Air drying kinetics and quality characteristics of oyster mushroom (*Pleurotus ostreatus*) influenced by osmotic dehydration

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Abstract: The study on osmotic pretreatment of oyster mushrooms was carried out in order to remove the moisture prior to further mechanical drying. Three salt concentration level (10, 15 and 20 g/100 g), two temperature levels of osmotic solution (30 and 45°C) and constant solution to mushroom ratio of 10 (w/v) were selected and the observations on water loss and solid gain were taken at an interval of 30 min up to 300 min. The osmotically pretreated samples were further dried up to its equilibrium moisture content in a tray drier at 60°C and experimental data were fitted successfully using Page and Henderson & Pabis model. The osmo-convective dehydrated samples were evaluated for its quality parameters i.e. color (*L*, *a*, *b*, ΔE, C* and h°), rehydration ratio and sensory attributes (flavor, appearance, texture and overall acceptability). The water loss from and solid gain by the mushroom sample increased non-linearly with the duration of osmosis at all concentrations and both were higher in the initial period of osmosis than the later period. Further, both increased with increasing salt concentration and osmosis solution temperature. Samples pretreated in salt of 20 g/100 g at solution temperature of 45°C showed lower drying rate due to deposition of salt molecules on outer surface of mushroom tissues. The analysis of variance (ANOVA) revealed that among the osmosis pretreatment variables, the concentration has the most significant effect on all the selected quality parameters whereas the interaction of solution temperature and salt concentration witnessed maximum effect on color and rehydration ratio.

Keywords: oyster mushrooms, osmotic dehydration, water loss, solid gain, drying, quality

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1 Introduction

Mushroom is one of a non- conventional source of food production, requiring negligible area and being indoor activity and free from natural calamities. It has a great potential for the production of protein rich quality food and for recycling of cellulose agro-residues and other wastes. Fresh mushroom contain high moisture content (85-95 %, wb) and hence are highly perishable commodities, and start deteriorating immediately after harvest. In view of their highly perishable nature, the fresh mushrooms have to be processed to extend their shelf life for off-season use. Among the various preservation methods the most frequently adopted methods include canning, drying, pickling, etc. It is reported that drying is a comparatively cheap and the easiest mean to increase the shelf life of high moisture products. On the other hand, mushrooms are very sensitive to temperature, therefore choosing a proper method of drying is a very important decision.

The osmotic process is a method of partial removal of water from product by immersing it in a hypertonic solution. The process is facilitated by the osmotic pressure difference between the food material (hypotonic medium) and concentrated osmotic solution (hypertonic medium). As osmotic dehydration does not give a product of low moisture content considered for shelf stable therefore osmosed products are needed further dried up to desired moisture content, in association with

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other methods of food preservation including freezing, vacuum dehydration and oven or freeze drying (Torringa et al., 2001).

The combination of osmotic dehydration with hot air drying, also known as 'osmo-convective drying' has been proposed by many researchers (Fabiano et al., 2005; Fabiano et al., 2006; Shukla and Singh, 2007; Kumar et al., 2009). The commodities dried under uncontrolled conditions yield poor quality in terms of texture, rehydration, colour and flavor etc. owing to uneven drying and sometimes longer exposure to high temperature. Therefore, osmo-convective drying must be applied in order to improve the rehydration characteristics, texture, and colour of dehydrated products to a great extent. The dry weight, nutrition-elements and organoleptic tests, and storage life of such products are also increased. The transportation cost of dried product is lower and product fetches higher price in consumers' market. This process of drying is considered to be an economical method of drying for fruit or vegetable material containing higher moisture content of 70%, though this aspect is hardly evaluated scientifically.

Keeping in view the advantages of osmo-convective drying, the present study was undertaken with objectives to investigate the effect of osmotic treatment on mass transfer and some quality characteristics of oyster mushrooms.

2 Materials and methods

2.1 Sample preparation

Oyster mushrooms were procured from the local vegetable market. The mushrooms were washed with tap water in order to remove soils or dust adhered to surface. The samples were blanched into hot water for 1 min prior to osmotic dehydration. Three different concentrations of salt i.e. 10, 15 and 20 g/100 g as suggested by Manivannan and Rajasimman (2008) were prepared by dissolving different proportions in measured amount of water. Salt was used as it retards oxidative non-enzymatic browning (Kumar et al., 2009).

2.2 Osmotic dehydration treatment

The osmotic dehydration experiments were carried out in a 500 mL steel container placed in an agitated incubator to ensure good mixing and close temperature control in the osmotic medium. The solution to mushroom ratio was maintained at 10 in order to avoid dilution of osmotic solution osmotic dehydration. The temperature of respective concentrated solutions was maintained at 30 and 45°C for 5 h. After completion of osmosis process, the samples were taken out from solution, drained and wiped with blotting paper to remove excess solution.

Water loss (WL) and solid gain (SG) were determined using the following relationship (Pokhrakar and Prasad, 1998).

$$WL = \frac{W_i.X_{wi} - W_o.X_{wo}}{W_i.X_i} \times 100 \quad (1)$$

$$SG = \frac{W_i.(1 - X_{wi}) - W_o.(1 - X_{wo})}{W_i} \times 100 \quad (2)$$

2.3 Air drying and drying kinetics

The osmotically treated mushroom samples were further dried in a tray dryer maintained at 60°C and drying kinetics was studied taking sample out of drier and measuring moisture content after every 1-h interval. The samples were dried to a final moisture content of 7±1% on dry basis. Total drying time of sample was also recorded.

The drying data were fitted to Page (Page, 1949) and Henderson & Pabis (Henderson, 1974) model which are an empirical modification of simple exponential models. The equations used were as follows:

Page: $\exp(-kt^n)$

Henderson and Pabis: $MR = a\exp(-kt)$

The model's and statistical parameters were determined using the non-linear regression from the SPSS version 16.0 software. The best predictive capacity of models for mass transfer was evaluated by obtaining the highest coefficient of determination and least root mean square error and mean relative percentage deviation of modulus as given equation:

$$RMSE = \sqrt{\left[\frac{\sum_{I=1}^{N}(Experimental\ value - Predicted\ value)^2}{N}\right]} \quad (3)$$

$$P = \frac{100}{N}\sum_{I=1}^{N}\left|\frac{Experimental\ value - Predicted\ value}{Experimental\ value}\right| \quad (4)$$

2.4 Quality attributes

For quality evaluation, similar drying experiments were conducted under same drying conditions. Drying was terminated when moisture content reached 7% or below on dry basis. The samples were then allowed to come to room temperature, packed and stored for quality analysis. The dried sample was analyzed for its quality by estimating the colour, rehydration ratio and sensory characteristics.

2.4.1 Colour

Colour characteristics of the fresh and rehydrated sample were measured in terms tri-stimulus values of L (100 yields lightness and 0 yields darkness), a (+ve indicate redness and –ve indicate greenness) and b (+ve indicate yellowness and –ve indicate blueness) value using Miniscan XE plus Hunter Lab Colorimeter (USA), Model No. 45/0-L (Hunter, 1975). One reading was made per mushroom slice by placing the colorimeter head directly above the cap. The data obtained in terms of *L*, *a* and *b* can be converted into hue angle and chroma, an index analogous to colour saturation or intensity. Total colour difference can also be calculated in order to evaluate the colour difference between tested sample and reference material or fresh sample. The following equations were used to calculate surface colour analysis.

$$\Delta E = \sqrt{[(L-L_0)^2 + (a-a_0)^2 + (b-b_0)^2]} \quad (5)$$

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

$$h^\circ = \tan^{-1}(b/a) \quad (7)$$

where, subscript “0” refers to the colour reading of fresh oyster mushroom used as the reference and a larger ΔE denotes greater colour variation from the reference material.

2.4.2 Rehydration ratio

The rehydration ratio (RR) of the dried mushroom samples was determined by mixing 5 g of sample with 50 mL of 1% NaCl solution 150 mL beaker. It was allowed to rehydrate for 20 min followed by draining of water; the weight of moisture content was determined (Ranganna, 2000). The RR was calculated using the relationship:

$$RR = \frac{\text{Mass of rehydrated mushroom sample, g}}{\text{Mass of dried mushroom sample, g}} \quad (8)$$

2.4.3 Sensory evaluation of dried mushrooms

Organoleptic quality of dried mushrooms was determined with the help of 20 semi trained consumer panel using a 9-point Hedonic scale. The panelists were asked to evaluate the OA on the basis of appearance, texture and flavor. OA was evaluated as an average of appearance, texture and flavour. The scale that was used for sensory evaluation is given in Table 1.

Table 1 Sensory evaluation scale

Score/Rating	Hedonic scale
9	like extremely
8	like very much
7	like moderately
6	like slightly
5	neither like nor dislike
4	Dislike slightly
3	Dislike moderately
2	Dislike very much
1	Dislike extremely

2.5 Statistical analysis

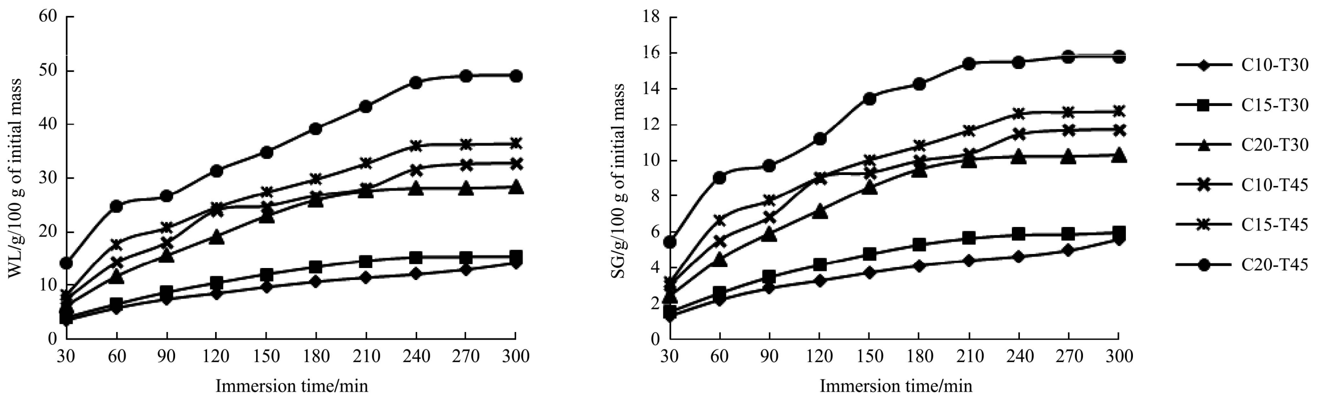
The experimental data were evaluated by analysis of variance (ANOVA) and means were compared by the critical difference values tested at a significance level of 5%, by using computer software package (Cheema and Singh, 1990).

3 Results and discussion

3.1 Effect of osmotic pretreatment on osmotic parameters

3.1.1 Water loss and Solid gain

The effect of osmotic parameters on water loss (WL) and solid gain (SG) during osmotic dehydration of oyster mushroom has been presented in Figure 1a and 1b. From an examination of figures it was observed that WL and SG increased with increase in osmotic solution concentration. This might be due to concentration difference between the salt solution and the mushroom which created two simultaneous diffusions of water from solution to sample and salt from the solution to the sample and led to increased entry of salt from solution to sample causing cell wall breakage and ultimately shrinkage of the sample. In all the experiments, the water loss was very fast at the beginning of the process and decreased gradually with the increase of time (Kar and Gupta, 2001, 2003). The dehydration process of mushroom (moisture content 86.4%, wb) in osmotic salt solution was found to slower down considerably as the immersion time exceeded 6 h. On the other hand, solution temperature showed positive effect on the overall water loss and solid gain within the studied moderate temperature range (30–45°C) due to reduction in the viscosity of the salt solution at high temperature which improved the surface contact between material and solution and ultimately, yielding an enhanced water loss and solid gain. On average the maximum value of water loss and solid gain were observed as 49.14 and 15.78 g/100 g of initial mass respectively for combination of higher solution temperature 45°C and salt concentration of 20 g/100 g. The analysis of variance for the effect of osmotic dehydration on water loss and solid gain of mushrooms has been given in Table 2. It was found that salt concentration exerted more pronounced effect on water loss and solid gain in comparison to solution temperature as corroborated with higher value of critical difference as that of salt concentration (CD < 5%).



(a) (b)

Figure 1 Effect of immersion time on (a) WL and (b) SG of oyster mushroom for different salt concentration and solution temperature during osmotic process

Table 2 Effect of immersion time, temperature and salt concentration on mass transfer parameters of osmosed oyster mushrooms

Mass transfer parameters	Salt concentrations, %, A			Temperature, °C, B		Osmotc time, min, C									
	10	15	20	30	45	30	60	90	120	150	180	210	240	270	300
WL	9.72	21.36	28.31	18	21.6	7.23	13.76	16.7	20.15	22.12	23.96	26.11	28.64	29.3	29.78
CD (<5%)	A = 1.33 B = 1.09 C = 2.55 AB = 1.88 AC = 4.42														
SG	3.72	7.79	9.9	6.59	7.68	2.81	5.21	6.26	7.43	8.08	8.68	9.34	10.05	10.25	10.41
CD (<5%)	A = 0.42 B = 0 .34 C= 0 .817 AB= 0.60 AC = 0.41														

3.1.2 Osmosis immersion time

The changing trend of water loss from and solid gain by the mushrooms against immersion time of osmosis for all treated sample at different salt concentrations and solution temperatures has been shown in Figure 1a and 1b. It was observed that the water loss as well as solid gain increased non-linearly with time at all concentrations and temperatures. Both, the water loss and solid gain were rapid in the initial period of osmosis and then the rate decreased towards equilibrium. This was probably due to reducing osmotic driving potentials for moisture as well as solid transfer with passage of time. Another reason might be due to smaller molecular size of salt that can penetrate easily inside the tissue and further increase in concentration resulted in to the formation of high solid subsurface layer; a barrier against removal of water and uptake of solid. Besides, rapid loss of water and uptake of solid near the surface in the beginning may result in structural changes leading to compaction of these surface layers and increased mass transfer resistance for water and solid. Similar trends have been reported for other fruits and vegetables during osmosis (Conway et al., 1983; Ertekin and Cakaloz, 1996; Karthanos et al., 1995). The analysis of variance for effect of different time intervals i.e. 30-300 min, on mass transfer showed highly significant difference in water loss and solid gain at all combinations of solution temperature and concentration (Table 2).

3.2 Air drying kinetics

The water activity can further be lowered through moderate drying. Lowering the water activity amounts inhibition of microbial growth thereby increase the shelf-life or improve the quality of the food after drying. The effect of osmo-convective drying on moisture content of mushrooms for different salt concentration and solution temperature have been plotted (Figure 2). It is observed that a major part i.e. 253.84% - 485.88%, db of the water present in the fresh mushroom was removed after 360 min osmotic pre-treatment in a brine solution. The samples immersed in salt solution of 25 g/100 g and osmosed at solution temperature of 45°C exhibited lower moisture content values in comparison to other treated samples for 30°C solution temperature. Further, it was observed that moisture content decreased rapidly with time during the initial stage of air-drying process. Specifically, samples treated with salt solution of 10 g/100 g at solution temperature of 30°C showed a faster removal of moisture decline in first 2 h drying in comparison to other treatment combination, probably due to presence of high moisture content in initial phase of drying whereas a considerably lower moisture removal rate was observed for remaining period of drying. According to Rahman and Lamb (1991) and Neito et al. (1998), increase in internal resistance to mass transfer during drying occurred due to greater diffusion of solid from solution to sample in osmotic process which was not observed during initial phase of drying but after certain time. Also the water which removed during initial phase was of free moisture that evacuated from cell membrane during osmotic process and deposited in the space near to the outer surface of cell. This free water resulted in to higher diffusion rate in comparison to water molecules present in internal capillary of cell tissues and led to faster drying rate.

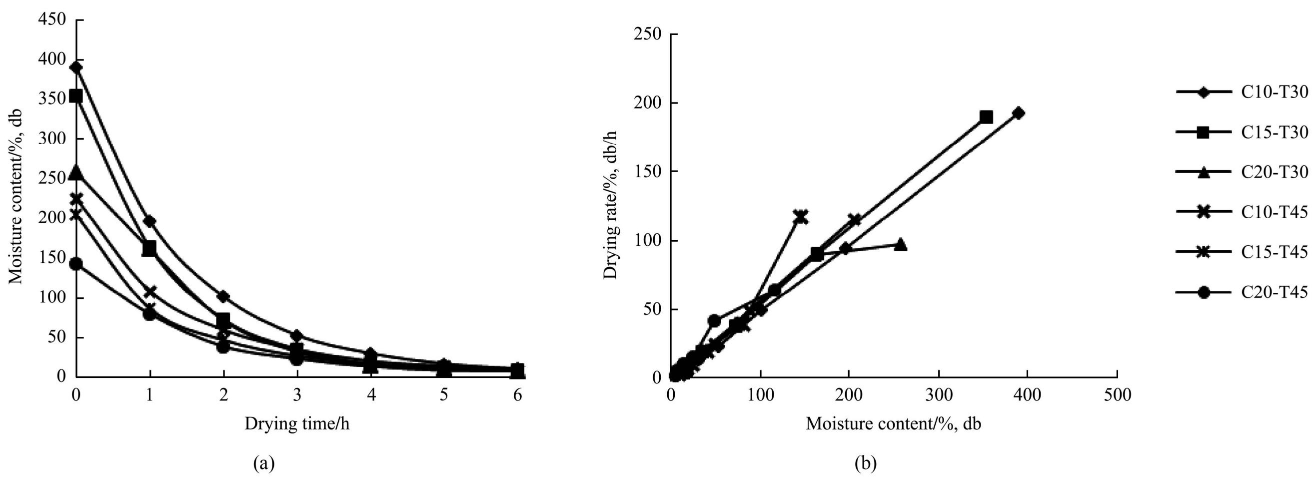


Figure 2 Linear plot of (a) Drying curves and (b) Drying rate of osmotically treated samples influenced by different salt concentration and solution temperature

Drying rates were calculated as quantity of moisture removed per unit drying time per unit dry solids and presented in Figure 2b. From an examination of figures, it was observed that the drying rate decreased with increase in drying time with some minor exceptions of irrespective of drying temperature. The decrease in drying rate being more drastic and pronounce in initial minutes of drying as compared to the later part of drying. Further it was observed that the drying occurred mostly in the falling rate period regardless of drying conditions. In spite of having high moisture content in mushroom, the sample has not shown a constant rate period owing to smaller thickness of sample allowing rapid drying rate during air drying of osmotically treated samples. A steeper falling rate was observed due to case hardening; a hard layer formed by diffusing solid at the surface of drying sample at high temperature which led to splitting, rupturing and cracking of tissues and forming open structures in the sample, so that moisture transfer occurred with a greater rate from the cracks and an open structure formed. In samples pretreated with 10 g/100 g salt solution at solution temperature of 30°C, a change in drying rate was as higher as 193.25% db/h. Thereafter, the samples showed lowest drying rate.

Page and Henderson model and statistical parameters calculated by using equation from 3 to 6 has presented in Table 3 which showed that Henderson and pabis equation has a very good fit to experimental data than that of page model. The parameter *k* and *n* of page equation representing water diffusion rate was found to show irregular trend with increase in salt concentration as well as solution temperature. On the other hand, *k* parameters of henderson and pabis equation showed decreasing trend with solution temperature but no clear trend was observed with salt concentration whereas, *a* was found to increase with salt concentration but represented decreasing trend with solution temperature from 45 to 30°C. Overall the calculated average high value of R^2 and least average value of RMSE and P respectively in case of Henderson and pabis model as that of page equation implied close agreement between experimental and predicted values.

Table 3 Models parameters and goodness of fit for drying kinetics of osmotically pretrested oyster mushroom

Page model						
Temperature, °C	Concentration, g/100 g	*k*	*n*	R^2	RMSE	P
30	10	0.71	12.41	0.90	0.10	7.68
	15	0.79	11.7	0.94	0.08	5.41
	20	0.49	14.25	0.91	0.11	7.50
45	10	0.77	11.99	0.91	0.10	7.61
	15	0.90	0.87	0.99	0.01	0.30
	20	0.61	13.07	0.91	0.10	7.45
Henderson and Pabis model						
Temperature, °C	Concentration, g/100 g	*k*	*a*	R^2	RMSE	P
30	10	0.72	1	1	0	0.36
	15	0.82	1	0.99	0.01	0.46
	20	0.66	1.02	0.98	0.04	1.55
45	10	0.74	0.99	0.99	0.01	0.08
	15	0.84	0.99	0.99	0.02	0.33
	20	0.69	1.01	0.99	0.02	0.77

3.3 Effect of osmo-convective drying on quality parameters

3.3.1 Colour

Colour is an important sensory attribute for marketing of products because it is usually the first characteristic noted by potential consumers. Moreover, colour is often associated with the quality of the product and may be taken as an indicator of the level of natural deterioration of fresh foods. Osmotic treatment can prolong pigment retention and minimize the browning associated with natural oxidative processes, thus making products more attractive to consumers. The values of *L*, *a*, *b* and Δ*E* obtained from the experimental data during osmo-convective drying has been given in Table 4. The change in the brightness of rehydrated samples can be taken as a measurement of browning resulted due to drying process, was found to reduce from 54.41 to 53.44 due to high salt osmotic pretreatment of oyster mushrooms at different temperatures of 30 and 45°C, respectively. Higher *L* value of rehydrated sample was observed for sample osmotically pretreated in 10 g/100 g salt solution for solution temperature of 30°C. For redness - greenness scale, the final *a* values were varied from 1.75 to 2.47 as the salt concentration and osmotic temperature increased from 10 to 20 g/100 g and 30 to 45°C, respectively. Therefore, mushroom sample gained redness when osmotically treated at higher salt concentration and temperature. An increase of the *b* value (Table 4) was also observed during osmo-convective drying. The final *b* values were varied from 5.05 to 6.69 as the salt concentration and osmotic temperature increased from 10 to 20 g/100 g and 30 to 45°C, respectively. Salt impregnation seemed to maintain lightness, resulting in a final product close to that of the fresh mushroom sample. Generally, it is well known that the colour difference resulted due to enzymatic browning by influencing parameters *L* and *a* (Mandala et al., 2005). As browning increased, *L* values decreased and *a* values increased. The increase in redness and yellowness was clear and seemed to be as result of solids uptake during osmosis pre-treatment.

As a whole, the Δ*E* of mushrooms decreased during osmo- air drying and it ranged from 11.41 to 10.205 as osmotic temperature increased from 30 to 45°C, respectively (Table 4). This occurred due to the solute uptake, which resulted in lower O_2 being transferred to the surface. All these resulted in less discoloration of the osmosed samples by enzymatic browning (Kim, 1990). Moreover, the use of low temperature i.e. 60°C during air-drying was justified by the great co-action of temperature on reactions maillard of surface salts.

Table 4 Effect of osmo- air drying parameters on quality attributes of oyster mushroom

Osmotic temperatures, °C	Parameters		Salt concentration, g/100 g		
			10	15	20
30	Color	*L*	38.42	40.77	54.41
		a	2.73	3.17	1.75
		b	6.16	6.57	5.05
		Δ*E*	22.02	19.7	11.41
		h°	66.13	64.27	70.92
		C*	6.73	7.29	5.34
	Rehydration ratio	RR	2.58	2.62	2.74
	Overall acceptability	OA	64.81	62.96	68.52
45	Color	*L*	46.5	50.87	53.44
		a	2.31	2.05	2.47
		b	5.29	5.64	6.69
		Δ*E*	15.72	12.56	10.2
		h°	66.44	70.06	69.77
		C*	5.77	6	7.13
	Rehydration ratio	RR	2.61	2.68	2.9
	Overall acceptability	OA	68.52	72.22	79.63

Osmosed samples in 20 g/100 g salt solution and at 45°C solution temperature were found to be slightly better than those that were pre-treated in 20 g/100 g salt solution and at solution temperature of 30°C in colour retention during drying. This may be due to lower moisture content of samples after osmosis, which could inhibit the oxidant enzymes action with drying time and keep the Δ*E* practically unchanged. The statistically analyzed data presented in Table 5 showed that the salt concentration and solution temperature interaction exerted more prominent effect on the brightness, redness and Δ*E* of the mushroom whereas, *L* was more significantly affected by the salt concentration only as indicated by CD value at 5 % level of significance.

The chroma index indicates the degree of saturation of color and is proportional to the strength of the color whereas, the hue angle value corresponds to whether the object is red, orange, yellow, green, blue or violet. These values were calculated using Eqs. (6)–(7) and are shown in Table 4. The data obtained showed that the values of C* and h° varied regardless of the salt concentration and osmotic temperature. The data on statistical analysis of C* and h° obtained for two replications for the respective solution temperature and salt concentration have been presented in Table 5. The main effects of pretreatments were found to be statistically significant (CD < 5%) on chroma index. On the other hand, hue angle was significantly affected by salt concentration only as indicated by CD value shown in Table 5. These finding implied that the osmotic dehydration at different salt concentrations followed by air drying was effective to improve hue angle and produce superior quality product.

Table 5 Effect of osmo-convective drying on quality attributes of osmosed oyster mushrooms

Quality parameter		Salt concentration, %, A			Solution temperature, °C, B		CD (<5%)
		10	15	20	30	45	
Color	*L*	42.46	45.82	53.92	44.53	50.27	A= 2.89, B = 2.36, AB = 4.09
	a	2.52	2.61	2.11	2.55	2.27	A = 0.31, B = 0.25, AB = 0.43
	b	5.72	6.1	5.87	5.92	5.87	A = 0.19, B = NS, AB = 0.27
	Δ*E*	19.03	16.36	11.21	17.91	13.15	A = 1.84, B = 1.50, AB = 2.61
	h°	66.3	67.16	70.34	67.1	68.76	A = 2.93, B = NS, AB = NS
	C*	6.25	6.64	6.23	6.45	6.3	A = 0.17, B= 0.14 , AB = 0.24
Overall Acceptability		63.89	68.52	5.92	68.51	70.37	A = 5.55, B=NS, AB = NS
Rehydration ratio		2.58	2.65	2.8	2.64	2.72	A = 0.03, B = 0.02, AB = 0.04

3.3.2 Rehydration ratio

Observations on rehydration ratio of mushrooms dried osmotically were shown in Table 4. It showed the increasing trend with advancement in solution temperature and salt concentration. The mushrooms dried osmotically in 20 g/100 g salt solution at 45°C gained maximum water and showed highest rehydration ratio. This might be due to higher WL, which resulted at higher concentration and solution temperature during osmosis. At the same time the samples gained solid, but WL was greater than the SG. Due to this fact, salt were not able to cover the vacuum spaces generated in plant tissue during osmo-air drying. The data on statistical analysis of rehydration ratio obtained for two replications for the respective solution temperature and salt concentration are presented in Table 5. This finding implied that the temperature: concentration interaction has more prominent effect on rehydration ratio as indicated by CD value at 5% level of significance.

3.3.3 Overall Acceptability

The overall acceptability of the dried mushrooms i.e. mean of the group of properties such as flavor, appearance and texture was evaluated to assess the consumer acceptance (Table 4). The statistically analyzed data presented in Table 5 clearly indicated that the samples treated in solution having temperature of 45°C and salt concentration of 20 g/100 g had higher OA in comparison to other treatments. On the other hand, the process conditions (30ºC and 15 g/100 g salt solution) resulted in lower sensory quality products. Among the various treatments the most liking was observed for osmosed sample at 45°C and 20 g/100 g salt concentration due to its bright color, crispiness and pleasant flavor.

4 Conclusions

The concentration and temperature of osmotic solution had a significant role in enhancement of mass transfer in terms of water loss and solid gain. Also, osmotic dehydration was found to be as an effective pretreatment method for reducing the moisture content for further drying. Henderson and Pabis model described drying kinetics adequately in comparison to Page model. On the other hand, during the rehydration process, the osmo-convective dried mushrooms gained moisture content almost equivalent to fresh mushrooms. The colour of osmo-convective dried vegetables was improved after rehydration. The mushrooms segment pretreated in 20 g/100 g salt concentration at 45°C solution temperature followed by air drying were very much acceptable in terms of sensory appealing appearance, texture and flavour, compared to other treatments.

Nomenclature

WL	Water loss in g/100 g of initial mass
SG	Solid gain in g/100 g of initial mass
W_i	Initial mass of mushroom in g
X_{wi}	Water content as a fraction of the initial mass of mushroom
W_o	Mass of mushroom after time 't'in g
X_{wo}	Water content as a fraction of the mass of mushroom at time 't'
MR	Moisture ratio
a, k, n	Model constants
t	Drying time
R^2	Coefficient of determination
RMSE	Root mean square error
P	Mean relative percentage deviation of modulus
ΔE	Color difference
C*	Chroma index
h°	Hue angle
RR	Rehydration ratio
OA	Overall acceptability
CD	critical difference in %

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