (F) AND OSMOTICALLY DEHYDRATED (OD) MUSHROOM AT TEMPERATURE OF 60C
MR, moisture ratio.

Figures 6 and 7 show the influence of the process variable temperature on the lightness L^* and chroma C^* of dried samples. Increases in temperature resulted in decreases in luminosity of dried samples with and without osmotic pretreatment. At high temperature, a slight increase in browning may be associated with the Maillard reaction, which is a nonenzymatic reaction involving carbonyl and amino compounds with the formation of brown pigments (melanoidins). This reaction is highly temperature dependent and its reaction rate generally increases from two to three times for each 10C rise in temperature (Davidek and Davidek 2004). Yapar *et al.* (1990) reported that high moisture associated with low temperature causes browning through enzymatic activity and that the use of high temperature results in Maillard reaction. They proposed temperature for drying mushroom in the range of 60–70C. Similar behavior was observed by Lidhoo and Agrawal (2008). These authors evaluated the effect of drying temperature (45–95C) on browning of mushroom slices and observed that the browning first decreased with increase in temperature up to 65C. Thereafter, the browning increased with increase in temperature. In respect to the effect of temperature on the color parameter C^*, significant differences were not observed between samples without pretreatment, only for osmosed samples. At lower temperature (40C), dried mushrooms presented high chroma value.

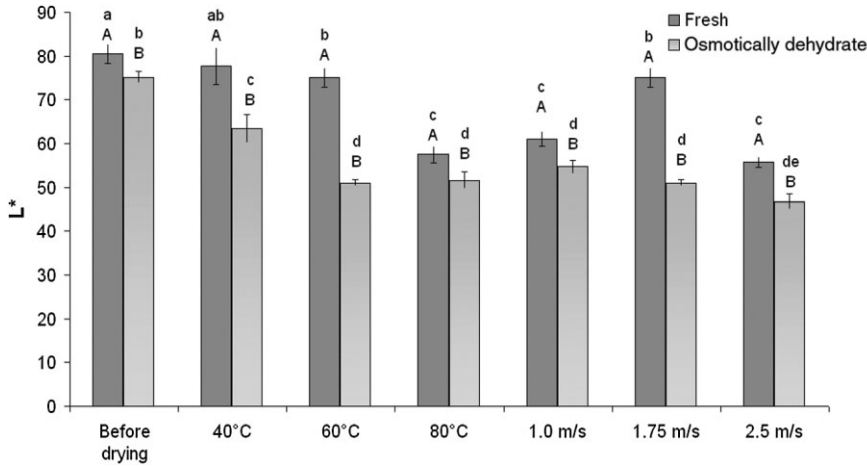


FIG. 6. EFFECT OF AIR VELOCITY AND TEMPERATURE ON LUMINOSITY PARAMETER OF MUSHROOMS

Different letters are considered significantly different at the 5% level ($P < 0.05$). Lowercase and capital letters represent the response variation for each process conditions and between sample with and without pretreatment osmotic, respectively.

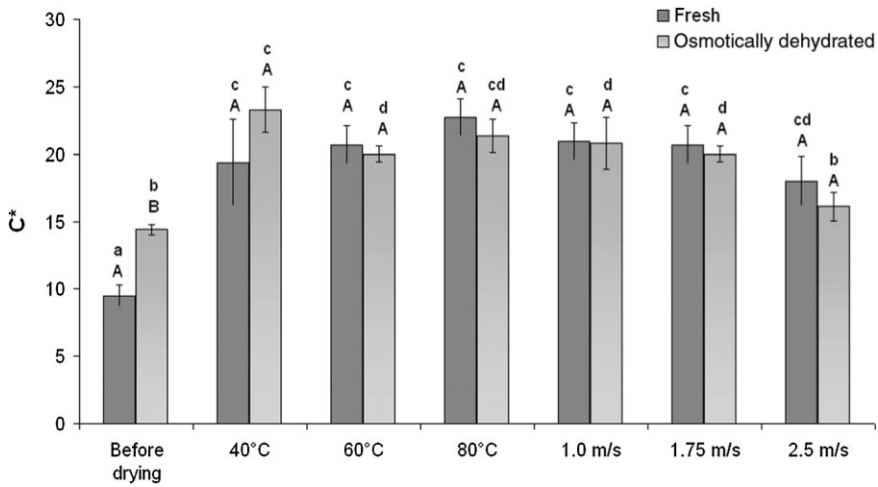


FIG. 7. EFFECT OF AIR VELOCITY AND TEMPERATURE ON CHROMA PARAMETER OF MUSHROOMS

Different letters are considered significantly different at the 5% level ($P < 0.05$). Lowercase and capital letters represent the response variation for each process conditions and between sample with and without pretreatment osmotic, respectively.

Increasing air velocity, a slight decrease in luminosity L^* and chroma C^* of mushrooms was observed, with exception on L^* values of sample without pretreatment. According to Weemaes *et al.* (1997), in the presence of oxygen and polyphenol oxidase, natural phenolic compounds are oxidized to the corresponding o-quinones, which subsequently polymerize to brown pigments. Probably, in increasing air velocity, the increase in sample temperature increased the reaction with oxygen, increasing browning and decreasing L^* values. However, the opposite behavior was observed when air velocity increased from 1.0 to 1.75 m/s (for fresh mushroom). Analyzing the chroma parameter C^*, there was only a slight decrease when air velocity increased from 1.75 to 2.5 m/s.

CONCLUSIONS

The air drying of fresh and osmotically dehydrated mushroom showed the influence of temperature and air velocity on drying kinetics and color of dried samples. Drying rates of osmosed mushroom decreased due to the presence of infused solids. Air temperature and velocity affected drying kinetics curves, decreasing the drying time of samples. However, when air velocities increased from 1.75 to 2.5 m/s, little difference between kinetics curves was observed, showing the predominance of internal mass transfer resistance over external resistance. Results of thin-layer modeling showed that the logarithmic model could be used to explain moisture transfer in mushrooms. This model could be used between drying air temperatures from 40 to 80C and velocities between 1.0 and 2.5 m/s. Osmosed mushrooms presented higher browning than fresh mushrooms, indicating that the osmotic pretreatment was not efficient in preventing color loss. Drying temperature strongly affected color parameters luminosity (or lightness) L^* and chroma C^* (or color intensity).

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