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Drying and Rehydration Behaviour of Bamboo (*Bambusa bambos*) Shoots during Convective Tray Drying

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ABSTRACT

This study investigated the thin-layer drying characteristics of bamboo slices in a convective tray dryer with three different temperatures viz., 75, 80 and 85°C. Four mathematical models were investigated for describing the thin-layer drying behaviour of bamboo shoot slices. The performance of these models was investigated by comparing the coefficient of determination (R^2), reduced chi-square (χ^2) and root mean square error (RMSE). All the four models showed good fit but Page model reflected the drying mechanism at 80°C temperature the better. The drying air temperature had the significant effect on the drying kinetics of bamboo shoot slices. Effective moisture diffusivity varied from 4.22×10-12 to 5.56×10-12 m^2/s over the temperature range studied, with an activation energy of 28.60 kJ/mol. Rehydration ratio elevated when the salt solution used for rehydration and the weight gain was more irrespective of temperature. Superior rehydration was noticed when the slices were dried at 80°C, and it was relatively poor at 85°C and 75°C.

Keywords: Bamboo shoot slices; Drying kinetics; Activation energy; Effective moisture diffusivity; Rehydration ratio

INTRODUCTION

Bamboo is a fast growing, wide spread, renewable, versatile, low-or-no cost, environment-enhancing resource with potential to improve livelihood security, in both rural and urban areas. The bamboo is an important resource in the Indian socioeconomic, cultural–ecological climate functional context, with 1,500 recorded uses. They are intermingled with the tradition and culture of rural and tribal populations and are an integral part of their cultural, social, and economic conditions (Tewari, 1988) from times immemorial due to which they have been variously called as "The Cradle to Coffin Plant," "The Poor Man's Timber," "Friend of the People," "Green Gasoline," "The Plant with Thousand Faces," and "The Green Gold." Bamboo shoots are now an important food crop in the international market, as bamboo shoot contains more moisture (89.3%), is low in fat (0.41 g/100 g), high in dietary fiber (3.90%) and rich in mineral content (1.03%), like an ideal vegetable has been used traditionally by tribes for decades, world over (Bhatt et al., 2003). In India, particularly in the North Eastern Himalaya, they form a part of the traditional diet. The market for bamboo shoots is growing steadily, and more and more people are developing a taste for them. Due to seasonal availability of bamboo shoot, processing for handling cyanogenic toxicity in a raw shoot while keeping nutrients intact and enhancement of shelf life of the value-added products assumes great significance for business potential. Obviously, it would demand process standardization for small-scale processing units (Kumar *et al.,* 2012). The basic objective of drying is the removal of water in the solid up to a certain level at which microbial spoilage, deterioration and chemical reactions are generally minimized (Krokida *et al.,* 2003). Moisture transfer can occur in two forms, surface evaporation and internal liquid vapour diffusion (Meziane, 2011). The traditional open-sun drying technique commonly employed in the tropics for the fruits and vegetables has some disadvantages, like slow speed of the process, contamination, and more time for drying and nutrient loss (Doymaz, 2005). Dehydration of food materials, especially fruits and vegetables, with antioxidant properties, is a difficult food process operation, mainly because of undesirable changes in the quality of the dehydrated products (Rajkumar *et al.,* 2007). Further direct exposure to solar radiation results in undesirable

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colour changes, lowering the quality of the dried products significantly. Therefore, use of hot air in controlled tray drying proves to be fruitful as it provides uniformity and hygiene for industrial food drying processes become inevitable. Drying as one layer of sample particles or slices is referred to as thin-layer drying. Detail investigation on thin-layer drying characteristics of bamboo slices have been carried out by Kumar *et al.* (2012). There have been many studies on thin-layer drying of apple (Sun and Woods 1994; Akpinar *et al.*, 2003), fruits (Doymaz, 2005; Karim &Hawlader, 2005) and vegetables (Doymaz, 2004). Various researchers (Freire *et al.*, 2005; Farkas, 2004) evaluated the drying kinetics of food products and mathematical models to describe thin-layer drying characteristics of the produces. Drying kinetics and model parameters are generally affected by air temperature, relative humidity, air velocity and material size (Hossain and Bala, 2002). Theoretical, semi theoretical and empirical mathematical models are developed to describe the thin-layer drying of food products (Midilli *et al.*, 2002). Among semi-theoretical drying models, exponential, Page, modified Page, Henderson and Pabis, Thompson, and the Wang and Singh model are frequently used (Ojediran and Raji, 2010). Bamboo shoot is one of the most important industrial crops, which is perishable in nature and lacks proper post-harvest technology. Therefore, bamboo shoot processing, preservation and utilization require much of the scientific inputs along with the indigenous knowledge of the tribal people. Under a market economy, bamboo product processing industry can lead to economic growth of bamboo sector, augment income of bamboo farmers, and improve the economic status of women in bamboo areas as well. Small scale industries located nearby such areas, where bamboos are grown in abundance, will be benefitted through value-addition of bamboo shoots. Very little information is available in the literature on drying characteristics of bamboo. Proper investigation is prerequisite to improve the efficiency of the drying process and drying systems. This study, therefore investigates the thin-layer drying characteristics of bamboo slices in a tray dryer; fit the experimental data to four popular drying models to identify the best-fit model and its quality evaluation by rehydration process.

MATERIALS AND METHODS

Sample Preparation

Experiments were conducted with *Bambusa bambos*, a common species used as food.Bamboo shoots were procured from fruits and vegetable market, Bengaluru, India. Tender bamboo shoots were selected and sheaths were removed and cut into circular shapes of 3-4 cm diameter and 5-7 mm thickness. Then, the shoots were blanched in water in the vessel for 20 min to remove the astringency and cyanogenic compounds. After completion of blanching, the slices were cooled on perforated trays for 20 min to get complete removal of adhered water from the surface of blanched bamboo slices.

Drying Experiment

The blanched bamboo slices were dried in a laboratory tray dryer(Industrial and Laboratory Tools Corporation, Chennai, India.) at 3 different temperatures viz., 75, 80 and 85°C. The dryer was adjusted to the selected temperature and was switched on for at least 30 min before the start of the experiment to bring the dryer to a steady state. The blanched bamboo slices were placed on the trays, 405±5 g per tray, weight loss was monitored using a weighing balance at every 20 min until 160 min, and thereafter the time intervals like 30, 60, 90, 120 and 200 min were chosen based on preliminary investigations. Drying process was terminated when two consecutive sample weights remained constant. Moisture content was determined using the oven dry method;five grams of the sample were oven dried at 105°C until the sample attained constant weight (Feiand Qian, 1990) by using hot-air oven (Ever flow scientific instruments, Chennai, India). Experiments were conducted in triplicate.

Mathematical Modelling

In this work, a simplified Fick's second law of diffusion was considered for moisture diffusion, which is governed by equation (1)

$$\frac{dw}{dt} = D_{eff}\frac{d^2w}{dx^2} \qquad \text{[Eq. 1]}$$

Where w is the local moisture content (g water/g mass), t is the drying time (s), x is length (m), $D_{eff}$is the diffusion coefficient in solid (m^2/s). The following assumptions were made: (a) the food sample was one dimensional (b) the initial moisture content was uniform throughout the solid. To determine the drying characteristics of the slices, the experimental data were fitted to four different models which are presented in table 1. These models described the relationship between moisture loss and drying time with variouscoefficients attached to each model.

Statistical Analysis

The constants of each model were estimated using curve fitting tool by non-linear least squares method

Table 1: Mathematical drying models

Model	Equation	Reference
Henderson and Pabis	MR = aexp(-kt)	Chinnan, (1984)
Logarithms	MR = aexp(-kt)+c	Togrul and Pehlivan, (2003)
Newton	MR= exp(-kt)	Kingsly *et al*., (2007)
Page	MR= exp(-ktn)	Karathanos and Belessiotis, (1999)

performed using MATLAB® version 7.11.0.584 (R2010b). Statistical criteria such as coefficient of determination (R^2), reduced chi-square (χ^2) and root mean square error (RMSE) were used to test the reliability of the models. A good fit is said to occur between experimental and predicted values of a model when R^2 is highest and χ^2 and RMSE is lowest (Demir *et al*., 2004). The RMSE gives the deviation between the predicted and experimental values and it is required to reach zero (Gürlek *et al*., 2009). The comparison criteria method was determined using equation(2) and (3):

$$\chi^2 = \frac{\sum_{i=1}^{n}(MR_{(exp)} - MR_{(pred)})^2}{N-z} \qquad [Eq.2]$$

$$RMSE = \left[\frac{\sum_{i=1}^{n}(MR_{(pred)} - MR_{(exp)})^2}{N}\right]^{1/2} \qquad [Eq.3]$$

Determination of Moisture Diffusivity

The simplified equation of Fick's law of moisture diffusion was adopted to determine the effective moisture diffusion from the samples during drying. For slab geometry, equation(1) was simplified to form equation(4) according to Srikiatden and Roberts (2005) which is represented as:

$$MR = \frac{M-M_0}{M_0-M_e} = \frac{8}{\pi^2}\sum_{n=0}^{n=1}\frac{1}{(2n-1)^2}\exp\frac{-(2n-1)^2\pi^2 D_{eff}t}{4l^2} \qquad [Eq.4]$$

Where D_{eff} is the moisture diffusivity (m^2/s), t is the drying time (s), l is the half of the slab thickness (m), MR= dimensionless moisture ratio, M_i = instantaneous moisture content (g water/g solid), M_e =equilibrium moisture content (g water/ g solid), M_o = initial moisture content (g water/ g solid). However, due to continuous fluctuation of relative humidity of the drying air in the dryer, Eq(4) is simplified in equation(5) according to Diamante and Munro (1993) and Goyal *et al*.(2007)

$$MR = \frac{M_i}{M_o} = \frac{8}{\pi^2}\sum_{n=0}^{n=1}\frac{1}{(2n-1)^2}\exp\frac{-(2n-1)^2\pi^2 D_{eff}t}{4l^2} \qquad [Eq.5]$$

The slope of plot of ln(MR) against drying time (t) was used to calculate the effective moisture diffusivity (D_{eff}) according to Doymaz(2004)and is represented in equation(6):

$$k = \frac{D_{eff}t}{4l^2} \qquad [Eq.6]$$

Where k is the slope, D_{eff} is the moisture diffusivity (m^2/s), t is the drying time (s), lis the half of the slab thickness (m). The model that best described the drying behaviour of the samples was used to evaluate the moisture diffusivity of the samples.

Determination of Activation Energy

The effect of temperatures often affects the effective moisture diffusivity of the product during drying. The correlation of temperature and moisture diffusion is inversely related which is expressed using an Arrhenius Equation (7).

$$D_{eff} = D_0 \exp(-\frac{E_a}{RT}) \qquad [Eq.7]$$

Where D_o is the pre-exponential factor of the Arrhenius equation in m^2/s, E_a is the activation energy in kJ/mol, R is the universal gas constant in kJ/mol K and T is the absolute air temperature in K. The activation energy was calculated by plotting the natural logarithm of D_{eff}against inverse of the absolute temperature.

Rehydration Characteristics

The rehydration ratio (RR) of dried bamboo slices was determined as the rehydrated mass to the dehydrated mass 30 days after dehydration.Samples of 5 g of the dried slices were put in a 250 ml beaker containing 150 ml of boiling distilled water and salt solution. The contents were boiled for 15 min for rehydration. After that excess water from the slices were removed. RR and percent gain in weight by the rehydrated samples were calculated (Ranganna, 2002). Triplicate measures were done and average value wastaken.

RESULTS AND DISCUSSION

Drying Assessment of Slices

As shown in the Fig.1, a non-linear relationship was noticed between the moisture content of the slices and the drying time. Initially the moisture content was 92% (wb), which gradually decreased with increase in time. The moisture content of bamboo slices decreased with respect to time in continuous rate irrespective of drying air temperature.

Thedrying temperature 75°C had a marked difference in removal of moisture as compared to 80°C and 85°C temperature. Distinct curves were noticed at lower temperature and higher temperatures of drying. The rate of moisture removal was found to be high at initial stage of drying which created a steeper slope, this was due to evaporation of free available surface moisture. Later the moisture removal rate was found to decrease with decrease in surface moisture, while indicating the beginning of sub-surface moisture evaporation.

Fig. 2 shows the effect of drying temperature on the moisture ratio of the slices. Fig.3 displays the natural logarithm of moisture ratio versus time. It was found that the drying rate was increased at higher temperatures thereby reducingthe drying time. For instance, sample dried at 85°C took 12.5 h to reduce the moisture ratio to < 0.01 , while it took 13 h for the sample dried at 80°C and 14h for sample dried at 75°C.

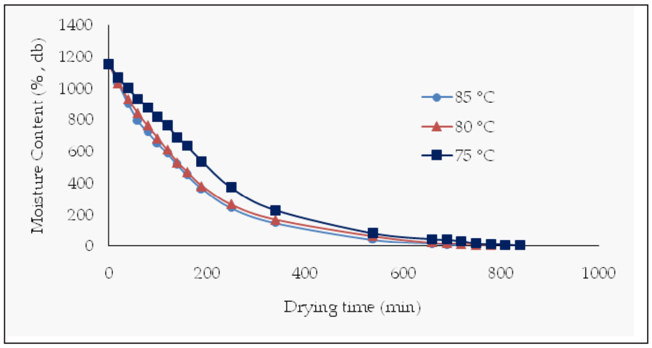

Fig. 1 Moisture content versus drying time

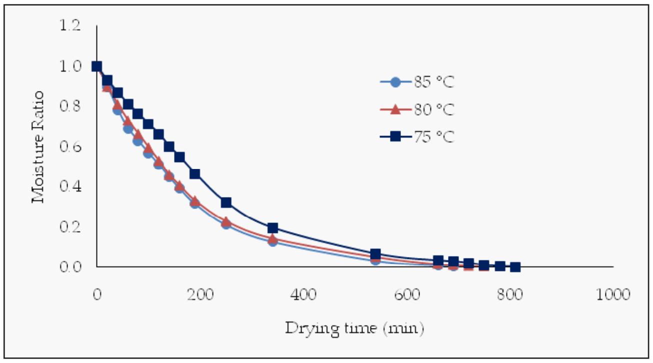

Fig. 2 Moisture ratio versus drying time

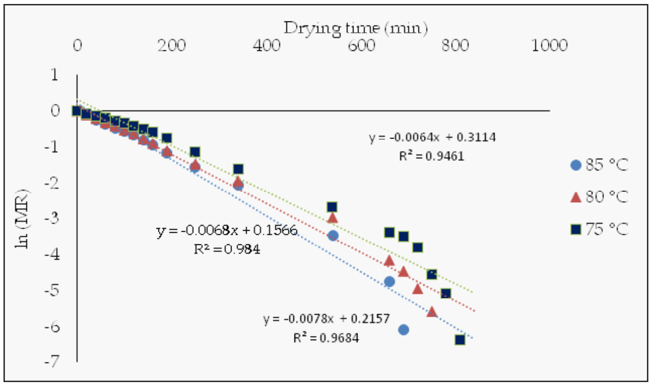

Fig. 3 Logarithmic of moisture ratio versus drying time

The drying rate curves of bamboo slices at three different temperatures are shown in Fig. 4. It was found that temperature played a major role in the drying of the samples. Abraham et al. (2004) reported similar observationfor other agricultural produce. It is apparent that the drying rate decreases continuously with moisture content or drying time. There is not any constant rate drying period in these curves, and all the drying operations are seen to occur in the falling rate period. In the falling rate period, the material surface is no longer saturated with water, and the drying rate is controlled by diffusion of moisture from the interior of the solid to the surface. Comparatively, faster drying at 85°C resulted into higher mass transfer of moisture from the sample causing reduction in drying time as reported by Aghbashlo *et al*.(2009).First and second falling rate period was observed clearly in case of 85°C and 80°C whereas in case of 75°C the drying rate was slow which created a smooth curve.

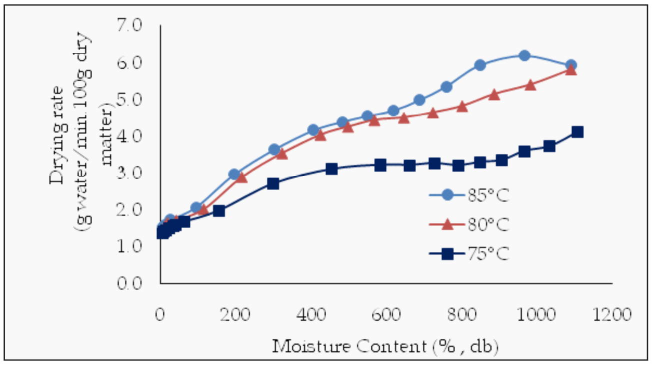

Fig. 4 Drying rate curve of bamboo slices

Table 2 and 3 shows the statistical analysis of the models for thin-layer drying andcomputed values of constants for the thin-layer drying models respectively. The performance of these models was investigated by comparing the coefficient of determination (R^2), reduced chi-square (χ^2) and root mean square error (RMSE) between the observed and predicted moisture ratios. With the highest R^2value, and lowest chi square and RMSE values, the best fit model was ascertained. Though, all the four models showed good fit based on high R^2, low RMSE and reduced chi square (χ^2), Page model reflected the drying mechanism at 80°C temperature best with the highest R^2 value of 0.999, lowest chi square value of 0.00007 and lowest RMSE

Table 2: Statistical analysis of the models for thin-layer drying

Model	Temperature (°C)	R2	χ2	RMSE
Henderson and Pabis	75	0.99310	0.00099	0.03129
	80	0.99880	0.00015	0.01216
	85	0.99880	0.00013	0.01144
Logarithms	75	0.99650	0.00053	0.02288
	80	0.99910	0.00012	0.01114
	85	0.99930	0.00009	0.00959
Newton	75	0.99050	0.00128	0.03566
	80	0.99850	0.00017	0.01313
	85	0.99880	0.00013	0.01131
Page	75	0.99880	0.00017	0.01298
	80	0.99940	0.00007	0.00827
	85	0.99910	0.00010	0.01004

value of 0.00827. Hence, the Page model was used to determinethe values for effective moisture diffusivities in bamboo slicesduring drying. In view of the greater value of R^2 and smaller RMSE, Kumar *et al.* (2012)found that the Page model was superior to exponential model for bamboo drying. Shivhare *et al.*(2000)also found that the Page model was capable of describing the drying behaviour of okra.

Fig. 5 shows the comparison of experimental and predicted moisture ratio obtained from Page model. A good agreement was observed between the predicted and experimental data, which implied that Page model was suitable to describe the drying process of the bamboo shoot slices.

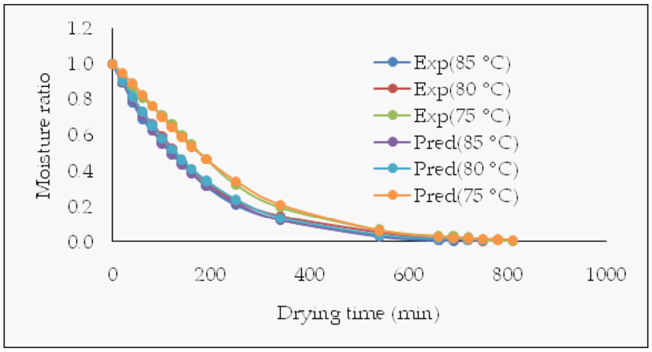

Fig. 5 Comparison of experimental and predicted moisture ratio versus drying tim

Determination of Effective moisture Diffusivity

The values of effectivemoisture diffusivity are shown in Table 4. Generally, an effective diffusivity is used due to limited information on the mechanism of moisture movement during drying and complexity of the process. Effective moisture diffusivity varied from 4.22×10^{-12} to 5.56×10^{-12} m^2/s over the temperature range studied. The data showed that moisture diffusion is temperature dependent. The value of D_{eff}increased with an increase in temperature. This was because of rapid moisture loss at higher temperatures as compared to lower temperatures. Hawlader *et al.* (1991), Belghit *et al.* (1999), Abraham *et al.* (2004)and Guine *et al.* (2009)reported similar observation. According to Hii *et al.* (2009), the values of moisture, diffusivity of food products lies in the range of 10^{-7} to $10^{-12}$$m^2/s$. However, the values of effective moisture diffusivity of bamboo shoot slices wereobtained on the extreme side of the given range.

Table 3:Computed values of constants for the thin-layer drying models

Model	Temperature (°C)	a	b	c	k	k1	k2	n
Henderson and Pabis	75	1.0460			0.0044			
	80	1.0150			0.0057			
	85	1.0060			0.0060			
Logarithms	75	1.0830		-0.0568	0.0038			
	80	1.0240		-0.0121	0.0055			
	85	1.0190		-0.0170	0.0058			
Newton	75				0.0041			
	80				0.0055			
	85				0.0059			
Page	75				0.0013			1.2220
	80				0.0039			1.0710
	85				0.0049			1.0380

Table 4: Values of effective moisture diffusivities at different temperatures

Drying air temperature (°C)	Effective moisture diffusivity, $D_{eff}\times 10^{-12}$ (m^2/s)
85	5.56
80	5.04
75	4.22

The logarithm of D_{eff} as a function of reciprocal of absolute temperature (T) is plotted in Fig. 6. The results show a linear relationship between (lnD_{eff}) and (1/T) or an Arrhenius-type relationship (equation 7). The diffusivity constant (D_0) and activation energy (E_a) calculated from the linear regression are 8.386 x10^{-8}(m^2/s) and 28.60 (kJ/mol), respectively.The activation energy is in a reasonable agreement with the data presented by several other authors, for instance,20 kJ/mol for potato (Bon *et al*., 1997),28.36 kJ/mol for carrot (Doymaz, 2004), 57 kJ/mol for onion (MazzaandLeMaguer, 1980), 82.93 kJ/molfor mint leaves (Park *et al*., 2002). The value of diffusivity constant (D_0) in this work is less than the value reported by Kuitche *et al*.(2007)which was 1.8x10^{-5}m^2/s for pre-treated okra and also it is less than the value reported byHii *et al*.(2009)which is 4.08x10^{-6}m^2/s for cocoa.

Rehydration Characteristics

The rehydration characteristics of dried products are widely used as the quality index. RR, gains in weight due to rehydration by samples are presented in Fig. 7. RR elevated when the salt solution used for rehydration and the weight gain was more irrespective of temperature. However, it was observed that superior rehydration was noticed when the slices were dried at 80°C, and it was relatively poor at 85 and 75°C. In practice, most changes caused by pre-drying and drying treatments are irreversible, and rehydration cannot be considered as simply as a process reversible to dehydration (Lewicki, 1998). Higher rehydration displayed by 80°C might be due to the faster drying process that causes less cellular and structural changes in the final product. However, RR was comparatively poor in low temperature, due to factors like, longer time for drying, poor texture of the product caused by poor RH maintenance and fluctuation in air flow. Loss of texture was the main reason for the poor RR of low temperature drying. Higher damage of cell wall occurred at very high temperature, leading to decreased water absorption capacities. It wasobserved that the material almost regained its original shape after rehydration at 80°C as gain in weight was recorded higher at 80°C, followed by 75°C. However, drying temperature beyond 80°C collapsed the internal structure of the dried tissues, which lead to poor rehydration. Loss of texture was the main reason for the poor RR of low temperature. Thus, dehydration at optimum temperature was a prerequisite for superior reconstitution of dried products. The addition of salt in the rehydration medium resulted in better regains of the structure RR and PW irrespective of temperature of drying. Similar findings were observed by Kumar and Sagar (2009) and Kar and Gupta (2003).

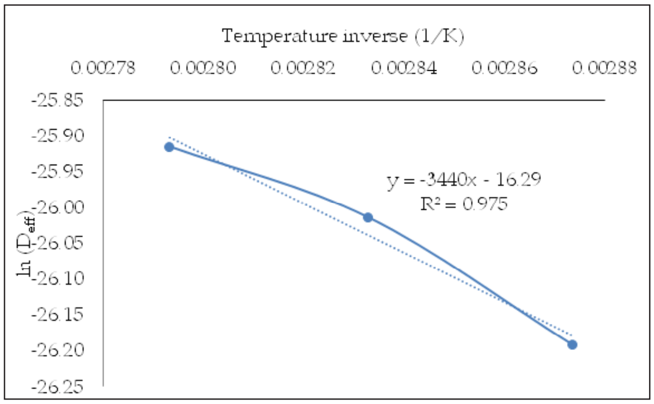

Fig. 6 Plot of ln (Deff) versus Temperature inverses

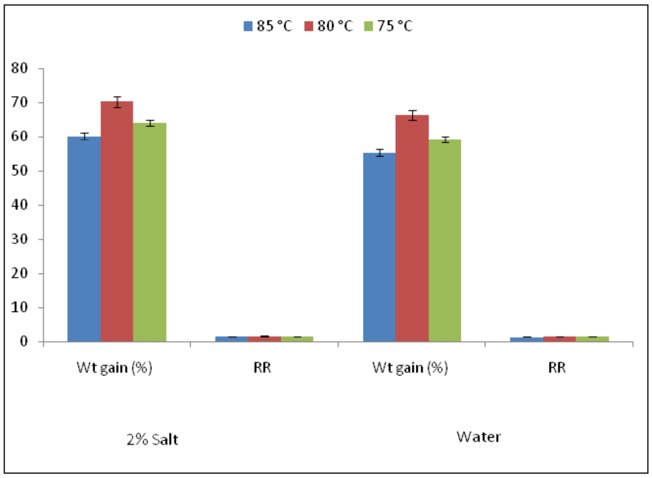

Fig. 7 Effect of rehydration medium and drying temperatures on rehydration characteristics of bamboo slices

CONCLUSION

Bamboo shoot slices were dried in a laboratory tray dryer at three temperatures 75°C, 80°C and 85°C.This study revealed that the moisture loss was governed by the diffusion mechanism. The drying air temperature had the significant effect on the drying kinetics of bamboo shoot slices. The first and second falling rate period was clearly eminent for higher temperatures (80°C and 85°C) as compared to drying at lower temperature (75°C).Though, all the four models showed good fit based on high R^2, low RMSE and reduced chi square (χ^2), Page model reflected the drying mechanism at 80°C temperature as the best.Effective moisture diffusivity is temperature dependent and increases with an increase in temperature. Effective moisture diffusivity varied from 4.22×10^{-12} to 5.56×10^{-12} m^2/s over the temperature range studied, with an activation energy of 28.60 kJ/mol. Superior quality in terms of rehydration behaviour was recorded for the samples dried at 80°C and it was relatively poor at 85°C and 75°C.

REFERENCES

Abraham DG, Arolilo AP, Rosimeire MR, Cala SSL and Amanda CF. 2004. The air drying behaviour of osmotically dehydrated jackfruit. In *Proceeding 14th int. drying symposium* pp1-3.

Aghbashlo M, Kianmehr MH, Khani S andGhasemi M. 2009. Mathematical modeling of thin-layer drying of carrot. *International Agrophysics*23(4): 313-317.

Akpinar EK, BicerYandMidilli A. 2003.Modeling and experimental study on drying of apple slices in a convective cyclone dryer. *Journal of Food Process Engineering*26(6): 515-541.

Belghit A, Kouhila M andBoutaleb BC.1999. Experimental study of drying kinetics of sage in a drying tunnel working in forced convection. *Revue des Energies Renouvelables*2(1): 17-26.

Bhatt BP, Singha LB, Singh K andSachan MS.2003. Some commercial edible bamboo species of North East India: Production, indigenous uses, cost-benefit and management strategies. *Bamboo Science and Culture*17(1): 4-20.

Bon J, Simal S, Rossello C andMulet A.1997. Drying characteristics of hemispherical solids. *Journal of Food Engineering*34(2): 109-122.

Chinnan MS.1984. Evaluation of selected mathematical models for describing thin-layer drying of in-shell pecans. *Transactions of the ASAE*. 27(2): 610-615.

Demir V, Gunhan T, Yagcioglu AK andDegirmencioglu A.2004. Mathematical modelling and the determination of some quality parameters of air-dried bay leaves. *Biosystems Engineering*88(3): 325-335.

Diamante LM and Munro PA. 1993. Mathematical modelling of the thin layer solar drying of sweet potato slices. *Solar Energy*51(4): 271-276.

Doymaz I.2004. Convective airdrying characteristics of thin layer carrots. *Journal of Food Engineering*61(3): 359-364.

Doymaz İ. 2005. Drying behaviour of green beans. *Journal of food Engineering*69(2): 161-165.

Farkas I. 2004. Solar-drying of materials of biological origin. In*Dehydration of Products of Biological Origin. Science Publisher, Inc., Enfield, USA*. pp 317-368.

Fei S and Qian Z.1990. Peoples Republic of China Special Industry Standard. China standards Publisher (Chinese) pp. 253-298.

Freire FB, Barrozo MA, Sartori DJ and Freire JT. 2005. Study of the drying kinetics in thin layer: fixed and moving bed. *Drying Technology*23(7): 1451-1464.

Goyal RK, Kingsly ARP, Manikantan MR and Ilyas SM. 2007. Mathematical modeling of thin layer drying kinetics of plum in a tunnel dryer. *Journal of Food Engineering*79: 176-180.

Guine R, Lopes P, Joao BM and Ferreira DMS. 2009. Effect of ripening stage on drying kinetics and properties of S. *Bartolomeu pears. International Journal of Academic Research*1(1):46-52.

Gürlek G, Özbalta N and Güngör A.2009. Solar tunnel drying characteristics and mathematical modelling of tomato. *J ThermSci Technol*.29(1): 15-23.

Hawlader MNA, Uddin MS, Ho JC and Teng ABW.1991. Drying characteristics of tomatoes. *Journal of Food Engineering*14(4): 259-268.

HiiCL, Law CL and Cloke M. 2009. Modeling using a new thin layer drying model and product quality of cocoa. *Journal of Food Engineering*90(2): 191-198.

Hossain MA and Bala BK. 2002. Thin-layer drying characteristics for green chilli. *Drying Technology*20(2): 489-505.

Kar A and Gupta DK. 2003. Air drying of osmosed button mushrooms. *Journal of food science and technology* 40(1): 23-27.

Karathanos VT and Belessiotis VG.1999. Application of a thin-layer equation to drying data of fresh and semi-dried fruits. *Journal of Agricultural Engineering Research* 74(4): 355-361.

Karim MA and Hawlader MNA. 2005. Drying characteristics of banana: theoretical modelling and experimental validation. *Journal of Food Engineering* 70(1): 35-45.

Kingsly RP, Goyal RK, Manikantan MR and Ilyas SM. 2007. Effects of pretreatments and drying air temperature on drying behaviour of peach slice. *International journal of food science & technology* 42(1):65-69.

Krokida MK, Karathanos VT, Maroulis ZB and Marinos-Kouris D. 2003. Drying kinetics of some vegetables. *Journal of Food engineering*59(4): 391-403.

Kuitche A, Edoun M and Takamte G. 2007. Influence of Pre-treatment on Drying on the Drying Kinetic of a Local Okro (*Hibiscus ersculentus*) Variety. *World Journal of Dairy & Food Sciences*2(2): 83-88.

Kumar PS andSagar VR. 2009. Effect of osmosis on chemical parameters and sensory attributes of mango, guava slices and aonla segments. *Indian Journal of Horticulture*66(1): 53-57.

Kumar PS, Kanwat M and Choudhary VK. 2012. Mathematical modeling and thin-layer drying kinetics of bamboo slices on convective tray drying at varying temperature. *Journal of Food Processing and Preservation***37**(5): 914-923.

Lewicki PP. 1998. Effect of pre-drying treatment, drying and rehydration on plant tissue properties: A review. *International Journal of Food Properties***1**(1): 1-22.

MazzaG and LeMaguer M. 1980. Dehydration of onion: some theoretical and practical considerations. *International Journal of Food Science & Technology***15**(2): 181-194.

Meziane S. 2011. Drying kinetics of olive pomace in a fluidized bed dryer. *Energy Conversion and Management***52**(3): 1644-1649.

Midilli A, KucukH and Yapar Z. 2002. A new model for single-layer drying. *Drying technology***20**(7): 1503-1513.

Ojediran JO and Raji AO. 2010. Thin layer drying of millet and effect of temperature on drying characteristics. *International Food Research Journal***17**(4): 1095-1106.

Park K, Vohnikova Z, and Pedro Reis Brod F. 2002. Evaluation of drying parameters and desorption isotherms of garden mint leaves (*Menthacrispa L.*). *Journal of Food Engineering***51**(3):193-199.

Rajkumar P, Kulanthaisami S, Raghavan GSV, Gariépy Y andOrsat V. 2007. Drying kinetics of tomato slices in vacuum assisted solar and open sun drying methods. *Drying Technology***25**(7-8):1349-1357.

RangannaS. 2002. *Handbook of analysis and quality control for fruit and vegetable products*. Tata McGraw-Hill Education.

Shivhare US, Gupta A, Bawa AS and Gupta P. 2000. Drying characteristics and product quality of okra. *Drying Technology***18(1-2)**: 409-419.

Srikiatden J and Roberts JS. 2005. Moisture loss kinetics of apple during convective hot air and isothermal drying. *International Journal of food properties***8**: 493-512.

Sun DW and Woods JL.1994. Low temperature moisture transfer characteristics of wheat in thin layers. *Transactions of the ASAE.***37(6)**: 1919-1926.

Tewari DN. 1988. Bamboo as poverty alleviator. *The Indian Forester***114(10)**: 610-612.

Togrul İT and Pehlivan D. 2004. Modelling of thin layer drying kinetics of some fruits under open-air sun drying process. *Journal of Food Engineering***65(3)**: 413-425.

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