INTERNATIONAL JOURNAL OF ADVANCED BIOLOGICAL RESEARCH

www.scienceandnature.org

RECENT ADVANCES IN PROCESSING OF BUTTON MUSHROOM (*Agaricus bisporus)*

[a]Mehta, B.K., [b]Jain, S.K., [b]Sharma, G.P. & [c]Kumar, A.
[a]Krishi Vigyan Kendra, Directorate of Extension Education, Birsa Agricultural University, Jirwabari, Sahibganj-816109, Jharkhand, India.
[b]Department of Processing & Food Engineering, College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur-313001, Rajasthan, India
[c]Department of Agricultural Engineering, Bihar Agricultural College, Bihar Agricultural University, Sabour-813210, Bihar, India.
[*]Corresponding Author email: bkmehtactae@gmail.com

ABSTRACT
Processing of mushroom (*Agaricus bisporus*) through osmo-convective drying process involve a combination of unit operations to achieve the intended changes to the raw materials. 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. The osmo-convectively dried mushroom sample retained 26.71 mg/100 g dm ascorbic acid with 60.99 colour (L-value) and 0.321 water activity at optimum conditions of drying. The osmo-convectively dried product was found superior with respect to taste, appearance and overall acceptability as compared to convectively dried product (without osmosis).

KEY WORDS: *Agaricus bisporus*, Osmosis, Osmo-convective, Processing, Water loss and Salt gain

INTRODUCTION

India is second largest producer of vegetables in the world. Button mushroom (*Agaricus bisporus*) is the most priced commodity among vegetables due to interest in their culinary, nutritional and health benefits. 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 (Kar and Gupta, 2001; Dehkordi, 2010 and Jain *et al.* 2011) 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 (Shukla and Singh, 2007; Jain *et al.* 2011 and Pisalkar *et al.* 2011). Very few attempts have been made to study osmo-convective drying of button mushroom. Therefore, a study was proposed to investigate recent advances in mushroom processing through osmo-convective drying process.

MATERIALS & METHODS

Freshly harvested, firm, dazzling white, mature button mushrooms of uniform size having about 87-91% moisture content (w.b.), were procured from All India Co-ordinated Research Project on Mushroom, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture & Technology, Udaipur, Rajasthan and used as raw material for all the experiments. Common salt (Brand name Tata) used as an osmotic agent, was procured from the local market. Button mushrooms were thoroughly washed under tap water to remove adhering impurities and 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. Moisture content of fresh as well as osmotically dehydrated mushroom slices were determined by method as suggested by Ranganna (2000).
Experiments were conducted at nine combinations of three concentration (10, 15 and 20%) and three temperatures

(35, 45 and 55ºC). A sample of mushroom slices of 50g were immersed in salt solution in 1:5 ratio in nine 500 ml beakers and held at constant temperature water bath. The beakers were manually stirred at regular intervals to maintain uniform temperature. Sample beakers were removed from water bath after every 15 min intervals. Samples were taken out and placed on absorbent paper for 5 min to eliminate excess concentration, weighed and moisture content was determined. The moisture loss and salt gain were calculated based on mass balance. Response surface methodology was used to investigate the effect of brine concentration (10-20%) solution temperature (35-55^{o}C),) and duration of osmosis (30-60 min) with respect to water loss (WL) and salt gain (SG). The solution to sample ratio of 5/1 (w/w) was used. The Box- Behnken design of three variables and three levels including 17 experiments formed by five central points was used for optimizing input parameters. The product obtained from the optimized levels of the osmotic dehydration was then air-dried in axial flow dryer at various temperatures of 45, 55, 65, 75 and 85^{o}C and velocity of air such as 1.0, 1.5 and 2.0 m/s. The stability and quality of the osmo-dried product were governed mainly by its water activity and colour. Therefore, these responses as well as ascorbic acid were also considered for optimizing the input parameters. The osmo-convectively dried mushroom samples with the optimized input parameters i.e. drying temperature-65^{o}C and air velocity-2.0m/s were further studied for their quality aspects, such as sensory evaluation.

RESULTS & DISCUSSIONS

The process parameters (brine concentration, solution temperature and duration of osmosis) were optimized for maximum water loss and optimum salt gain (2.98%). This optimum salt gain was decided by taking sensory evaluation of osmo-convectively dried mushroom samples having different salt gain levels. Values of various responses (water loss and salt gain) at different experimental combinations for coded variables are given in Table 1.

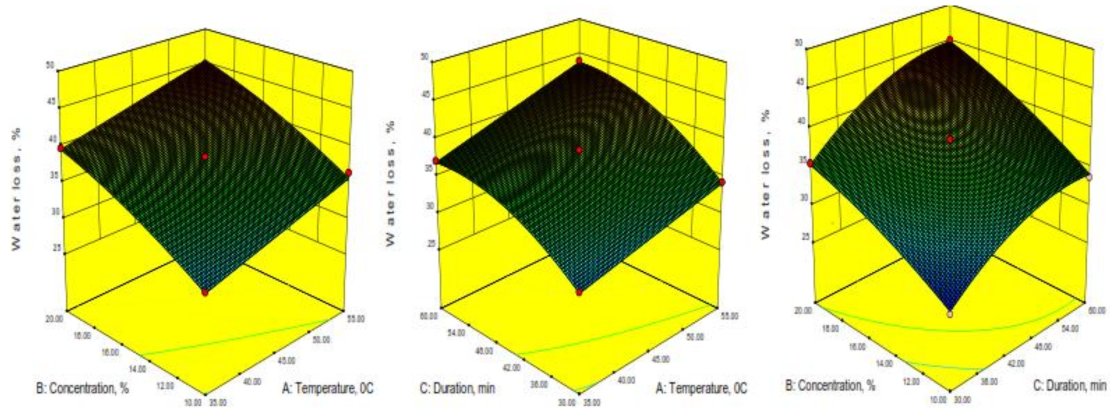
TABLE 1: Experimental data for three-variables and three levels response surface analysis

S.No.	Brine Temp. (^{o}C)	Brine Conc. (%)	Duration of osmosis (min)	Initial mass (g)	Final mass (g)	IMC (wb) (%)	FMC (wb) (%)	Water loss (%)	Salt gain (%)
1	(1)55	(1)20	(0)45	50.05	29.18	90.47	78.10	44.93	3.24
2	(1)55	(-1)10	(0)45	50.12	32.40	90.48	80.67	36.38	1.03
3	(-1)35	(1)20	(0)45	50.05	31.46	90.59	80.37	39.70	2.56
4	(-1)35	(-1)10	(0)45	50.08	35.39	90.67	82.75	29.92	0.59
5	(1)55	(0)15	(1)60	50.01	29.50	90.55	79.26	43.92	2.90
6	(1)55	(0)15	(-1)30	50.06	34.04	90.55	82.24	34.23	2.24
7	(-1)35	(0)15	(1)60	50.08	32.67	90.64	81.08	37.09	2.34
8	(-1)35	(0)15	(-1)30	50.03	36.11	90.64	83.20	29.54	1.73
9	(0)45	(1)20	(1)60	50.09	29.05	90.67	79.07	45.04	3.03
10	(0)45	(1)20	(-1)30	50.13	33.44	90.67	82.24	35.51	2.22
11	(0)45	(-1)10	(1)60	50.11	33.76	90.58	81.31	33.69	1.06
12	(0)45	(-1)10	(-1)30	50.01	37.08	90.58	83.12	26.18	0.33
13	(0)45	(0)15	(0)45	50.04	32.29	90.65	80.94	38.05	2.57
14	(0)45	(0)15	(0)45	50.07	32.14	90.65	81.01	38.44	2.64
15	(0)45	(0)15	(0)45	50.13	32.27	90.65	81.12	38.27	2.64
16	(0)45	(0)15	(0)45	50.09	32.18	90.65	80.88	38.55	2.79
17	(0)45	(0)15	(0)45	50.02	32.12	90.65	81.07	38.60	2.82

Effect of variables on water loss

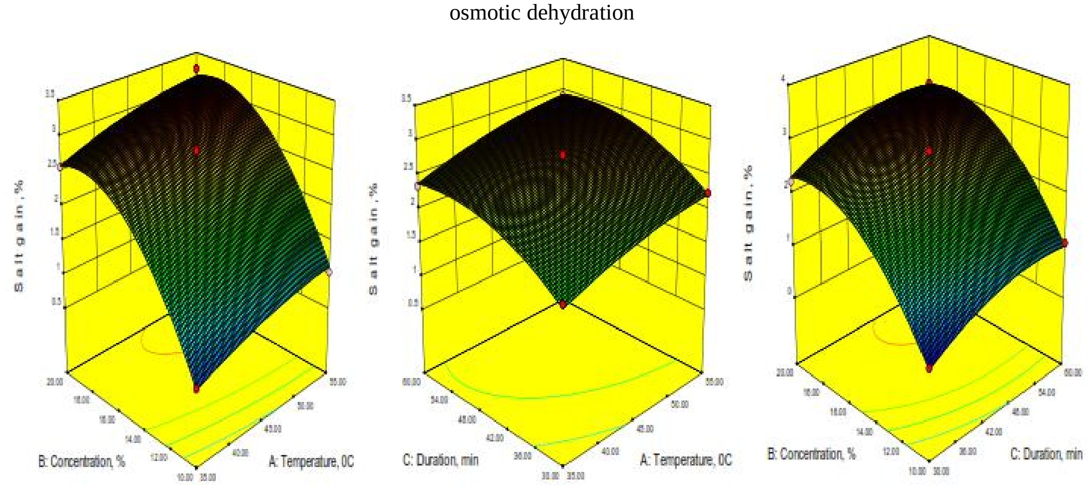
The variation in water loss by changing brine temperature, concentration and osmosis duration has been presented in Table 1. To visualize the combined effect of two variables on the water loss, the response surface and contour plots (Fig 1 A, B and C) were generated for the fitted model as a function of two variables while keeping third variable at its central value. The water loss increased rapidly in the early stages of osmosis, after which the rate of water loss from mushroom sample into salt solution gradually slowed down with time. Rapid removal of water in early stages of osmosis has been reported for litchi (Vishal *et al.* 2009), aloe-vera (Pisalkar *et al.* 2011), papaya (Jain *et al.* 2011), mushroom (Kar and Gupta 2003; Murumkar *et al.* 2006; Shukla and Singh 2007; Mehta *et al.*2013), etc.

Higher temperatures seem to promote faster water loss (Fig1 A and B) through swelling and plasticizing of cell membranes as well as the better water transfer characteristics on the product surface due to lower viscosity of the osmotic medium (Uddin *et al.*, 2004). Water loss increased with concentration of salt (Fig1 A and C) as well as with duration of osmosis (Fig1 B and C) over the entire osmotic dehydration process. In the osmosis of other fruits and vegetables, also such effect has been observed (Kar and Gupta 2003; Dehkordi 2010 and Jain *et al.* 2011).



(A)At 45 min duration of osmosis (B) At 15% brine concentration (C) At 45^{o}C brine temperature

FIGURE 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^{o}C brine temperature

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

Effect of variables on salt gain

The salt gain during the osmotic dehydration was found to be dependent on the brine temperature, concentration and duration of osmosis (Table 1). To visualize the combined effect of two variables on the salt gain, the response surface and contour plots (Fig 2 A, B and C) were generated for the fitted model as a function of two variables while keeping third variable at its central value.

The salt gain increased rapidly in the early stages of osmosis after which the rate of salt gain from brine solution to mushroom sample slowed down with duration. The salt gain was found to increase with temperature (Fig 2 A and B). As it was explained for water loss, temperature has an effect on the cell membrane permeability that could allow solute to enter by loosing its selectivity. Decrease of solution viscosity at higher temperature may influence salt gain due to fact that lower viscosity decreases the resistance to diffusion of solutes into the sample (food product) tissue. Increased concentration of the brine solution also led to increase in salt gain (Fig 2 A and C) probably due to an increase of osmotic pressure gradient and consequent loss of functionality of cell plasmatic membrane that allows solute to enter.

It was observed from these figures (Fig 1 and 2) that the moisture loss as well as the solid gain increased non-linearly with time at all concentrations. Both moisture loss and solid gain were faster in the initial period of osmosis and then the rate decreased. This was because osmotic driving potential for moisture as well solid transfer will keep on decreasing with time as the moisture keeps moving from sample to solution and the solids from solution to sample. Further progressive solid uptake would result in the formation of high solid sub surface layer, which would interface with the concentration gradients across the sample solution interface and would set as barrier against removal of water and uptake of solid. Besides, rapid loss of water and uptake of solids near the surface in the beginning may result in structural changes leading to compaction of this surface layers and increased mass transfer resistance for water and solids (Lenart and Flink 1984). Similar trends have been reported for other fruits and vegetables during osmosis (Pokharkar and Prasad, 2002; Ghosh, *et al.* 2006 and Alam *et al.* (2010).

Optimization

Design expert version 8.0.6 software was used for simultaneous optimization of the multiple responses. The process parameters for osmotic dehydration process were numerically optimized for desirability function having equal importance (+) to all the three process parameters and equal importance (+++++) to two responses. The goal setting begins at a random starting point and proceeds up the steepest slope on the response surface for a maximum value of water loss and targeted value of salt gain. The optimum operating conditions were found to be brine temperature of 44.89°C, salt concentration of 16.53% and osmosis time of 47.59 min.

Osmo-dehydrated products at the optimum process conditions were further dried at temperature of 45, 55, 65, 75 and 85°C with air velocities of 1.0, 1.5 and 2.0 m/s. The stability and quality of the osmo-dried product were governed mainly by its water activity and colour. Therefore, these responses as well as ascorbic acid were also considered for optimizing the input parameters. As per two independent variables (drying temperature and air velocity) having five levels of drying temperature and three levels of air velocity, total fifteen experiments were performed for maximizing ascorbic acid and colour (L-value) and minimizing water activity and drying time as responses for each treatment. Numerical optimization was carried out using design-expert 8.0.6 statistical software (trial version). The goal was fixed to be in the range for ascorbic acid, colour (L-value), water activity and drying time. The goal seeking begins at a random starting point and proceeds up and down the steepest slope on the response for a maximum or minimum value of the response respectively. All the responses and independent variables were given similar (+++) importance.

Based on above mentioned criteria the optimization was carried out and different solutions were found. Among them, one that suited the criteria most i.e. maximizes ascorbic acid and colour and minimizes water activity and drying time, was selected. The most suitable optimum point is given in the Table 2. Thus convective drying of osmotically dehydrated mushroom sample with 65°C drying temperature and 2.0 m/s air velocity is best for optimum response (ascorbic acid =26.71mg/100g dm, colour =60.99, water activity =0.321 and drying time =450min) among the range of variables taken for the study.

TABLE 2: Optimum levels of variables for convective drying of osmotically dehydrated mushroom sample

S. No.	Variable	Optimum level
1.	Drying air temperature, °C	65
2.	Air velocity, m/s	2.0

Sensory Evaluation

The sensory evaluation was carried out for colour, flavour, taste, appearance and over all acceptability. The independent sample t test was applied to compare between convectively dried and osmo-convectively dried product for various organoleptic characteristics.

TABLE 3: Mean sensory score data for individual characters

Character	Mean		Sd		SEd	t
	Convectively dried	Osmo-convectively dried	Convectively dried	Osmo-convectively dried		
Colour	72.93	73.73	2.404	2.939	0.980	0.816^{NS}
Flavour	73.60	74.60	2.131	2.640	0.876	1.141^{NS}
Taste	67.27	77.60	3.973	2.293	1.184	8.725**
Appearance	65.53	76.40	3.720	2.165	1.111	9.779**
Overall acceptability	66.33	76.53	3.244	2.100	0.998	10.223**

** Significant at 1% level, **NS** - Non-significant

The difference between convectively dried and osmo-convectively dried product was significant for taste, appearance and overall acceptability at 1 per cent level of significance (Table 3) whereas colour and flavour was non-significant. Hence the osmo-convectively dried product was found superior with respect to taste, appearance and overall acceptability as compared to convectively dried product (without osmosis). The osmo-convectively dried product was appreciated by the panellist because of its salty taste, but convectively dried product (without osmosis) had no taste. It is in agreement with an earlier study (Torringa *et al*. 2001; Kar and Gupta, 2003; Vishal *et al*. 2009 and Jain *et al.* 2011) where osmotic pre-treatment was able to improve quality of dried product.

CONCLUSION

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 of 0.321 water activity having 26.71 mg/100 g dm of ascorbic acid, 61 colour (L-value) 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,* 157.153-

Ghosh, P.K., Agrawal, Y.C., Jayas, D.S. and Kumbhar B.K. (2006) Process development for osmo hot air drying of carrot. *J. Food Sci. Technol*., **43**(1):65-68.

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. J. Food Sci. Technology., 48(2), 211-217.

Kar, A. and Gupta, D.K. (2001) Osmotic dehydration characteristics of button mushroom. *Journal of Food Science and Technology,* **38**(4): 352-357.

Kar A. and Gupta D.K. (2003) Studies on air-drying of osmosed button mushrooms. Journal of food science and technology., 40(1), 23-27.

Lenart, A. and Flink, J.M. (1984) Osmotic concentration of potato. I Criteria for the end point of the osmotic process. *Journal of Food Technology,* **19**: 45-63.

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

Murumkar R.P., Jain S.K., Verma R.C. and Doshi A. (2006) Studies on osmo-convective drying of white button mushroom. Mushroom Research-An International Journal, 15(2), 135-140.

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

Pokharkar, S.M. and Prasad, S. (2002) Air drying behaviour of osmotically dehydrated pineapple. *J. Food Sci. Technol,* **39**:384–387.

Ranganna, S**. (**2002) Handbook of Analysis and Quality Control for Fruits and Vegetable Products (II Edition). Tata McGraw Hill Publishing Co. Ltd., New Delhi.

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

Torringa, E., Esveld, E., Scheewe, I., Van Den Berg, R. and Barlets, P. (2001) Osmotic dehydration as a pre-treatment before combined microwave hot air drying of mushrooms*. Journal of Food Engineering,* **43**(2): 185-189.

Uddin, M.B., Amswrth, P. and Ibanoglu, S. (2004) Evaluation of mass exchange during osmotic dehydration of carrots using response surface methodology. *Journal of Food Engg,* **65**:473-477.

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.