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Drying Characteristics of Button Mushroom

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A B S T R A C T

Button mushrooms are highly perishable in nature because of its high moisture content about (85-90%) hence starts deteriorating immediately within a day after harvest. So as to increase its shelf life three different samples of Button Mushroom Slices viz. untreated, blanched and optimized osmosed samples were taken for drying experiment at each level of drying air temperature (50, 60 and 70^{o}C). Drying of osmosed Button Mushroom slices at 70^{o}C drying air temperature provided shortest drying time to produce best quality dried product as compared to blanched and untreated Button Mushroom samples. The drying time of osmosed sample was reduced to 480 minutes as compared to 600 and 660 minutes taken by blanched and untreated button mushroom samples. The osmotically dehydrated button mushroom samples showed best rehydration characteristics like Rehydration ratio of 4.98 and coefficient of rehydration of 0.493 and also produced the sample with good nutritional composition as compared to the other samples.

Introduction

Mushroom is a macroscopic fungus with distinctive fruiting body and lacks in chlorophyll, hence it requires a substrate for absorption of nutrients. The real fungus which is a microscopic fine thread like structure is used to grow on the substratum or below the surface of soil, it comes together in very compact form and spread out like an umbrella structure, when it is matured. Mushrooms have been found as time honoured food of many cultures all over the world (Chang and Buswell, 1996). They have not only been used for the consumption but also for medicinal purposes (Yang *et al.*, 2001). Mushroom is an abundant supply of protein and it has been valued throughout the world for their flavour, texture as well as of their health benefits. Button mushrooms are highly perishable in

nature because of its high moisture content about (85-90%) hence starts deteriorating immediately within a day after harvest. Enzymatic action of polyphenol oxidase on phenolic substances causes deterioration of mushroom, which is identified by development of brown colour, and it shortens the shelf life (Dunkwal *et al.,* 2007). Because of their high perishable nature, it needs to be processed to preserve for the off-season use.

Drying is an energy intensive process among the different methods of preservation. It reduces the water activity by decreasing moisture content. It is an easiest method to increase the shelf life of high moisture products (Shukla and Singh, 2007). But choosing a proper method of drying is important because of very sensitive nature of mushroom towards high temperature (Rezagah *et al.,* 2010). The suitable method of drying should minimize the enzymatic and microbiological activities. Employing the osmotic dehydration as a pre-treatment of convective drying can improve the quality of final product. Hence, the hot air drying is to be done after osmotic dehydration of mushrooms (Shukla and Singh, 2007 and Dehkordi, 2010).

Materials and Methods

Sample preparation

The fresh and good quality button mushrooms were procured from the Mushroom Research Unit. Dr. RPCAU, Pusa. White button mushrooms of uniform size were washed thoroughly to remove adhering impurities and were graded properly to avoid variation in exposed surface area. The samples were vertically cut into uniform shape and size (approximately 5 mm thickness).

Determination of moisture content

The moisture content of the untreated, osmotically treated, blanched and osmo- air dried mushroom samples was determined by using the standard hot air oven method. Samples (20 g) were dried for 24 hr. in the hot air oven at 102 ± 2 ^{o}C (AOAC, 1990).

Moisture content (MC_W) was determined on wet basis as:

$$MC_w = \frac{W_m}{W_m + W_d} \times 100$$

Where,

MC_W= Moisture content on wet basis, (percent)

W_d = Bone dry weight, (g)

W_m= Moisture evaporated, (g)

Osmotic dehydration of button mushroom

Osmotic dehydration of button mushroom slices was carried out prior to tray drying using salt solution as an osmotic agent. The experimental design was prepared by using independent and dependent variables as per the previous works of osmotic dehydration of different fruits and vegetables are given below. The solution to product ratio (SPR) was kept fixed at 10:1.

Blanching of Button Mushroom

Blanching of mushroom samples was done by using the method as described by Pacific Northwest (Extension Publication, Washington). The blanched mushroom samples were prepared by boiling the mushroom slices in water at 90^{o}C for 2 minutes. After blanching, the samples were taken away from the boiling pan and left for cooling (15 to 20 minutes) and then remove excess water, by passing it through steel strainer. Finally, the mushroom slices were gently blotted with absorbent paper to remove the surface moisture.

Tray drying

The drying operation was performed with the independent and dependent parameters/ variables to study the drying characteristics of different types of mushroom slices (osmosed, blanched and untreated).

The drying of mushroom slices was done by using laboratory tray drier. Untreated, blanched and selected osmosed mushroom slices were dried separately in tray drier with 200g samples each.

The temperature of the dryer was set and fixed at three temperatures- 50°C, 60°C and 70°C for different drying runs which were replicated thrice. For a particular time interval the samples were taken out one by one and then final weight was measured using electronic balance (sensitivity: 0.01/0.1g)

All experiments were carried out at above mentioned three temperatures. Drying was carried out until the constant weight obtained.

$$W_m = \{1 - \frac{w_i}{w_t}(1\text{-}M)\} \times 100\}$$

Where,

W_m=Moisture reduction, (percent, w.b).

W_i = Initial sample weight. g

W_t= Sample weight at any time, g.

M = Initial moisture content in decimal, w.b.

Bone dry material (W_{bd}) in the sample was determined by the following formula:

$$W_{bd} = \frac{100}{100 + MC\ (db\%)} \times W_i$$

Drying rate (DR) was evaluated using the following formula:

$$DR = \frac{\text{Amount of water removal}}{\text{Time taken} \times W_{bd}}$$

Where,

Amount of Moisture Removal = W_i-W_t, (g)

DR = Drying rate, $(\frac{Kgwater}{Kgdm.h})$

W_i= Initial weight of the sample (g)

W_t=weight of the sample at any time, (g)

Time taken is equal to the interval of time between W_i and W_t, in hour.

Rehydration characteristics

The rehydration quality of dehydrated mushroom samples was evaluated by rehydration test (Ranganna, 1986). It was done by placing the 10 g of samples with distilled water in glass beaker were heated in hot water bath at 60°C for 60 min. The excess water was drained and surface moisture was removed by using filter paper then final weight of rehydrated samples was taken using electronic balance.

Rehydration ratio (R_r) can be calculated from (Ranganna, 1999):

$$R_r = \frac{C}{D}$$

Where,

C = Weight of rehydrated samples after draining, g

D = weight of dehydrated samples taken for rehydration test, g

The coefficient of Rehydration (C_r), were computed using the equation (Ranganna, 1999):

$$C_r = \frac{C\times(100-A)}{(\frac{D-BD}{100})\times 100}$$

$$\text{m.c., (\% w.b.)} = \left(\frac{C-\left(\frac{D-BD}{100}\right)}{C}\right)\times 100$$

Where,

A = initial moisture content of the sample before dehydration, percent (w.b.)

B = moisture content of dehydrated sample, percent (w.b.)

C = weight of rehydrated samples after draining, g

D = weight of dehydrated samples taken for rehydration test, g

Nutritional composition of button mushrooms

Approximate composition of the mushroom was determined by standard analytical methods. The total protein, fat, ascorbic acid, ash content and carbohydrates of the fresh and dehydrated mushroom samples were analyzed by standard procedures of Micro-Khjeldahl Method, Soxhlet method, Iodine titration method respectively.

Results and Discussion

Drying characteristics

From the Table 1 it has been revealed that there is an increase in reduction in moisture loss or weight reduction with increase in drying air temperature. A high temperature of drying air helps to bring down the time required for drying to bring the moisture content of all types' of mushroom samples to equilibrium.

It also reveals that the drying time required to dry untreated, blanched and osmo dehydrated mushroom samples at 50°C drying air temperature was 1020,840 and 660 minutes to reach moisture content of 9.21 %, 9.08 % and 8.79 % respectively. It took 960, 720 and 600 minutes to reduce the moisture content to 7.83, 7.59 and 7% for untreated, blanched and osmo treated button mushroom samples respectively at 60°C. Whereas at 70°C it took only 720, 660, and 480 for untreated, blanched and osmo treated button mushroom samples to reach moisture content of 6.83 %, 6.56 % and 6.69 % respectively.

From the Figures (1, 2 and 3) we have concluded that whole drying was carried out in falling rate period for the entire duration, it was due to the internal mass transfer occurred by the diffusion in all the samples.

Drying time reduces with increasing drying air temperature. According to kinetic theory the energy of water molecules increases as the temperature increases and it makes the water molecules to escape easier and faster. Higher temperature causes difference in vapour pressure between the surroundings and the product, which drives the moisture diffusion process (drying). (Prabhanjan *et al.*,1995)

Similar trend was quoted by Vergara *et al.*, (1997) for osmotically dehydrated apple, Kar and Gupta (2003); Pokharkar (2002) for pine apple, Murumkar *et al.*, (2007), and Jain *et al.*, (2011) for papaya.

Rehydration characteristics

From the table 3, it is clearly observed that the osmosed dehydrated mushroom sample dried at drying air temperature of 50ºC had the highest rehydration ratio (4.98) as well as the highest coefficient of rehydration (0.443).

Table.1 Variation in moisture content (% w.b.) of mushroom samples during tray drying for different drying air temperatures

Time (min)	Moisture content (% w.b.)								
	Raw Samples			Blanched Samples			Osmosed Samples		
	50° C	60° C	70° C	50° C	60° C	70° C	50° C	60° C	70° C
0	92	92	92	91.6	91.54	91.5	75.17	75.3	75.65
15	90.33	90.09	89.69	90.09	89.68	89.40	74.59	73.10	73.22
30	88.46	88.24	86.85	88.38	87.82	86.84	73.48	70.99	70.96
45	87.56	85.91	85.28	86.42	85.40	83.70	72.21	68.86	68.37
60	86.04	83.92	82.82	84.77	82.51	80.62	70.97	66.51	65.24
90	83.55	80.80	79.73	82.19	79.15	77.09	68.30	63.82	61.78
120	80.90	77.43	76.02	76.48	75.52	72.96	65.87	60.24	56.96
150	77.55	73.81	70.77	74.17	71.04	68.41	62.64	55.82	51.38
180	72.96	70.08	64.60	71.47	65.31	63.16	58.72	50.48	41.40
240	68.86	65.11	57.67	64.59	60.36	55.31	54.04	41.15	32.32
300	62.25	60.11	48.49	58.54	52.42	46.44	48.35	35.21	17.97
360	54.76	54.45	41.92	52.81	39.15	35.17	39.81	24.49	7.59
420	47.51	50.03	34.87	45.57	25.82	26.22	29.21	11.99	6.69
480	39.74	43.98	24.20	41.65	18.65	11.74	15.25	8.688	6.69
540	34.29	32.13	15.88	30.66	11.03	8.022	9.620	7.4	
600	30.02	22.93	8.734	22.94	8.260	6.56	8.79	7.4	
660	18.07	17.08	6.83	15.09	7.59	6.56	8.79		
720	15.49	13.67	6.83	11.38	7.59				
780	11.60	10.84		9.08					
840	9.825	8.762		9.08					
900	9.52	7.83							
960	9.21	7.83							
1020	9.21								
1080									

Table.2 Drying rate of mushroom samples during tray drying at different air temperatures

Time (min)	Drying rate (kgw. $(kg.dm)^{-1}.h^{-1}$)								
	50 °C			60°C			70 °C		
	Untreated	Blanched	Osmosed	Untreated	Blanched	Osmosed	Untreated	Blanched	Osmosed
0									
15	8.61	7.23	0.89	9.63	8.33	1.32	11.19	9.74	1.48
30	7.66	6.58	0.76	7.98	7.14	1.20	9.77	8.50	1.32
45	5.94	6.05	0.73	7.19	6.58	1.11	7.60	7.60	1.26
60	5.33	5.33	0.69	6.27	6.07	1.06	6.67	6.66	1.22
90	4.27	4.19	0.65	4.86	4.66	0.85	5.04	4.96	0.99
120	3.63	3.82	0.59	4.03	3.85	0.76	4.16	4.05	0.89
150	3.21	3.21	0.57	3.47	3.34	0.71	3.63	3.45	0.81
180	2.93	2.79	0.56	3.05	2.97	0.67	3.22	3.02	0.80
240	2.32	2.27	0.48	2.40	2.32	0.58	2.53	2.38	0.65
300	1.97	1.89	0.43	1.99	1.94	0.50	2.11	1.98	0.57
360	1.71	1.63	0.40	1.71	1.69	0.45	1.79	1.70	0.50
420	1.51	1.43	0.38	1.49	1.49	0.41	1.56	1.48	0.43
480	1.35	1.27	0.36	1.33	1.32	0.36	1.39	1.33	0.37
540	1.21	1.16	0.32	1.22	1.18	0.32	1.25	1.18	
600	1.10	1.06	0.29	1.12	1.07	0.29	1.140	1.07	
660	1.02	0.97	0.26	1.02	0.97		1.03	0.97	
720	0.94	0.89		0.94	0.89		0.95		
780	0.87	0.83		0.87					
840	0.81	0.77		0.81					
900	0.75			0.76					
960	0.71			0.71					
1020	0.67								
1080									

Table.3 Rehydration characteristics of rehydrated mushroom slices at different drying air temperatures.

Sample Type	Temperature (°C)	Moisture in Rehydrated Sample (%w.b.)	Rehydration ratio	Coefficient of Rehydration
Untreated	50	86.93	3.24	0.302
Blanched	50	87.13	3.87	0.378
Osmosed	50	88.46	**4.98**	**0.443**
Untreated	60	86.13	3.09	0.297
Blanched	60	86.97	3.63	0.347
Osmosed	60	87.88	4.63	0.423
Untreated	70	85.83	2.97	0.254
Blanched	70	86.26	3.54	0.326
Osmosed	70	86.97	4.48	0.401

Table.4 Proximate composition of dehydrated mushrooms

Mushroom samples	Parameters (g/100g)						
	Moisture content (g)	Protein (g)	Fat (g)	Ascorbic acid (g/100)	Ash content (g)	Fibre (g)	Carbohydrate (g)
Fresh	91.7	2.1	0.33	0.1025	0.76	1.3	3.78
Untreated dehydrated	7.9	25.4	2.0	0.0278	9.5	11.04	44.14
Blanched dehydrated	7.68	25.9	2.23	0.0193	10.02	10.87	43.26
Osmosed dehydrated	7.54	26.2	2.42	0.0227	10.23	10.59	43.1

Values are average of three replications

Fig.1 Deviation of drying rate for different types of mushroom slices with average moisture content (%, w.b.) at 50 ºC dying air temperature

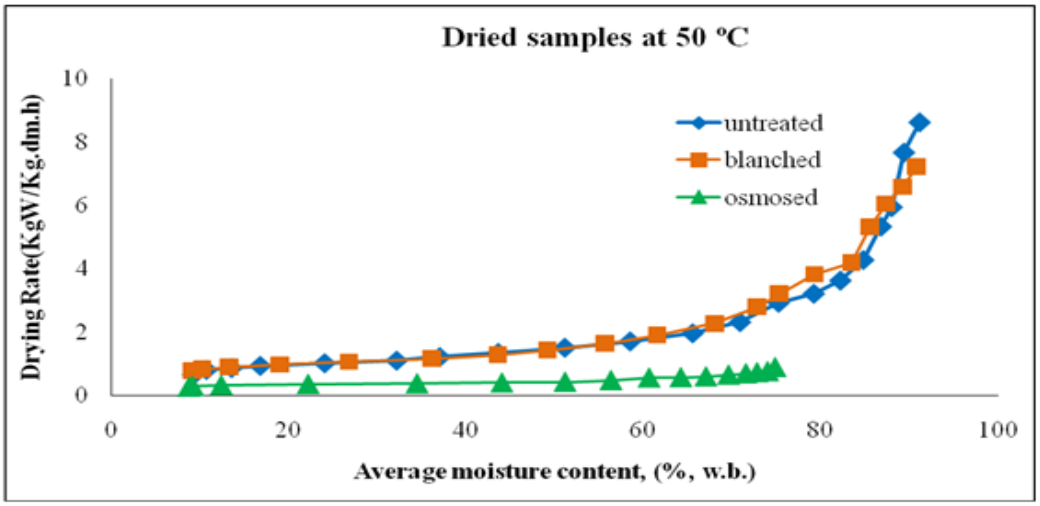


Fig.2 Deviation of drying rate for different types of mushroom slices with average moisture content (%, w.b.) at 60ºC drying air temperatures

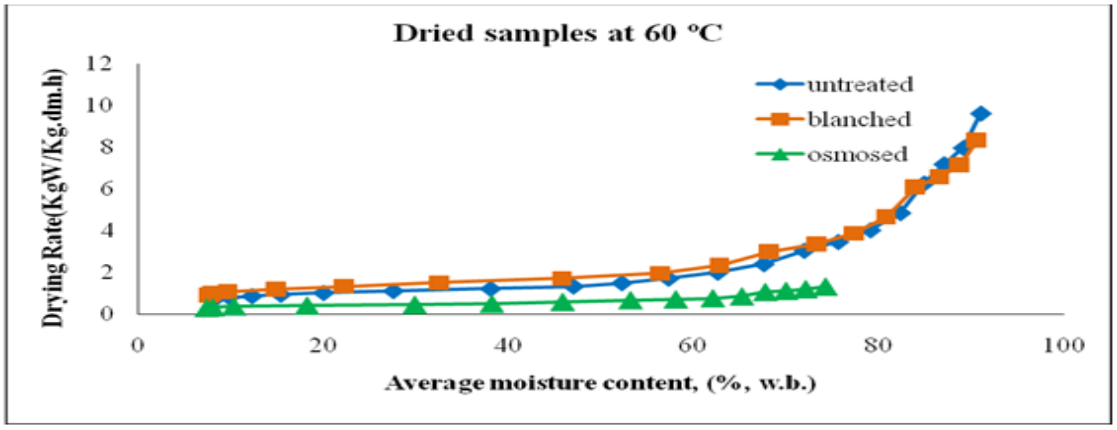
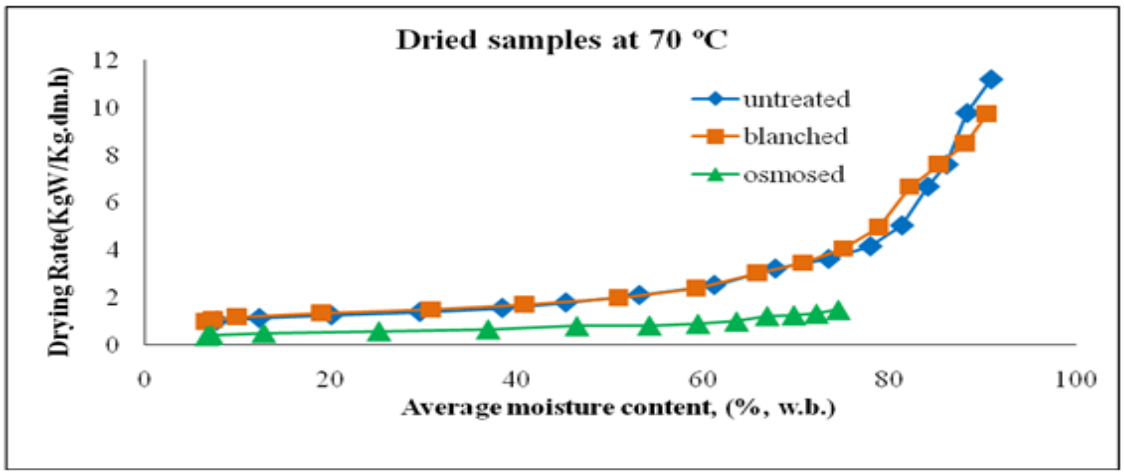


Fig.3 Deviation of drying rate for different types of mushroom slices with average moisture content (%, w.b.) at 70 ºC drying air temperatures



The rehydration ratio of osmo dehydrated mushroom is higher as compared to untreated samples at all drying temperatures. It may be noted that the sample having the higher rehydration ratio found to have better quality. Similar results were reported by (Kulshreshtha *et al.,* 2009, Bhuvaneswari *et al.,* (1999).

Nutritional composition of button mushroom

The proximate analysis of fresh button mushroom (*A. bisporus*) sample shown in table 4, had 91.7 % moisture, 2.1 % crude protein, 1.3 % of crude fibre, 0.76 % ash, 3.78 % carbohydrates and 0.33 % fat (w.b) similar range was obtained in other study (Mattila *et al.,* 2002). According to present study there is an increase in protein content, fat, ash, fibre and carbohydrates in dried mushroom samples as compared to fresh sample. The decrease in the value of ascorbic acid was found in all the dried samples, ascorbic acid (vitamin C) is very sensitive and might get degraded at higher temperature. An increase of protein in dried samples is due to the dehydration of water that exists in between the proteins. The carbohydrates percentage increased with decrease in moistures content during the drying due to the concentration of nutrients (Reid *et al.,* 2017). A similar trend was observed by Longvah and Deosthale (1998). The increase in ash content in osmotically dried mushrooms is might be due to the presence of sodium in the solution, which might have diffused into the mushroom slices when the water drained out. This is due to the simultaneous process of water and solute diffusion in osmotic dehydration (Krokida *et al.,* 2003 and Lerici *et al.,* 1985). The tray drying of osmosed button mushroom at 70 ℃ air temperature needed short drying time to make stable product with good quality dried product as compared to blanched and raw mushroom samples. The time needed to dry the osmotically treated mushroom was reduced to 480 minutes at 70 ℃ whereas the blanched and untreated mushroom samples needed 600 and 660 minutes respectively.

The osmo dehydrated button mushrooms were found to have better rehydration characteristics as well as better nutritional composition as compared to other samples treated at all drying air temperature. The higher rehydration ratio (R_r) and coefficient of rehydration (C_r) of osmo dehydrated sample was found as 4.98% and 0.443 respectively at 50 ℃ drying air temperature.

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