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Dehydration of Oyster Mushroom and Studies on Acceptability and Storability of the Product

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ABSTRACT. Processing conditions were established to produce a ready-to-use product from oyster mushroom (Pleurotus spp.) by cabinet air drying. Changes in moisture, total carbohydrate, crude fat, crude protein, total ash, total calcium and total iron contents during dehydration were determined. The acceptability of the product was tested by using a sensory evaluation panel and a five-point Hedonic scale. A suitable packaging material for storage of the product was selected based on the moisture content, water activity, 'L' value and rehydration ratio of the product.

Immersing the mushroom torn into 3 cm strips in 0.05% sodium bicarbonate for one minute was successful as a pre-treatment to improve the physical properties of the dehydrated product. Drying at 45°C for 5 h was sufficient to reduce the water activity from 0.84-0.56 and to obtain a shelf stable product with good physico-chemical properties. Dehydrated product packed in pouches made out of aluminium foil laminated with high density polyethylene could be stored at 27±2°C and 82±3% RH for 9 months without significant changes in the moisture content, water activity, product colour and rehydration ratio.

INTRODUCTION

Mushroom (*Pleurotus* spp.) is an important source of good quality proteins, which is also easily digestible. The FAO has recommended mushroom as a protein source particularly for people in the developing countries where malnutrition is a serious problem (Bahl, 1994). Though the demand for mushroom is increasing due to its high nutrient content, unique flavour and medicinal properties, supplying to meet the demand is a problem due to high postharvest losses. Cultivated mushroom contains about 90% moisture and tends to spoil rapidly particularly due to polyphenoloxidase activity (Komanowsky *et al*., 1970). Moreover, high respiration rate of mushroom causes changes such as browning, liquefaction, loss of moisture and texture, resulting in reduced market value and unacceptability (Amuthan, *et al*., 1999). Air drying and freeze drying are the two most widely used processing methods to prevent mushroom spoilage (Loch-Bonazzi and Wolff, 1991). Though air drying is less expensive than freeze drying, the product quality is inferior due to shrinkage, low rehydration capacity and dark colour (Loch-Bonazzi and Wolff, 1991). However, dehydration has the advantage of producing a light-weight product which is cheap, easy to pack, store and transport (Li-Shing-Tant and Jeelan, 1987).

This study was carried out to establish processing variables to improve the quality of dehydrated oyster mushroom. The physico-chemical properties of the fresh and the dehydrated products were analysed. The sensory quality of the dehydrated product was

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tested and compared with the fresh commodity. A suitable packaging material for the dehydrated product was also identified.

MATERIALS AND METHODS

Oyster mushrooms were purchased from a commercial farm at Nugawela, Kandy. Undamaged and disease free mushrooms of uniform size (cap diameter, 8±0.5 cm) were selected, torn into strips of 3 cm arc and used for the study. The mushroom strips were subjected to a number of pre-treatments. In the 1st stage, the strips were immersed in 0.1% potassium metabisulphite, 0.1% sodium bicarbonate or 0.1% sodium chloride for 1 min. The solutions were maintained either at 95±2°C or room temperature. The samples were drained and dried at 60°C for 7 h (Singh *et al.*, 1996). Observations were made on the colour of the dehydrated product and also colour, texture and taste of the rehydrated product. Based on the quality of the rehydrated product, the best pre-treatment condition was selected.

In the 2nd stage, the samples immersed in 0.1% sodium bicarbonate for 1 min at room temperature was dried at 45, 50 and 55°C for 7 h as the dehydrated product was somewhat dark in colour and extremely shrunk when dried at 60°C. Based on the colour and appearance of the dehydrated product 45°C was selected as the drying temperature. In the 3rd stage of the preliminary study, the mushroom strips were subjected to a 3×2 factorial in a completely randomised design with immersing in 0.1% sodium bicarbonate, 0.05% sodium bicarbonate or water as one factor and immersing time of 1 or 2 min as the 2nd factor. The samples were drained, loaded in a loading density of 1.35 kg m^{-2} and dried at 45°C for 7 h. The dehydrated product was analysed in six replicates for colour and rehydration ratio as described below. The data of this experiment were analysed using ANOVA, and the means were separated according to the Duncan multiple range tests. Based on rehydration ratio and colour of the dehydrated product, an immersion time of 1 min in 0.05% sodium bicarbonate was selected. The drying curve was constructed to determine the time required to reduce the water activity below 0.6 by air drying at 45°C.

Processing steps for dehydration of mushroom are given in Fig. 1. Dehydration was repeated three times and samples from each batch were used for physico-chemical analyses.

Mushroom
↓
Sorting, cap diameter 8±0.5 cm
↓
Tearing, strips of 3 cm outer perimeter
↓
Immersing in 0.05% sodium bicarbonate, 1 min
↓
Draining
↓
Drying at 45°C, 5 h
↓
Packaging
↓
Dehydrated mushroom

Fig. 1. Process flow diagram for dehydration of oyster mushroom.

Physico-chemical analyses

The dehydrated product was kept in a desiccator soon after removal from the dryer and used for analyses. Rehydration ratio was determined in six replicates according to the method described by Ranganna (1986). Colour of the fresh and dehydrated product was measured in six replicates using a colour difference metre (ZE 2000 Nippon Denshuku). Moisture, total carbohydrate, crude fat, crude protein, total ash, calcium and total iron contents of the dehydrated and fresh mushroom were determined in triplicate according to the standard methods of AOAC (1990). Water activity of the fresh and dehydrated products was determined in triplicate according to the method of Karel (1975) by measuring the equilibrium relative humidity using a hygrometer (Testo 635, accuracy ±0.03). An incubator (Yamato, IC 600) was used to obtain a constant temperature, 27°C, for water activity measurements. Data on the physico-chemical study were analysed by ANOVA and the means were separated by the Least Significance Difference test.

Sensory evaluation

Two soups were prepared by taking equal weights from fresh and dehydrated mushroom in dry weight basis. The prepared soup was tested for colour, taste consistency and overall acceptability by using a sensory evaluation panel consisting of 30 panelists and a five-point Hedonic scale (1-extremely dislike, 5-extremely like). The results were analysed by the Friedman test of the MINITAB statistical package.

Storage study

A storage study was conducted using three packaging materials, 0.05 mm polypropylene (PP), 0.02 mm oriented polypropylene (OPP) laminated with 0.025 mm cast polypropylene (CPP) and 0.009 mm aluminium foil laminated with 0.012 terephthalate (PET) and 0.04 mm high density polyethylene (HDPE), as treatments in a completely randomised design with triplicates for each material. The packages (5 g in 10×9 cm^2) were stored at 27±2°C and 82±3% RH for 9 months. Three packages from each material were withdrawn at one-month interval and analysed for moisture, water activity, colour and rehydration ratio (results after 3, 6 and 9-month storage are given). The data of this experiment were analysed using ANOVA, and the means were separated according to the Duncan multiple range test.

RESULTS AND DISCUSSION

Pre-treatment conditions affected the colour, texture and taste of the rehydrated product (Table 1). Blanching at 95°C resulted in a leathery rehydrated product regardless of the chemical treatment and was thus found to be unsuitable as a pre-treatment for dehydration of oyster mushroom. Undesirability of blanching of oyster mushroom prior to solar drying has been reported by Nehru *et al.* (1995).

Sodium chloride (0.1%) was not effective in improving the colour. Though 0.1% potassium metabisulphite improved the colour, it imparted a rubbery flavour to the product. Immersing the mushroom strips in 0.1% sodium bicarbonate solution at room temperature

Table 1. Effect of pre-treatments on quality of rehydrated mushroom.

Pre-treatment condition	Observation
0.1% potassium metabisulphite, 95±2°C	Light colour, leathery texture, rubbery flavour
0.1% potassium metabisulphite, room temperature	Light colour, soft texture, rubbery flavour
0.1% sodium bicarbonate, 95±2°C	Dark colour, leathery texture, pleasant flavour
0.1% sodium bicarbonate, room temperature	Light colour, soft texture, pleasant flavour
0.1% sodium chloride, 95±2°C	Dark colour, leathery texture, pleasant flavour
0.1% sodium chloride, room temperature	Dark colour, soft texture, pleasant flavour

The samples were immersed in the chemical solutions for 1 min and dried at 60°C for 7 h.
Ten samples from each treatment were observed for colour, texture and taste.

resulted in a product with light colour, soft texture and pleasant flavour. However, immersing in 0.05% sodium bicarbonate for 1 min was found to be better than immersing in the same for 2 min or immersing in water and 0.1% sodium bicarbonate for 1 or 2 min as reflected by significantly higher ($p<0.05$) rehydration ratio, the lightness 'L' value and significantly lower ($p<0.05$) yellow saturation index, 'b' value for the former (Table 2). The rehydration ratios of dried button mushroom had decreased from 2.65-2.25 with increase in drying temperatures from 60-110°C (Singh *et al.*, 1999), which are lower than the values obtained in this study (Table 2). Moreover, the rehydration ratio of milky mushrooms subjected to osmo-air dehydration at 55°C was about 1.25 (Amuthan *et al.*, 1999). The higher rehydration ratio observed in this study may probably be due to minimum changes in the structure of proteins and consequently minimum changes in protein functionality at the low drying temperature of 45°C.

Table 2. Effect of the sodium bicarbonate (SBC) treatment on physical properties of mushrooms dried at 45°C for 7 h.

Treatment	Rehydration ratio	Colour	
		'L' value	'b' value
Water (1 min)	7.6 b	40.1 b	12.6 a
Water (2 min)	7.5 b	39.2 b	16.4 a
SBC 0.05% (1 min)	8.3 b	46.8 a	5.4 b
SBC 0.05% (2 min)	7.7 b	41.0 b	12.8 a
SBS 0.1% (1 min)	7.6 b	39.4 b	14.3 a
SBC 0.1% (2 min)	7.8 b	43.4 ab	15.1 a

Each value represents mean of six replications. Means in each column followed by the same letter are not significantly different ($p<0.05$).

According to a study conducted by Singh *et al.* (1999) drying of white button mushroom at 60°C by hot air oven method has caused minimum changes in the physico-chemical properties. However, they have not given information on the quality of dried mushrooms in terms of colour and appearance. In this study, dehydration at 60°C for 7 h resulted in a product that was somewhat dark in colour and extremely shrunk. Among different drying temperatures tried out in this study, drying at 45°C was found to be the best as it produced the lightest and the least shrunk dehydrated product.

During drying, a slow rate of drying was observed up to 2 h followed by a constant drying period of 3 h and thereafter a falling rate period (Fig. 2).

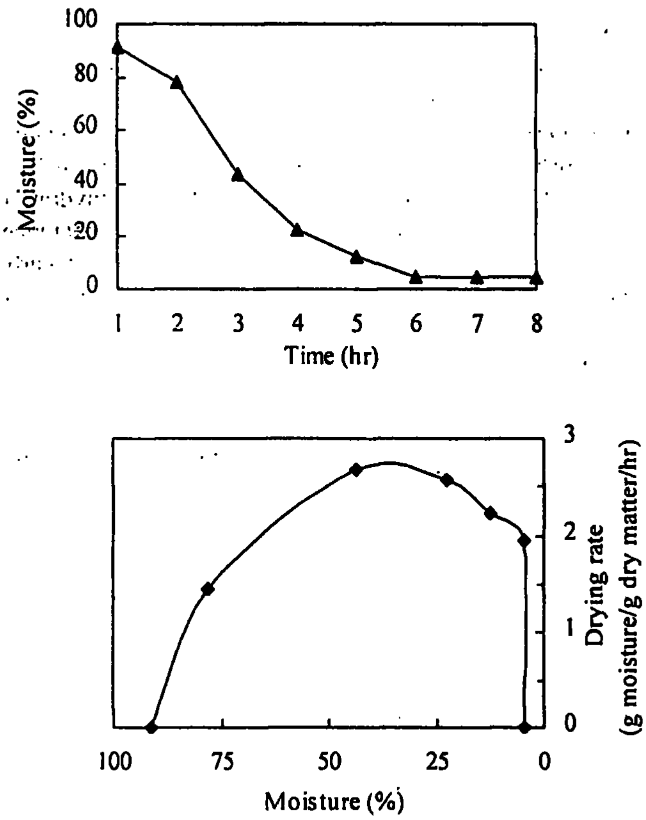

Fig. 2. Drying and drying rate curves for dehydration of oyster mushroom at 45°C.

Equilibrium moisture content of 4.5% was observed after 5 h of drying (Fig. 2). Drying at 60°C for 8.5 h has reduced the moisture content of button mushroom to 6.5% (Singh *et al.*, 1999) and drying at 60°C for 7 h has reduced the moisture content of paddy straw mushroom to 5% (Singh *et al.*, 1996). The lower equilibrium moisture content at a lower temperature within a shorter time than those reported by Singh *et al.* (1996, 1999) may be due to better drying conditions used in this study and/or compositional differences among different mushroom species. Moisture content of 4.5% is satisfactory, as the dried mushroom samples containing 5% moisture have been reported to have good storage stability (Singh *et al.*, 1999).

Water activity reduced from 0.84 to 0.56 when the moisture content was reduced from 91 % to 4.5 % during drying at 45°C for 5 h. Dehydration has not significantly changed ($p<0.05$) the crude fat, crude protein, total ash, calcium and iron contents (Table 3). Reduction in total carbohydrate content may be due to the loss of water-soluble carbohydrates when cut tissues were immersed in 0.05% sodium bicarbonate. The lightness and yellow saturation indices of the product given by the 'L' and 'b' values, respectively, did not change significantly during dehydration (Table 3). Non-significant change ($p<0.05$) in almost all the nutrients and colour indicated that processing parameters and the steps were successfully established in this study to minimise changes in quality attributes. The same was reflected in the mean preference scores of 30 panelists (Fig. 3). The estimated means for colour, consistency and overall acceptability of the soups prepared from fresh and dehydrated mushroom were above the point 'like very much', which corresponds to number 4 of the '5-point Hedonic scale' (Fig. 3). Tastes of the soups were above the point 'neither like nor dislike', which corresponds to number 3 of the '5-point Hedonic scale'. A necessity to treat oyster mushroom with 0.5% potassium metabisulphite before dehydration to obtain a product with acceptable sensory properties in terms of colour and appearance has been identified (Nehru *et al.*, 1995). However, treating with 0.05% sodium bicarbonate and dehydrating at a lower temperature than those used in most of the studies (Singh *et al.*, 1996, 1999; Kumar *et al.*, 1980; Amuthan *et al.*, 1999; Komanowsky *et al.*, 1970) was sufficient to obtain a product with good sensory attributes (Fig. 3).

Table 3. Physico-chemical properties of fresh and dehydrated mushroom.

Property	Fresh	Dehydrated	$LSD_{0.05}$
Water activity	0.84 a	0.56 b	0.01
Colour 'L' value	47.8 a	46.8 a	3.5
'b' value	4.5 a	5.4 a	2.6
Total carbohydrate (g)	54.2 a	52.4 b	1.4
Crude fat (g)	6.2 a	4.6 a	2.5
Crude protein (g)	25.1 a	25.2 a	1.9
Total ash (g)	5.5 a	5.5 a	1.1
Calcium (mg)	84.4 a	83.4 a	1.4
Iron (mg)	10.5 a	10.0 a	0.6

Each value represents mean of triplicate. The composition is given as a percentage on dry weight basis per 100 g of edible portion.

Moisture content, the water activity, the 'L' value and rehydration ratio did not change significantly ($p<0.05$) during storage for 9 months at 27±2°C and 82±3% RH in pouches made out of aluminium foil laminated with HDPE (Table 4). Shelf-life up to 3 months at 27°C has been reported for dehydrated mushroom packaged in foil laminate pouches (Kumar *et al.*, 1980). PP and OPP/CPP were found to be unsuitable for storage of dehydrated mushroom as the moisture content and water activity increased and the 'L' value and rehydration ratio decreased during storage (Table 4).

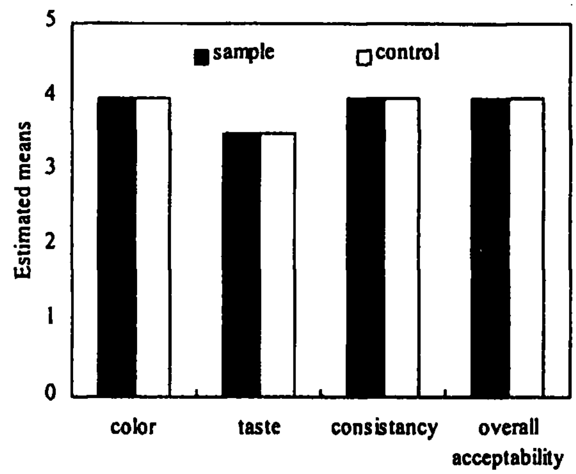

Fig. 3. Estimated means for sensory quality attributes of soups prepared using fresh and dehydrated mushroom.

[Note: Hedonic scale: 1-extremely dislike, 2-dislike very much, 3-neither like nor dislike, 4-like very much, 5-extremely like].

Table 4. Effect of packaging materials on physical properties of dehydrated mushrooms during storage at 27±2°C and 82±3% RH.

Packaging material	Storage period (months)	Moisture %	Water activity	'L' value	RR
-	0	4.5	0.56	46.8	8.3
PP (0.05 mm)	3	6.7	0.65	37.2	6.3
	6	8.0	0.73	28.3	5.9
	9	15.0	0.80	25.1	5.5
OPP (0.02 mm)/CPP (0.025 mm)	3	6.3	0.64	39.2	6.6
	6	6.8	0.65	31.6	6.4
	9	9.1	0.70	26.5	6.0
PET (0.012 mm)/Al foil (0.009 mm)/HDPE (0.04 mm)	3	5.0	0.60	44.2	7.9
	6	5.4	0.60	44.3	7.8
	9	5.8	0.60	42.0	7.8
Duncan critical value		1.8	0.03	4.2	0.5

PP-polypropylene; OPP-oriented polypropylene; CPP-cast polypropylene; PET-polyethylene terephthalate; HDPE-high density polyethylene; RR-rehydration ratio

High crude protein content of 25% in dehydrated oyster mushroom (Table 3) makes it an important protein source. Thus value addition by dehydration could be an encouragement for mushroom growers.

CONCLUSIONS

Immersing mushroom torn into 3 cm strips in 0.05% sodium bicarbonate for 1 min followed by drying at 45°C for 5 h was sufficient to reduce the water activity from 0.84-0.56 and to obtain a product with good physico-chemical and organoleptic properties. Pouches made out of aluminium foil laminated with HDPE were found to be suitable for storage of the product for 9 months at 27±2°C and 82±3% RH.

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