Int.J.Curr.Microbiol.App.Sci (2018) Special Issue-7: 1341-1349

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 Special Issue-7 pp. 1341-1349
Journal homepage: http://www.ijcmas.com

Original Research Article

Osmotic Dehydration as a Pre-treatment Before Hot Air Drying of Mushroom (*Agaricus bisporus*)

B.K. Mehta[1*], Maya Kumari[2], Surabhi[3] and S.K. Jain[4]

[1]Krishi Vigyan Kendra, Birsa Agricultural University, Jirwabari, Sahibganj (Jharkhand), Pin-816109, India
[2]Department of Civil Engineering, Amity University, Sector-125, Noida (Uttar Pradesh), Pin-201313, India
[3]Department of Processing & Food Engineering, CTAE, MPUAT, Udaipur (Rajasthan), Pin-313001, India
*Corresponding author

Keywords

Mushroom (Agaricus bisporus), Osmotic Dehydration

A B S T R A C T

Osmotic dehydration is used as a pre-treatment before hot-air drying of mushrooms (Dehkordi, 2010; Mehta *et al.* 2017a and Mehta *et al.* 2017b) because it has the advantage of improving nutritional, sensorial and functional aspects of foods, without changing its colour, texture and aroma. The osmotic drying of button mushroom was carried out by immersing sliced mushroom in 10, 15 and 20% salt solutions at 35, 45 and 55ºC temperatures for two hours. The effect of process parameters (duration of osmosis, salt concentration and temperature of brine) on mass transport data (water loss and salt gain) were studied. The process parameters for osmotic dehydration of mushroom sample were optimized using response surface methodology. The optimum operating conditions were found to be brine temperature of 44.89^{o}C, salt concentration of 16.53% and osmosis time of 47.59 min. At this optimum point, water loss and salt gain were predicted to be 40.55 per cent and 2.98 per cent respectively. Since, osmotic dehydration process cannot remove moisture to a level that will avoid microbial growth. Hence, osmo-treated mushroom sample at optimized conditions were then air dried at various temperatures and air velocities for getting self stable products. Study revealed that, convective drying of osmotically dehydrated mushroom sample with 65^{o}C drying temperature and 2.0 m/s air velocity was best for optimum responses among the range of variables taken for the study.

Introduction

Osmotic dehydration is one of the methods of moisture removal where the product is dried by concentration difference or by use of osmotic pressure difference. Although, osmotic process will not give a product of sufficiently low moisture content to be considered as a shelf stable and therefore, osmosed product needs to be further dried, through air, vacuum or freeze drying.

Cultivation of mushroom is one of the biggest money spinning enterprises in the world and mushroom is an important horticultural cash crop. Its production has tremendous scope as an income generating activity. Mushroom being an indoor crop does not require arable land, except for some non-agricultural land to build infrastructure for preparation of substrate, raising of crop, preparation of spawn and post harvest handling, hence it is of great importance for landless and marginal farmers (Mehta *et al*., 2011). But post-harvest problems of mushroom arise due to its high moisture content (i.e. about 90 per cent) and respiration at a very fast rate. It starts deteriorating immediately just after harvest due to presence of high moisture content. They develop brown colour on the surface of the cap due the enzymatic action of phenol oxidase, this results in shorter shelf life.

In view of their high perishable nature, the fresh mushrooms have to be processed to extend their shelf life for off season use. Processing of mushroom involve a combination of unit operations to achieve the intended changes to the raw materials.

The combination and sequence of operations determines the nature of the final product. Osmotic dehydration is used as a pre-treatment before hot-air drying of mushrooms (Dehkordi, 2010 ; Jain *et al.* 2011; Mehta *et al.* 2013; Mehta *et al.* 2017a and Mehta *et al.* 2017b) because it has the advantage of improving nutritional, sensorial and functional aspects of foods, without changing its colour, texture and aroma. Since, osmotic dehydration process cannot remove moisture to a level that will avoid microbial growth, Hence, osmo-treated mushroom sample is then air dried for getting self stable products (Jain *et al.* 2011 ; Pisalkar *et al.* 2011; Mehta *et al.* 2017a and Mehta *et al.* 2017b).

Very few attempts have been made to study osmo-convective drying of button mushroom. Therefore, a study was proposed to investigate "use of osmotic dehydration as a pre-treatment before hot air drying of mushroom".

Materials and Methods

Selection of raw materials

Mushroom of *Agaricus bisporus* variety, having about 87-91 per cent moisture content (wb), was procured on daily basis. Freshly harvested, firm, dazzling white, mature mushrooms of uniform size were manually sorted and selected as the raw material for all the experiments. Common salt (Brand name Tata) used as an osmotic agent, was procured from the local market.

Sample and solution preparation

The white button mushrooms of uniform size were thoroughly washed under tap water to remove adhering impurities. They were then dried on a blotting paper, and then cut into 5±0.5 mm thick slices with the help of sharp stainless steel knife. The brine solution of desired concentration was prepared by dissolving the required quantity of salt (w/v) in tap water.

Determination of moisture content

Moisture content of fresh as well as osmotically dehydrated mushroom slices were determined. A brief description of the method is as follows:

A thin layer of finely divided asbestos (Gooch grade) powder was spread into a flat bottom moisture box and dried at 110°C for 1 hour, cooled and weighed.

About 5-8g sample of mushroom was kept in a pre-dried and weighed moisture box. The mass of the sample was recorded as W_1.

The box was placed in oven and temperature was maintained at 100°C for 18 h.

After drying the sample was cooled in a desiccator to room temperature and then weighed. The mass of the dried sample was recorded as W_2.

A single pan analytical balance of 0.001g sensitivity was used.

The moisture content of the sample was calculated by using following equation:

$$MC\,(\%db) = \frac{W_1 - W_2}{W_2} \times 100 \qquad \ldots 1$$

Where,
W_1 = mass of original sample, g
W_2 = mass of sample after drying, g

Total soluble solids

The total soluble solids of prepared brine solutions were determined by hand refractometer of range from 0 to 32.

Mass transport data for osmotic dehydration

Mass transport data during osmotic concentration have been used by various researchers such as Pisalkar *et al*., 2011 and Jain *et al*., 2011 for many food products.

Water loss (WL)

Water loss is the net loss of water from food material on an initial mass basis.

$$WL = \frac{W_{si}X_{swi} - W_{s\theta}X_{sw\theta}}{W_{si}} \times 100 \qquad \ldots 2$$

Mass reduction (WR)

Mass reduction is the net mass reduction of the food material on initial mass basis.

$$WR = \frac{W_{si} - W_{s\theta}}{W_{si}} \times 100 \qquad \ldots 3$$

Solid gain (SG)

Solid gain is the net uptake of solids by food material on an initial mass basis.

$$SG = \frac{W_{s\theta}\left(1 - X_{sw\theta}\right) - W_{si}\left(1 - X_{swi}\right)}{W_{si}} \times 100 \qquad \ldots 4$$

From Eqns (3) and (4), the solid gain (SG) can be correlated with mass reduction (MR) and water loss (WL) as

$$SG = WL - WR \qquad \ldots 5$$

Where,
WL = water loss (g water per 100 g initial mass of sample)
WR = mass reduction (g mass per 100 g initial mass of sample)
SG = solid gain (g solids per 100g initial mass of sample)
W_{si} = initial mass of sample, g
$W_{s\theta}$ = mass of the sample after time θ, g
X_{swi} = water content as a fraction of the initial mass of the sample
$X_{sw\theta}$ = water content as a fraction of the brine at time θ

Optimization of input parameters for osmotic dehydration

Response surface methodology (RSM) is an useful statistical technique for investigation of complex processes, hence the process parameters for osmotic dehydration of mushroom samples have been optimized using this technique. RSM is a collection of certain statistical techniques for designing experiments, building models, evaluating the effects of the factors and searching for optimal conditions for desirable responses (Alam *et al*., 2010; Jain *et al.*, 2011 and Mehta *et al.* 2017b). The response surface analysis involves fitting the experimental values of water losses/solute gain to a general quadratic polynomial equation and subsequently optimizing the values with suitable optimization software or mathematical solutions. The studies of optimization have been carried out by various research workers (Shi *et al*., 2008; Dehkordi, 2010; Jain *et al.,* 2011and Mehta *et al.* 2017b).

The process parameters such as salt concentration, brine temperature and duration of osmosis were optimized for maximum of water loss and optimum (targeted) salt gain.

Convective drying of osmotically dehydrated mushroom samples

Osmotically dehydrated product, generally, may not have moisture content low enough to be considered as shelf stable. It is therefore, needed it to be further air dried to obtain a shelf stable product *i.e.* stable with respect to prevention of microbial growth and enzymatic colour changes (Shukla and Singh, 2007; Vishal *et al*., 2009; Pishalkar *et al*., 2011and Mehta *et al.* 2017b).

Hence, the product obtained from the optimized levels of the osmotic dehydration was then air-dried in conventional tray drier.

Convective drying experiments

Drying process is influenced by temperature, velocity, relative humidity, time of drying, loading density, *etc.* Among these parameters listed above, the drying air temperature (T) and air velocity (V) were selected to study drying characteristics of the osmotically dehydrated mushroom samples. The osmotically dehydrated samples were dried in the above stated laboratory tray dryer at 45, 55, 65, 75 and 85^{o}C drying air temperatures and at three air velocities (1.0, 1.5 and 2.0 m/s). Air velocity was measured with the help of a digital anemometer, while drying air temperature was adjusted by temperature indicator cum controlling unit and conditions were allowed to stabilize at desired temperature. The relative humidity of the ambient air was measured by a hygrometer.

The osmotically dehydrated mushroom samples were loaded on drying trays and inserted into the dryer. The mass of samples were recorded at 5 minute interval for first half an hour, at 10 minute interval for next half hour and at 30 minute interval until completion of experiment.

Results and Discussion

Based on the results of preliminary investigations on water loss and salt gain, the ranges of input parameters were fixed for further experimentation of optimization as shown in Table 1. Among these, the brine to sample ratio was taken as constant at 5:1 level, which was also suggested by various researchers for various fruits and vegetables (Jain *et al.*, 2006; Jain *et al.*, 2011and Pisalkar *et al.*, 2011). However, the ranges of the other parameters namely, brine temperature; salt concentration and duration of osmosis were selected and optimized on the basis of salt gain. The optimum salt gain was decided on the basis of consumer's taste panel.

Product quality

In an osmotic dehydration process higher the water loss better is the dehydration process. However, high solid gain affects the products quality and sensory characteristics. When high levels of solids are incorporated into the products (mushroom slices) during the osmotic dehydration significant sensory alterations can occur and the final product may present a taste that is very different from fresh sample, thus affecting the overall acceptability. Thus considering the importance of the salt gain in product quality and acceptability of osmotic dehydration, this factor was mainly used for optimization of the input parameters of the process. For this purpose, it was necessary to fix the level of salt gain in the final product, so that it is acceptable by the consumers. Fifteen judges were given the mushroom samples having the various levels of salt gain ranging from 2.15 to 4.09 per cent as shown in Table 2. The judges were asked to taste the samples and give the marks according to their liking ranging from like extremely (score-9) to dislike extremely (score-1). The details of the mean sensory score for the salty characteristics of the product as well as the result of these tests are presented in Table2.

It can be observed from the Table 2 that as the salt gain increased from 2.15 to 4.09 per cent; the mean sensory scores were increased up to 2.98 per cent of salt gain and then decreased.

From the analysis of variance, it could be seen that the coefficient of variance among the different judges was 4.95 per cent, which is less than 10 percent indicating coherence amongst the score attributed by the judges.

The F value was significant and the CD (5%) indicated that the product with 2.98 per cent salt gain was most liked by the judges.

The highest sensory score attributed to the product indicated that osmo-convectively dried mushroom product having 2.98 per cent salt gain may acquire higher liking by the consumer. Therefore the input parameters namely, brine temperature; salt concentration and duration of osmosis (Table 1) were optimized on the basis of maximum water loss and targeted salt gain (2.98 per cent).

The comparative effect of each factor on water loss was observed by the F values in the ANOVA (Table 3) and also by the magnitudes of coefficients of various process variables of Eqn. (1). The F values indicated that concentration of brine was the most influencing factor followed by duration of osmosis and temperature of brine was least effective over water loss.

Table.1 Process parameters selected for investigations

Process parameters	Levels
Brine temperature	35, 45 and 55^{o}C
Brine concentration	10, 15 and 20%
Duration of osmosis	30, 45 and 60 min

Table.2 Effect of salt gain in osmo-dehydrated samples on mean sensory score

Product code	Salt gain, %	Mean score	Remark given by consumer panel
01	2.15	7.38^{c}	Liked moderately
02	2.57	7.63^{b}	Liked moderately
03	2.98	8.32^{a}	Liked very much
04	3.37	7.86^{b}	Liked moderately
05	3.74	7.59^{b}	Liked moderately
06	4.09	72.1^{c}	Liked moderately

*The values superscripted by similar letters are non-significantly different from each other.
F-cal = 3.03 (significant), CD at 5% level = 0.670, CV = 4.95%

Table.3 Analysis of variance for water loss during osmotic dehydration of mushroom sample

Source	Sum of squares	df	Mean sum of squares	F value
Model	435.01	7	62.14	377.07*
T	67.34	1	67.34	408.58*
C	190.22	1	190.22	1154.20*
θ	146.89	1	146.89	891.27*
T θ	1.14	1	1.14	6.95**
C θ	1.02	1	1.02	6.19**
C^2	3.11	1	3.11	18.87*
$θ^2$	24.23	1	24.23	147.03*
Residual	1.48	9	0.16	
Lack of Fit	1.28	5	0.26	5.08^{NS}
Pure Error	0.20	4	0.050	
Cor Total	436.49	16		
R^2	0.997			
Adj. R^2	0.995			
Pred. R^2	0.983			
C.V. %	1.10			

* Significant at 5 % Level, ** Significant at 1 % Level and NS - Non significant

Table.4 Analysis of variance for salt gain during osmotic dehydration of sample

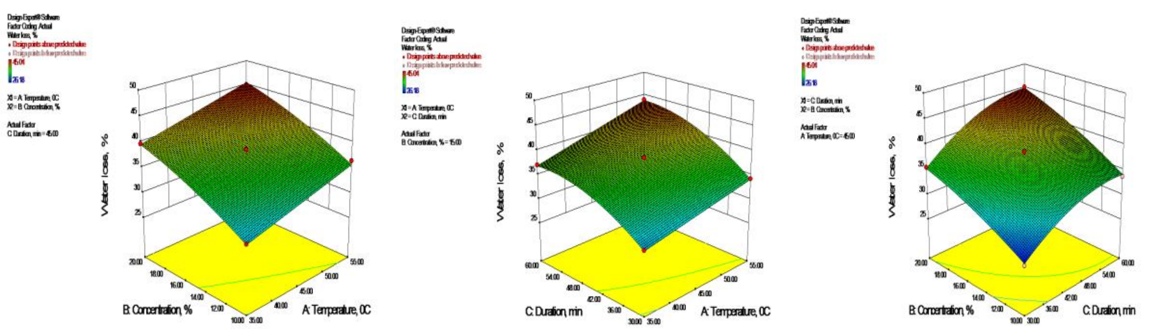
Source	Sum of squares	df	Mean sum of squares	F value
Model	12.54	6	2.09	245.41*
T	0.60	1	0.60	70.42*
C	8.08	1	8.08	949.16*
θ	0.99	1	0.99	115.94*
T^2	0.04	1	0.04	4.68*
C^2	2.30	1	2.30	270.66*
$θ^2$	0.36	1	0.36	42.24*
Residual	0.09	10	0.009	
Lack of Fit	0.04	6	0.006	0.56^{NS}
Pure Error	0.05	4	0.012	
Cor Total	12.62	16		
R^2	0.993			
Adj. R^2	0.989			
Pred. R^2	0.982			
C.V. %	4.27			

* Significant at 5% level, NS - Non significant

Table.5 Solution generated by the software for osmotic dehydration of mushroom sample

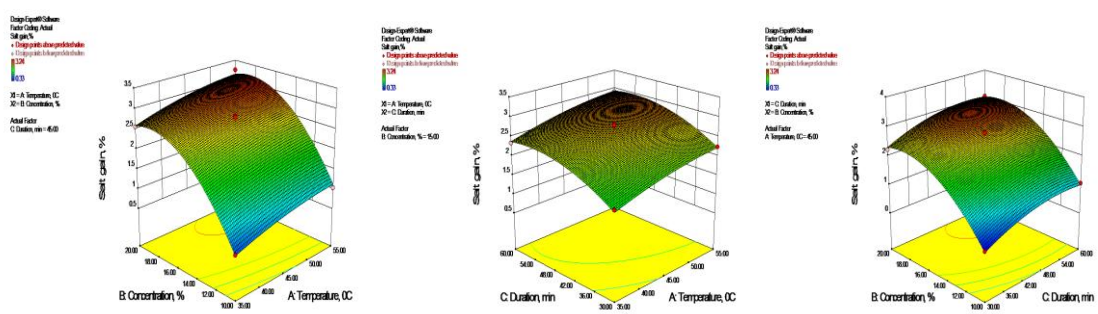
No.	Temperature, °C	Concentration, %	Duration, min	Water loss, %	Salt gain, %
1	44.89	16.53	47.59	40.55	2.98

Fig.1 The contour and response surface showing the effect of temperature, concentration and duration on water loss during osmotic dehydration



(A)At 45 min duration of osmosis **(B) At 15% brine concentration** **(C) At 45°C brine temperature**

Fig.2 The contour and response surface showing the effect of temperature, concentration and duration on salt gain during osmotic dehydration



(A)At 45 min duration of osmosis **(B) At 15% Brine Concentration** **(C) At 45°C brine temperature**

The regression equation describing the effects of process variables on water loss in terms of coded values of variable is given as

$$WL = 38.47 + 2.90x_1 + 4.88x_2 + 4.29x_3 + 0.54x_1x_2 + 0.51x_2x_3 - 0.86x_2^2 - 2.40x_3^2 \quad ...1$$

$R^2 = 0.997$

Replacing x_1, x_2 and x_3 with (T-45)/10, (C-15)/5 and (θ-45)/15 respectively in Eqn. 1, the water loss in real terms of brine temperature, concentration and duration of osmosis can be given by

$$WL = 19.58 + 0.13T + 1.70C + 0.98\theta + 3.57 \times 10^{-3}\,T\theta + 6.73 \times 10^{-3}\,C\theta - 3.43 \times 10^{-2}C^2 - 1.06 \times 10^{-2}\theta^2 \quad ...2$$

Water loss increased with concentration of salt (Fig 1 A and C) as well as with duration of osmosis (Fig 1 B and C) over the entire osmotic dehydration process (Dehkordi, 2010; Jain *et al.*, 2011and Mehta, *et. al*., 2017b).

The comparative effect of each factor on salt gain could be observed by F values in the ANOVA (Table 4) and also by the magnitudes of various process variables of Eqn. 3. The F values indicated that concentration of brine was the most influencing factor followed by duration of osmosis and temperature of brine was least effective over salt gain.

The regression equation describing the effects of process variables on salt gain in terms of coded values of variables is given as

$$SG = 2.69 + 0.27x_1 + 1.01x_2 + 0.35x_3 - 0.097\,x_1^2 - 0.74x_2^2 - 0.29x_3^2 \quad ...3$$

$R^2 = 0.993$

Replacing x_1, x_2 and x_3 with (T-45)/10, (C-15)/5 and (θ-45)/15 respectively in Eqn. (3), the salt gain in real terms of brine temperature, concentration and duration of osmosis is given by

$$SG = -13.87 + 0.11T + 1.09C + 0.14\theta - 9.73 \times 10^{-4}T^2 - 2.96 \times 10^{-2}C^2 - 1.29 \times 10^{-3}\theta^2 \quad ...4$$

The linear positive terms (Eqn. 4) indicated that salt gain increased with increase in brine temperature, concentration and duration of osmosis.

The convective drying behaviour of osmo-dehydrated mushroom samples at brine temperature 44.89°C, salt concentration 16.53% and duration of osmosis 47.59min were investigated at drying air temperature of 65°C air temperature having 2.0 m/s drying air velocity for 450 min duration, which reduces the moisture cotent upto 9.20 per cent (db). This optimized process parameters will yield a shelf stable product.

It can be concluded that the osmotic dehydration of button mushroom should be carried out for 5:1 ratio of brine to sample at 45°C of brine temperature for 48 min duration in 17 per cent salt concentration. This may cause a water loss of 41 per cent and salt gain of 2.9 per cent, which is considered to be optimum. The convective drying of osmotically dehydrated button mushroom should be carried out in tray drier at 65°C air temperature having 2.0 m/s drying air velocity for 450 min duration, which reduces the moisture cotent upto 9.20 per cent (db). This optimized process parameters will yield a shelf stable product and was found superior with respect to taste, appearance and overall acceptability.

References

Alam, M. S., Singh, A. and Sawhney, B. K. 2010. Response surface optimization of osmotic dehydration process for anola slices. J. Food Science Technology. 47(1): 47-54.

Dehkordi Behrouz. Mosayebi. 2010. Optimization the process of osmo-convective drying of edible button mushroom. World Academy of Science, Engineering and Technology. 153-157

Jain, S. K., Verma, R. C., Murdia, L. K., Jain, H. K. and Sharma, G. P. 2011. Optimization of process parameters for osmotic dehydration of papaya cubes. Journal of Food Sci. Technology. 48(2): 211-217.

Jain, S.K., Verma, R.C., Murdia, L.K., Dashora, P.K. and Jain, H.K. 2006. Osmotic dehydration kinetics of papaya cubes. ADIT Journal of Engineering. **3**(1): 72-76.

Mehta, B.K., Jain, S.K., Sharma, G.P., Doshi, A. and Jain, H.K. 2011. Cultivation of button mushroom and its processing: an techno-economic feasibility. International Journal of Advanced Biotechnology and Research, **2**: 201-207.

Mehta, B.K., Jain, S.K., Sharma, G.P., Doshi, A. and Kumar. A. 2017b. Recent advances in processing of button mushroom (Agaricus bisporus). International Journal of Advanced Biological Research.7(3): 485-489

Mehta, B.K., Jain. S. K. and Surabhi. 2017a. Post-harvest management of button mushroom (Agaricus bisporus). Environment & Ecology. 35(4D): 3578-3584.

Mehta, B.K., Jain, S.K., Mudgal, V. D. and Chatterjee, K. 2013. Osmotic Dehydration characteristics of button mushroom slices (Agaricus bisporus). Environment & Ecology.31(1): 148-153.

Pisalkar, P., Jain, N.K. and Jain, S.K. 2011. Osmo-convective drying of aloe-vera gel, Journal of Food Science Technology. **48**(2): 183-189.

Shi, Q.L., Xue, C.H., Zhao, Y., Li, Z.J., Wang, X.Y. and Luan, D.L., 2008. Optimization of processing parameters of horse mackerel (Trachurus japonicus) dried in a heat pump dehumidifier using response surface methodology. Journal of Food Engineering. **87**:74–81.

Shukla, B. D. and Singh, S. P. 2007. Osmo-convective drying of cauliflower, Mushroom and Greenpea. Journal of Food Engineering. 80: 741-747.

Vishal, K., Gunjan, K. and Sharma, P.D. 2009. Effect of osmo-convective drying on quality of litchi. Journal of Agricultural Engineering. **46**(4): 31-35.