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Texture and quality parameters of oyster mushroom as influenced by drying methods

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A b s t r a c t. The effect of the drying methods on textural characteristics, protein content, and residual enzyme activities was studied. The mushrooms dried by the freeze-drying method showed the least firmness, with mean firmness force of 1.42 N and firmness strength of 4.27 N-mm. The highest firmness was observed in the osmo-air dried oyster mushrooms. High cutting force of 12.94 N and cutting energy of 14.73 N-mm were observed for those dried by osmo-air drying. Lower force of 1.07 N and energy of 1.58 N-mm were sufficient to fracture the freeze-dried mushrooms, and the highest fracture force and energy were observed for the fluidized-bed dried mushrooms. High protein content and residual activities of catalase and peroxidase were observed in mushrooms dried by the sun-drying method, which was closely followed by the osmo-air drying method. In terms of retention/improvement of texture in oyster mushrooms, osmo-air drying yielded hard and tough dried mushroom and freeze-drying method yielded very soft texture of mushrooms.

K e y w o r d s: oyster mushroom, drying, texture, protein, peroxidase, catalase

INTRODUCTION

Oyster mushroom (*Pleurotus florida*) is the third largest cultivated edible mushroom in the world in terms of production and consumption (Rai, 1995). However, very high moisture content and open-gills in this mushroom lead to very high perishability, as compared to the common button mushroom which has closed gills and a membrane-type outer layer over the fruit body. All mushrooms continue to grow, mature, respire and senesce after harvest, resulting in mass loss, other undesirable changes and spoilage, depending upon the mushroom type, leading to poor market value and at times even to total loss of the produce (Tewari *et al*., 2004).

Among various methods for the preservation of oyster mushrooms, drying is an easy, economical and most frequently used practice (Rai *et al.,* 2003). The dehydrated product offers, apart from increased shelf-life, the advantages of decreased mass and volume which have the potential for savings in the cost of packaging, handling, storage and transport of the product (Amuthan *et al.,* 1999; Karimi, 2010). Conventional hot-air drying is considered to be a comparatively simple, economical and efficient method of extending the shelf life of mushrooms. Fluidized bed drying is faster and produces better quality product than that obtained by conventional hot air drying (Kulshreshtha *et al*., 2009; Arumuganathan *et al*., 2009). Freeze drying is frequently applied to materials that are prone to heat damage and produces products with excellent structural characteristics, nevertheless, being a costly process (Lin *et al*., 1998). The effect of hot air drying, vacuum drying and freeze drying on colour, rehydration and sensory quality of oyster mushrooms was investigated by Martinez-Soto *et al*. (2001).

The texture of food material is mainly addressed to describe the structure of the food and the manner in which that structure reacts to applied force (Szcześniak, 1968). Mushrooms are accepted or rejected on the basis of their chemical and physical properties, specially the texture, a physical quality very important in the case of mushrooms (Matser *et al.,* 2000). Textural characteristics, particularly softness, are perhaps the most important characteristic of the mushrooms for which these are consumed by mankind (Szcześniak, 1987). Heat treatment like drying has been reported to affect texture of various products like oyster mushroom (Kotwaliwale *et al.,* 2007), button mushroom (Argyropoulos *et al*., 2008; Arumuganathan *et al*., 2009), banana (Boudhrioua *et al*., 2002; Cano-Chauca *et al*., 2002; Maskan, 2000) and potato (Caixeta *et al*., 2002).

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The quality in terms of protein content and residual enzyme activities associated with dried mushroom is also important for its acceptance and storage for further usage. When dealing with materials very sensitive to temperature, such as mushrooms, the choice of the right drying method can be the key factor for developing dried products of superior quality (Giri and Prasad, 2006).

A study was conducted to generate information on the suitability of various drying methods for the texture profile and quality of dried mushrooms, as information pertaining to these aspects is not available. The various methods involved in the dehydration of mushroom were sun-drying, cabinet air-drying, fluidized-bed drying, freeze-drying and osmo-air drying. The textural profile characteristics studied included firmness, firmness-strength, cutting-force, cutting-energy, fracture-force and fracture-energy. A few quality parameters, *viz*. protein content, catalase and peroxidase activity, were studied for oyster mushrooms dried by the various methods.

MATERIALS AND METHODS

Freshly harvested oyster mushrooms (*Pleurotus florida*) were obtained from the Test-cum-Demonstration Facility (TDF) of the National Research Centre for Mushroom, Solan, India, and were dehydrated to a safe final moisture content of about 10% (d.b.) by different drying methods, *viz*. sun-drying (21-35°C for 7 h of first day and 22-36°C for 7 h of second day), fluidized bed-drying (Fluidized Bed Drier RETSCH TG100 at 60°C for 6 h), cabinet air-drying (WINDSONS, at 60°C for 8 h), osmo-air drying (overnight soaking treatment with osmotic solution containing 15% NaCl, 0.3% citric acid, 0.5% ascorbic acid, 1% sugar and 100 mg kg^{-1} KMS followed by cabinet drying at 60°C for 6 h), freeze-drying (Freeze drier CHRIST-ALPHA 1-2, at -60°C for 16 h) and dehumidified air cabinet drying (50°C for 12 h). The initial moisture content of mushroom was determined by the AOAC method No. 934.06 (AOAC, 2000) and was 91.40% (w.b.).

The effect of the drying methods on texture characteristics, namely, firmness, firmness strength, cutting force, cutting energy, fracture force and fracture energy, were analyzed on the Texture Analyzer (Stable Micro-System Texture Analyzer Model TA-HDi) at the Central Institute of Post Harvest Engineering and Technology, Ludhiana, India. The dried oyster mushroom was placed in the natural rest position on the working platform of the texture analyzer and the following test specifications were used:

– Test mode: measure force in compression,
– Test speed: 1 mm s^{-1},
– Test distance: 3 mm,
– Probe: P 25 – 25 mm dia - cylinder aluminium (firmness test),
– Probe: HDP/BSK blade set with knife (cutting test),
– Probe: P 0.25 S ¼” spherical stainless (fracture test).

The appropriate probes were selected and the test was conducted thrice. The results of the firmness, cutting test and fracture tests were reported as means of three non significant (5% level) replications. The graph was drawn between force (N) and test distance (mm) during the test with the help of software (Texture Expert Exceed^{TM}, MS Windows) provided with the texture analyzer. The maximum forces resisted by the dried oyster mushroom against the appropriate probes were considered as firmness, cutting force and fracture force. From the graph, the maximum values of the forces were considered as forces and the areas falling beneath (between the origin and the maximum force) were considered as strength or energy (N-mm). The protein content, catalase and peroxidase activities were determined by methods described by Ranganna (1994).

RESULTS AND DISCUSSION

The different forces and energy, *viz*. firmness, firmness strength, cutting force, cutting energy, fracture force and fracture energy experienced by dried mushrooms and the values are presented in Table 1. The effect of six different drying methods on textural profile characteristics of dried oyster mushroom is discussed here.

It is clear from the data presented in Table 1 that the drying methods had a significant effect on the texture of mushrooms. The mushrooms dried by freeze-drying method showed the least firmness, with mean firmness force of 1.42 N and firmness strength of 4.27 N-mm. The highest firmness force and strength were observed for the osmo-air dried oyster mushroom with values of 26.91 N and 80.70 N-mm, respectively, which may be due to the fact that osmo-air drying process yielded tough and hard dried mushroom due to the osmotic effect. Based on the critical difference (C.D. at $P<0.05$) value, no significant difference in firmness and firmness strength was observed among all drying methods except osmo-air drying. The reason for the soft mushroom in the case of freeze-drying may be due to the fact that the temperature involved in the freeze-drying was very low. During freeze drying, the original dimensions of the product are maintained first by freezing. The ice is then sublimed, usually under a high vacuum. Since there is no aqueous phase, there is no migration of water to the surface but, instead, a receding interface between frozen and dry layer. The effect of concentration of water-soluble components due to the mobility of the aqueous phase is thereby prevented and hence the resulting product is of tender texture (Martinez-Soto *et al.,* 2001). Decreased firmness of mushroom indicates its suitability for consumption among the pediatric and geriatric classes. The other drying methods, namely sun-drying and fluidized bed-drying, registered their effect on the firmness of mushroom reasonably on par with each other. Kotwaliwale *et al*. (2007) also reported an increase in hardness during hot air drying of oyster mushroom.

T a b l e 1. Texture parameters of dehydrated oyster mushroom

Drying method	Firmness force (N±)SE	Firmness energy (N-mm)±SE	Cutting force (N)±SE	Cutting strength/ energy (N-mm) ±SE	Fracture force (N)±SE	Fracture energy (N-mm) ±SE
Sun	2.35 ± 0.57	7.06 ± 2.23	5.06 ± 1.16	6.88 ± 1.69	4.21 ± 1.79	4.85 0.96
Cabinet-air	3.81 ± 1.24	11.43 ± 2.01	6.71 ± 1.64	6.19 ± 0.39	7.44 ± 1.61	8.08 2.04
Fluidized-bed	2.45 ± 0.89	7.34 ± 1.86	3.71 ± 1.09	4.85 ± 1.09	7.67 ± 1.38	8.14 0.67
Freeze	1.42 ± 0.68	4.27 ± 1.12	2.68 ± 0.97	4.21 ± 2.47	1.07 ± 0.69	1.58 1.13
Osmo-air	26.91 ± 2.54	80.70 ± 2.93	12.94 ± 2.24	14.73 ± 0.95	6.95 ± 0.57	7.35 2.25
Dehumidified air-cabinet	3.48 ± 1.30	10.43 ± 1.95	6.31 ± 1.51	9.33 ± 1.23	4.31 ± 2.21	5.62 2.36
C.D. ($P<0.05$)	10.41	31.22	3.80	4.07	2.70	2.64

T a b l e 2. Quality of dehydrated oyster mushroom

Drying method	Protein content*	Catalase activity	Peroxidase activity
Sun	5.32	++	+++
Cabinet-air	4.22	+	+
Fluidized-bed	4.06	–	+
Freeze	4.69	+	++
Osmo-air	5.04	++	+++
Dehumidified air-cabinet	4.82	+	++

*g per 100 g dry mass, +++ very high, ++ high, + normal, – no activity.

It is apparent from the Table 1 that less force (2.68 N) and energy (4.21 N-mm) were required to cut the mushrooms dried by freeze-drying which produces soft dried mushrooms. In freeze drying the ice is sublimed, producing materials with tender texture. Conversely, very high force (12.94 N) and energy (14.73 N-mm) were observed for the osmo-air dried oyster mushrooms, which may be due to the osmotic effect of the salt solution which made the surface of the mushrooms hard and tough. Hot air drying of osmotic mushrooms probably caused heat damage and collapse of the internal mushroom structure throughout the drying process, adversely affecting quality characteristics like texture. Cano-Chauca *et al*. (2002) also reported that cutting force, a measure of hardness, increased as drying of banana progressed. They attributed this to increase in concentration of other components with moisture removal during drying. Information about the cutting energy and force is important for the design and development of the blades for cutting and slicing of dried mushrooms for further usage. Similar results were reported by Argyropoulos *et al*. (2008) and Arumuganathan *et al*. (2009) on drying of button mushroom.

From Table 1 it is noticed that less force (1.07 N) and energy (1.58 N-mm) was sufficient to make a fracture in freeze-dried oyster mushroom. The highest force and energy were, however, required for fracturing the fluidized-bed dried oyster mushrooms, which was closely followed by the cabinet-air drying and osmo-air drying methods. The importance of this fracture property is felt in the area of safe packaging, handling and transportation of raw as well as packed dried mushroom.

The data observed on parameters such as protein content and residual enzyme activity, *viz*. catalase activity and peroxidase activity, are presented in Table 2. It is seen from Table 2 that a higher protein content was observed for the oyster mushroom dried by sun-drying method when compared to the other treatments. This may be due to the fact of the low temperature (21-36°C) involved in the sun-drying method when compared to other treatments. A low protein content of 4.06 % was observed in the fluidized bed drying method. High temperature air at 60°C with high velocity was circulated in the plenum chamber of the dryer in this method and it ultimately resulted in denaturation of protein and finally lead to a reduction in protein content. It was also found that though a very low temperature of -60°C was involved in the freeze-drying method, the protein content was significantly affected. In the case of residual enzyme activity, very high peroxidase enzyme activity and high catalase activity were observed for the oyster mushroom samples dried by the sun drying method and the osmo-air drying method. As the temperature involved was low and the conditions for drying were favourable, very high enzyme activities were noted. Oyster mushroom samples dried by the fluidized bed drying method showed no catalase activity and normal activity of peroxidase. This clearly indicated that the higher temperature involved ultimately resulted in a significant loss in residual enzyme activity.

CONCLUSIONS

1. Very soft texture of oyster mushroom was obtained by the freeze drying method.

2. Osmo-air drying method yielded hard and tough dried mushroom.

3. Osmo-air dried oyster mushroom required more cutting force and energy and freeze dried mushroom required less cutting force and energy.

4. Lower force and energy were required to fracture the freeze dried mushroom while higher fracture force and energy values were needed in the case of fluidized bed dried mushroom.

5. Protein content and residual enzyme activity were greater in sun dried mushroom while they were lower in fluidized bed dried mushroom.

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