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EVALUATION OF QUALITY ATTRIBUTES OF OSMO-AIR DEHYDRATED BUTTON MUSHROOM (*Agaricus bisporus)* AT OPTIMIZED CONDITIONS

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ABSTRACT
Consumption of food is directly related to the quality. Quality commonly thought of as a degree of excellence, is one of the major positioning tool of the producer for marketability and for consumers satisfaction. The input parameters during convective drying of osmotically dehydrated mushroom sample were optimized to 65°C drying air temperature and 2.0 m/s air velocity for better response. The rehydration ratio of the osmo-convectively dried mushroom samples at optimized condition was in the range of 2.35 to 2.82. Amino acid presence of osmo-convective dehydrated mushroom products were found maximum compared to convectively dried product (without osmo). Bacterial count and fungal count of osmo-convectively dehydrated (optimized conditions) and convectively dehydrated mushroom samples were within permissible limit even in fresh samples. But, yeast and mould count in both osmo-convectively and convectively dehydrated products were nil. Osmo-convectively dried mushroom product at optimized input parameters was highly appreciated by the consumers than convectively dried product (without osmo).

KEY WORDS: Osmo-convective, Optimized condition, Sensory evaluation, Re-hydration ratio, Amino acid and Micro flora count.

INTRODUCTION

Button mushroom (*Agaricus bisporus)* is a rich source of good quality proteins having most of the essential amino acids, vitamins and minerals and is popular for its delicacy and exotic flavour. Indian diet, essentially vegetarian, supplemented with highly digestible superior quality mushroom protein will help eradicate malnutrition in our country. Realizing the importance of mushrooms to fight malnutrition, poverty and to manage agro-waste, FAO has recommended mushrooms for developing countries to bridge the protein gap (Nehru *et al*., 1995). Today, mushroom cultivation 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. In the peak period of harvesting due to the gluts in the market, owing to highly perishable nature, ensuring income security to farmers and bring nutritional security, its preservation in the form of more stable products is of great importance. Application of osmo-convective drying for vegetables improves the quality of final product (dried vegetables). Hence, osmotic dehydration is used as a pre-treatment before hot-air drying of mushrooms (Shukla and Singh, 2007 and Dehkordi, 2010) because it has the advantage of improves nutritional, sensorial and functional aspects of foods, without changing its colour, texture and aroma. Besides, the osmotic dehydration minimizes the thermal damage on colour, flavour and prevents enzymatic browning (Islam and Flink, 1982) that is the main critical factor on the quality of this kind of mushrooms. Therefore controlled and regulated osmotic process plays an important role in improving the quality of dehydrated products and this can be achieved by optimization of osmotic process. Also there is a need to investigate the osmo-air drying process in order to get shelf stable quality dehydrated products. Air drying leads to physical and biochemical changes in food stuffs. These changes are frequently disastrous for the product quality, it is important to optimize the drying conditions. The quality of the product needs to be evaluated for the acceptance of the consumer. The functional characteristics of the final dehydrated product such as re-hydration are essential to get a better picture about the product regarding its keeping quality. Brining (addition of salts) in combination with drying decreases the microbial load. In addition, sensory evaluation has to be undertaken to assess the product characteristics such as taste, colour, flavour and appearance to the level of the consumers' acceptance.

MATERIALS & METHODS

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. 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. The total soluble solids of prepared brine solutions were determined by hand refractometer of range from 0 to 32 (Ranganna, 2000).

In order to decide range of independent variables for in-depth experimentation to study drying kinetics and optimization of osmotic dehydration process, preliminary experiments were performed. After the preparatory steps whole mushroom was cut into pieces of 5±0.5 mm size and have been referred as samples throughout the thesis.

The process parameters for osmotic dehydration of mushroom samples have been optimized using Response surface methodology (RSM) technique (Alam *et al*., 2010; Jain, *et al.,* 2011). As quality is important in food processing, control should be exercised at every stage from pre-processing to packing, storing, *etc*. Quality parameters viz. colour and ascorbic acid as well as water activity and drying time were further considered for the optimization of input parameters of convective drying (Mehta *et. al.*,2013). At optimized input parameters (drying air temperature-65^{o}C and velocity-2.0m/s), the osmo-air dried mushroom samples were further studied for their quality aspects, such as sensory evaluation, re-hydration ratio, amino acid and micro flora count.

Sensory evaluation of the product

Sensory evaluation is important to assess the consumer's requirements. It is difficult to quantify the sensory characteristics of product 100 per cent by machine because it is a subjective factor. To test the organoleptic characteristics, sensory evaluation was done based on numerical sensory card (BIS-6273).

Osmo-convectively dried product (Optimized conditions) was evaluated for its sensory characteristics such as colour, taste, appearance and over all acceptability and compared with sensory characteristics of convectively dried product (without osmo) (Drying air temperature-65^{o}C, Velocity-1.0m/s). Both the products were served for the evaluation to a fifteen panellists at a time. The score sheet was provided with product and panellists were requested to mark the product according to their liking. The average scores of all the panelists were computed. The independent sample t test was applied to compare between convectively dried and osmo-convectively dried product for various organoleptic characteristics as suggested by Torringa *et al*., 2001; Vishal *et al*., 2009 and Jain *et al*., 2011

Rehydration characteristics

Sensory evaluation is important to assess the consumer's requirements. It is difficult to quantify the sensory characteristics of product 100 per cent by machine because it is a subjective factor. To test the organoleptic characteristics, sensory evaluation was done based on numerical sensory card (BIS-6273).

The rehydration characteristics viz. rehydration ratio and coefficient of rehydration of the osmo-convectively dried mushroom product were determined by using following relations as explained by (Pokharkar and Prasad, 2002 and Jain *et al.*, 2011).

$$\text{(a) Rehydration ratio } (RR) = \frac{C}{D} \quad \text{-----------------------1}$$

$$\text{(b) Coefficient of rehydration } (CR) = \frac{C \times (100 - A)}{\left(D - \frac{BD}{100}\right) \times 100} \quad \text{------------------------------ 2}$$

Where,

A = moisture content of samples before dehydration, IMC, % (w.b.)

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

C = drained weight of rehydrated sample, g

D = test weight of dehydrated samples, g

The osmo-convectively dried products obtained after 1 h of rehydration in distilled water, 5, 10, 15 and 20% salt solution were evaluated for organoleptic quality (*viz*. firmness, taste, flavour, and swelling). For each of the product characteristics, numerical scoring was given by the consumer panel from zero to hundred, representing five quality grades, such as very poor, poor, fair, good and excellent. Then average scores of the entire panellist were computed.

Amino Acid Analysis

Amino acid content in the fruit bodies of button mushroom was carried out by paper chromatography method as suggested by Mahadevan and Sridhar (1982). Chromatography is defined as the technique for identification, separation and purification of the coloured components of a mixture. Chromatography is based on differential adsorption of component on adsorbent. There are two phases in chromatography:

1. Stationary phase: act as adsorbent
2. Mobile phase: containing a mixture of component (adsorbate) to be separated.

Five gm sample were grounded with 50 ml of 80 per cent hot alcohol in a mortar pestle and centrifuged at 3000rpm for 10 minutes to remove cellular materials. The supernatant solution containing amino acid was transferred in a small beaker and evaporated to dryness on a water bath. The contents were diluted with 10 ml water and used for the estimation.

Chromatography paper (What man No.1 Sheet) was taken and about 8 cm line was drawn on it with the help of a pencil from one end. Ten micro litre (10 µl) of each amino acid was spotted on paper at equidistant and it was dried in hot air oven at 60^{0}C for 10 minutes. Ten µl of unknown solution was also spotted as per method. The chromatogram were placed in the chromatography jars containing butanol : glacial acetic acid : water (4:1:1) mixture up-to the height of 6 cm and allowed to run the chromatogram. The chromatograms were removed from the jars and dried at room temperature. The spraying was done with 0.2 per cent ninhydrin reagent (200 mg of ninhydrin in 100 ml absolute alcohol) with the help of a glass atomizer. Air dried and then chromatograms were placed in a ventilated oven having 100^{0}C temperature for 2-3 minutes for developing colour. The RF values of each amino acid were calculated by employing the following formula:

$$\text{Retention factor (Rf)Value} = \frac{\text{Distance of Migration of component (a)}}{2!\,Distance\ moved\ by\ the\ solvent\ (b)}$$

Micro flora count

In microbiology, flora refers to the collective bacteria and other micro-organism. The yeast and mould count for mushroom samples were determined by direct plate count using Potato Dextrose Agar (Hi-media). 1.0g each from freshly harvested, convectively dried and osmo-convectively dried mushroom sample were dipped in 0.1 per cent buffered peptone water and then 0.1 ml from each dilution was plated in fifteen times on Potato dextrose agar medium. The plates were incubated at 21ºC for 7 days. After incubation, colonies were counted and average results were computed.

RESULTS & DISCUSSION

The osmo-convectively dried mushroom samples with the optimized input parameters i.e. drying air temperature-65°C and velocity-2.0m/s were further studied for their quality aspects, such as sensory evaluation, re-hydration ratio, amino acid and micro flora count.

Sensory evaluation

Convectively dried product (Drying temperature-65°C, Air velocity-2.0m/s) and osmo-convectively dried product (Optimized conditions) were served for the evaluation to the panellists at a time. The score sheet was provided with product and panellists were requested to mark the product according to their liking. 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 1: 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 1) 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 (Jain *et al.*, 2003a; Vishal *et al.*, 2009) where osmotic pre-treatment was able to improve quality of dried product.

Rehydration characteristics

The reconstitution qualities of osmo-convectively dried mushroom samples (optimized conditions) were determined by conducting re-hydration tests. The osmo-convectively dried samples were immersed in 0, 5, 10, 15 and 20% salt solution and the mass of the products after every 10 minutes intervals up to one hour were measured. The data pertaining to moisture content of the sample during the rehydration tests are reported in Table 2. The dehydrated sample absorbed water during rehydration and became soft. Three replications of each sample were rehydrated to avoid any experimental error and average values are reported in Table 2.

The initial moisture content of the samples was 9.34% (db). The moisture content of the samples increased to 200.88 per cent during rehydration test when immersed in water for 1 h. Similarly this increment was 189.55, 165.29, 154.33 and 148.74 per cent for 5, 10, 15 and 20% salt solutions for the same duration of rehydration (Table 2).

TABLE 2: Moisture content data (%, db) during rehydration behaviour of osmo convectively dried mushroom samples

S. No.	Time, min	Concentration of salt solutions ,%				
		0	5	10	15	20
1	0	9.34	9.34	9.34	9.34	9.34
2	10	123.62	120.72	119.14	116.46	112.37
3	20	134.65	129.13	124.41	121.05	117.88
4	30	150.11	140.92	133.65	129.44	124.33
5	40	172.39	162.76	152.09	143.43	134.05
6	50	197.84	186.21	171.79	158.83	149.44
7	60	206.88	193.55	179.29	164.33	153.74

The rehydration ratio and coefficient of rehydration of osmo-convectively dried mushroom samples were determined and are presented in Fig. 1. The rehydration ratio of the samples increased to 2.82 with duration of rehydration when immersed in water for 1 h. Similarly this increment was 2.72, 2.50, 2.40 and 2.35 for 5, 10, 15 and

20% salt solutions for the same duration of rehydration. Similarly for coefficient of rehydration, the corresponding values were 0.308, 0.297, 0.273, 0.262 and 0.257 for 0, 5, 10, 15 and 20% salt solutions for the same duration of rehydration. It can be seen from the figures that maximum rehydration ratio and coefficient of rehydration were present for the samples dipped in water and minimum for the samples soaked in 20% salt solution.

It can be observed from the Fig. 1 that moisture absorption during rehydration was decreased with increase in the salt concentration from 0 to 20% for a period of 10 to 60 min. This may be due to the increase in salt content of the rehydration solution. This is a good feature that the salt treated materials do not absorb water i. e. their rehydration is less that gives a crisper texture and can be stored for a longer period without impairing quality. These results are also in confirmation with the results obtained by (Kar and Gupta, 2003; Murumkar *et al.*, 2007 and Dehkordi, 2010) for osmo-convective dehydration of button mushroom slices.

The osmo-convectively dried products obtained after 1 h of rehydration in distilled water, 5, 10, 15 and 20% salt solution were also evaluated for organoleptic quality (*viz.* firmness, taste, flavour, and swelling). For each of the product characteristics, numerical scoring was given by the consumer panel from zero to hundred, representing five quality grades, such as very poor, poor, fair, good and excellent. The details of the mean scores given by the consumer panel for individual character are presented in Table 3.

TABLE 3: Relative rating for quality evaluation of rehydrated mushroom samples

Quality characteristics	Rehydrated in				
	Water	Salt solution,%			
		5	10	15	20
Firmness	54	61	71	78	82
Swelling	84	76	71	56	42
Taste	52	68	76	77	79
Overall acceptability	63.5	68.5	72.75	70.25	67.75

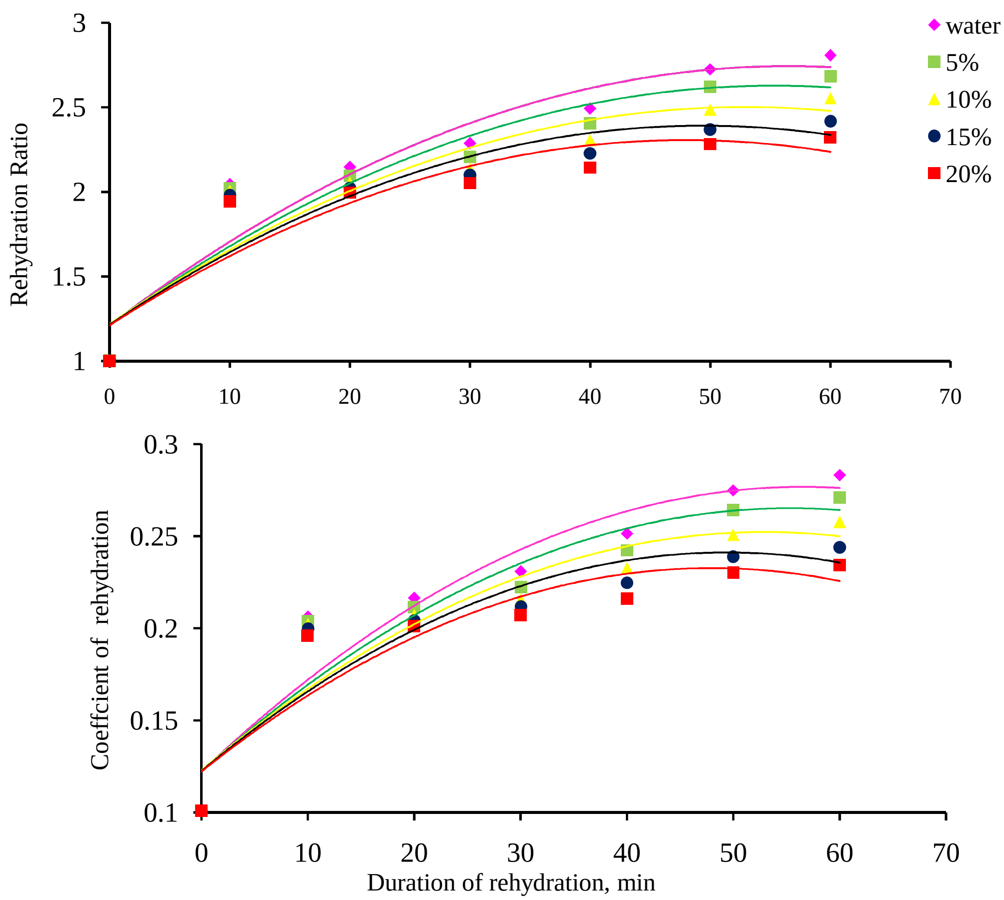


FIGURE 1: Rehydration ratio and coefficient of rehydration of osmo-convectively dried mushroom samples

It can be observed from the Table 3 that the texture was firmer for the product which was rehydrated in higher concentrated salt solution. The osmo-convectively dried product rehydrated in water showed higher swelling than product rehydrated in higher concentration of salt solution because mushroom samples absorbed more salt molecules from the solution. It can also be seen that rehydrated product obtained from 10% salt solution had a higher overall acceptability rating.

Amino acid analysis

The different amino acids present in osmo-convectively dried (Optimized conditions) and convectively dried (Drying temperature-65^{o}C, Velocity-2.0m/s) button mushroom slices are presented in Table 4. It can be seen from table that fresh button mushroom contains all the 17 standard amino acids studied, further it can be observed that convectively dried samples retain less number of amino acids after dehydration as compared to osmo-convectively dried mushroom samples.

Plate 1 shows the amino acid profile of osmo-convectively and convectively samples dried in axial flow dryer. It can be seen from Table 4 that out of 17 standard amino acids, seven amino acids such as L-Proline, L-leucine, DL-Methionine, L-Glutamic acid, DL-Valine, DL-Isoleucine and L-Cystine are present in both osmo-convectively and convectively dried sample and L-Lysine, L-Arginine, DL-Tryptophan, Glycine, L-Histidine and L-Tyrosine (total six) is absent in both of the samples. But, DL-Serine, DL-Alanine, DL-Threonine and DL-Aspartic amino acids are present only in osmo-convectively dried samples. Thus, it can be seen from table that osmo-convectively dried mushroom samples showed maximum presence of amino acid in comparison to convectively dried samples. The similar results for button mushrooms were also reported by Arumuganathan *et al.* (2003); Murumkar *et al*. (2007) and Singh *et al*. (2008).

TABLE 4: Amino acid profile of osmo-convectively and convectively dried button mushroom slices along with fresh mushrooms

Amino acid	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Fresh mushroom	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Convectively dried sample	+	-	-	-	+	-	+	+	-	-	+	-	-	-	+	+	-
osmo-convectively dried sample	+	-	-	+	+	+	+	+	+	-	+	+	-	-	+	+	-

(+)ve sign = presence of amino acids (-)ve sign = absence of amino acids

1. L-Leucine 5. L-Proline 9. DL-Aspartic acid 13. Glycine 17. L-Tyrosine
2. L-Lysine 6. DL-Alanine 10. DL-Tryptophan 14. L-Histidine
3. L-Arginine 7. DL-Methionine 11. DL-Valine 15. DL-Isoleucine
4. DL-Serine 8. L-Glutamic acid 12. DL-Threonine 16. L-Cystine

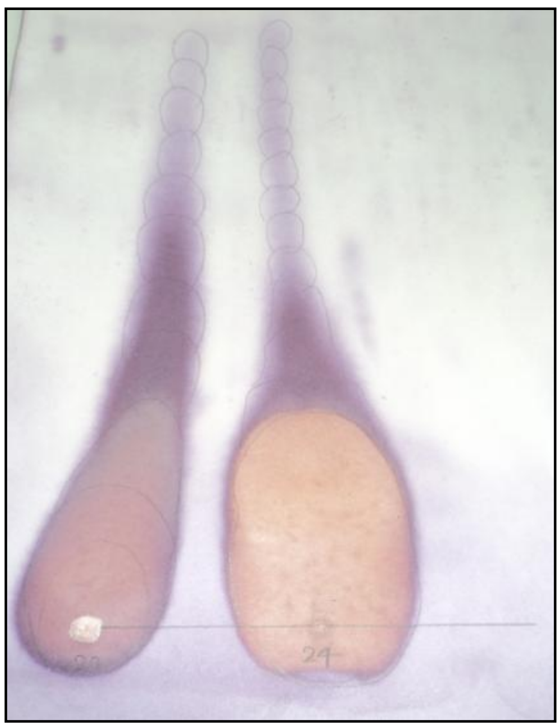


PLATE1: Amino acid profile of convective and osmo-convective dried sample respectively

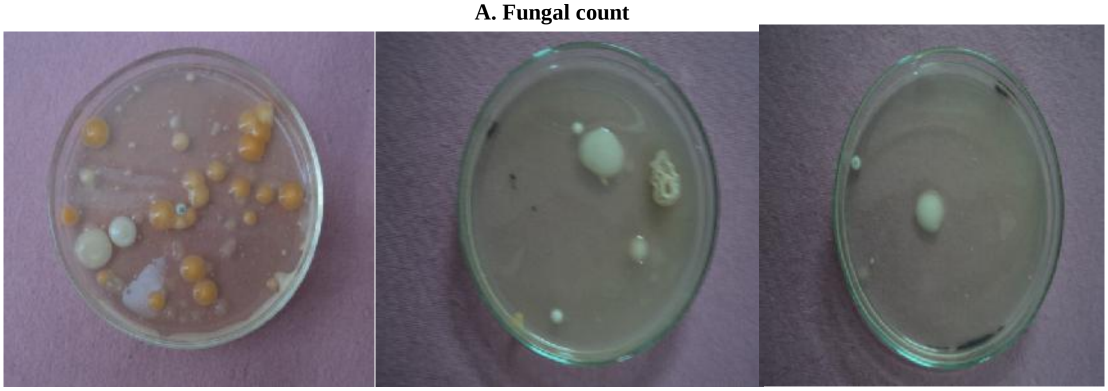
Micro flora count

The microbiological loads such as bacterial count, fungal count, yeast and moulds count (Plate 2) for freshly harvested, osmo-convectively dehydrated (optimized conditions) and convectively dehydrated (air temperature-65^{o}C, Velocity-2.0m/s) mushroom samples were counted and are presented in Table 5. It appears that the microbiological loads of samples in both dehydrated conditions were within permissible limit even in fresh samples. It also appears that the microbiological loads decreased or disappeared in both osmo-convective and convective drying, may be because of sufficient heat treatment during processing. The similar results were also reported by Shukla and Singh, 2007 for cauliflower, green pea and button mushroom.

TABLE 5: Counts of microbiological loads of button mushroom in freshly harvested, osmo-convectively dehydrated and convective dehydrated samples

Freshly harvested			Convective dried			Osmo-convective dried		
Bacterial count (per g)	Fungal count (per g)	Yeast and mould count (per g)	Bacterial count (per g)	Fungal count (per g)	Yeast and mould count (per g)	Bacterial count (per g)	Fungal count (per g)	Yeast and mould count (per g)
0.13×10^2	1.27	nil	0.12×10^2	0.545	nil	0.11×10^2	0.333	nil

A. Fungal count



B. Bacterial count

PLATE 2: Fungal count and bacterial count for freshly harvested, convectively dehydrated and 0smo-convectively dehydrated mushroom samples respectively

CONCLUSION

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. With the optimized input parameters the osmo-convectively dried mushroom product having 9.20 % (db) moisture content and 0.321 water activity could be obtained within 450 min. The osmo-convectively dried mushroom samples with optimized input parameters were further studied for their quality aspects, such as sensory evaluation, re-hydration ratio, amino acid and micro flora count. Sensory evaluation revealed that, the osmo-convectively dried product was appreciated by the panelists than convectively dried product (without osmosis). The rehydration ratio of the osmo-convectively dried mushroom samples was in the range of 2.35 to 2.82. The moisture absorption during rehydration was observed to decrease with increase in the concentration of salt solution from 0 to 20% for the period of 10 to 60 min. The osmo-dehydrated product absorbed less water in salt solution, resulting in a product of crispier texture. The rehydrated product obtained from 10% salt solution had a highest overall acceptability rating. The osmo-dehydrated mushroom sample convectively dried with optimized input parameters could retain 26.71 mg/100 g dm ascorbic acid. Among the amino acid profile studied, the osmo-convectively dehydrated mushroom sample showed maximum presence of amino acid in comparison to convectively dried samples (without osmosis). Among microbiological loads, yeast and mould count were nil in osmo-convectively dehydrated mushroom sample, but bacterial and fungal count were seen within permissible limit.

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