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Effect of Different Drying Techniques on the Nutritional Values of Oyster Mushroom (*Pleurotus sajor-caju*)

(Kesan Teknik Pengeringan Berbeza terhadap Nilai Pemakanan Cendawan Tiram (*Pleurotus sajor-caju*))

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ABSTRACT

Mushrooms are basically fungi, which have fleshy and spore-bearing fruiting body. This family of fungi literally has thousands of varieties of mushroom throughout the world. Oyster mushrooms are uniquely distinctive and they do look like oysters. Drying these mushroom confer a stabilizing property to it and then can be stored for a longer period. The nutritional values of the dried oyster mushroom with different drying techniques were thus determined. There were three different drying techniques used. These include low heat air blow (LHAB, Anjaad™), sun drying (SD) and gas laboratory oven (LO) drying. All three samples were analyzed for beta-glucan content, water activity, colour, proximate analysis and dietary fibre concentration. The result showed that LHAB method confers the lowest water activity compared with the other two drying methods. It also has the lowest colour measurement for brightness. Mushroom samples dried by LHAB techniques contain the highest concentration of both fat and carbohydrate compared with the other two methods. Besides, SD method confers the highest beta-glucan content. On the other hand, dietary fibres observed in LO dried samples contain the highest fibre content among the three drying treatments. In conclusion, LHAB method is recommended in reducing water activity and increasing proximate contents while both SD and LO are good in preserving beta-glucan and dietary fibre contents, respectively.

Keywords: Drying techniques; nutritional value; oyster mushroom

ABSTRAK

Cendawan adalah sejenis kulat yang mempunyai isi dan struktur badan yang mengandungi spora. Keluarga kulat ini dikenali mempunyai ribuan jenis varieti kulat di seluruh dunia. Cendawan tiram adalah sangat unik dan berbentuk seperti tiram. Pengeringan cendawan jenis ini akan membantu menstabilkan sifatnya supaya ia dapat disimpan dalam tempoh masa yang lama. Nilai pemakanan cendawan tiram yang dikeringkan menggunakan proses pengeringan yang berbeza telah ditentukan. Sebanyak 3 jenis teknik pengeringan telah digunakan. Teknik ini termasuklah suhu rendah berhembusan angin (LHAB) (Anjaad™), matahari (SD) dan ketuhar makmal (LO). Semua 3 sampel telah dianalisis untuk penentuan kandungan beta-glucan, aktiviti air (a_w), warna, analisis proksimat dan kandungan serabut diet. Keputusan kajian mendapati teknik LHAB menunjukkan nilai a_w paling rendah berbanding 2 teknik pengeringan yang lain. Teknik LHAB juga memberi nilai warna yang terendah untuk keamatan kecerahan. Sampel cendawan yang dikeringkan menggunakan teknik LHAB mengandungi kandungan lemak dan karbohidrat paling tinggi berbanding dengan teknik pengeringan yang lain. Selain daripada itu, kaedah SD mengekalkan nilai kandungan beta-glucan yang paling tinggi. Dalam aspek yang lain, sampel yang dikeringkan dalam LO mengandungi nilai serabut diet yang paling tinggi berbanding teknik pengeringan lain. Secara ringkas, teknik LHAB disarankan untuk memperoleh nilai a_w yang rendah dan kandungan proksimat yang tinggi manakala kedua-dua teknik SD dan LO masing-masing dapat mengekalkan kandungan beta-glucan dan serabut diet.

Kata kunci: Cendawan tiram; nilai pemakanan; teknik pengeringan

INTRODUCTION

Mushrooms are not true vegetable in the sense that it does not have any leaves therefore contain no chlorophyll, roots, or seeds and really does not need any light to grow. It is a fungus, which grows in the dark and propagates by releasing spores. Mushrooms are found all over the world and have been a time honored food in many cultures (Chang & Buswell 1996). They have been in use not only for consumption but also for medicinal purposes (Bobek

et al. 1997; Chocksaisawasdee et al. 2010; Yang et al. 2001).

Mushrooms come in literally thousands of varieties. Some experts estimate their number in tens of thousands with less than 10% of the edible species and roughly equal proportion of them is considered to be poisonous (Mattila et al. 2000). Today, mushrooms are eaten by people for their flavor, texture as well as for the health benefits that they accord. Mushrooms are healthy foods, poor in calories

and in fat, rich in proteins, chitin, vitamins and minerals (Manzi et al. 1999).

Pacioni and Lincoff (1981) described that *Pleurotus ostreatus* have cap size 6-14 cm, often imbricate, superposed, violet black to brownish gray in colour, fading with age, eccentric and asymmetrical, shell or spatula shaped and smooth shiny. Oyster mushroom powder rich in protein and low in fat contents can be incorporated into various recipes for improving the nutritional status of vulnerable population in developing countries (Dunkwal et al. 2007).

Beta-glucan has been shown to decrease blood LDL-cholesterol concentration in animal models and clinical intervention studies (Queenan et al. 2007). Research indicates that β -glucan is very effective at activating white blood including the macrophages and neutrophils, both of which provide the immune system's first lines of defence against foreign material in the body. Fungal β -glucan appears to act by stimulating the whole immune system so they may have an advantage in treating diseases (Chen & Seviour 2007).

Celen et al. (2010) found that drying temperature has a significant effect on the moisture removal from mushrooms. Heat treatments like drying have been reported to affect colour and texture of various products like tofu, milk paneer, banana and potato (Kotwaliwale et al. 2005). The authors found that banana dried at lower temperature and retained more brightness compared with the samples dried at higher temperature. The efforts are being made presently to minimize the deleterious effects of drying while preserving the functional properties of the oyster mushroom. Thus, the present study was conducted to investigate the effect of different drying techniques on the nutritional values of oyster mushroom (*Pleurotus sajor-caju*).

METHOD

Oyster mushrooms (*Pleurotus sajor-caju*) were supplied by the National Kenaf and Tobacco Board of Malaysia (LKTN) from Bachok Kelantan. The samples were dried using three different techniques namely low heat air blow (LHAB, Anjaad™), sun drying (SD) and gas lab oven (LO). LHAB is a method using low heating coupled with air blowing developed by Anjaad manufacturing Industries (Anjaad™), a local company who's actively drying various types of local herbs based in Malacca, state of Malaysia. For SD and LO drying, samples were cut into pieces and dried using temperature of around 50°C.

The samples were measured using Megazyme enzymatic kits Mixed-Linkage β -glucan (Streamlined Method) AOAC Method 995.16, AACC Method 32-23 and ICC Standard Method No. 168. The beta-glucan content was determined according to a modification of the method of McCleary and Glennie-Holmes (1985). Mushroom samples are submitted with or without pre-treatment with aqueous ethanol (50% v/v) solution, to a lichenase enzymatic hydrolysis and further degraded by β -glucosidase. The released free glucose is measured spectrophotometrically

at 510 nm against a blank necessary to subtract the free glucose eventually present in the sample. Lichenase acts at 40°C on mixed-links β (1 \rightarrow 3) (1 \rightarrow 4) and the hydrolysis of the other links β (1 \rightarrow 4), β (1 \rightarrow 3), β (1 \rightarrow 6) were catalysed by β -glucosidase. The addition of β -glucosidase was carried out after separating the solid residue of lichenase action by filtration in order to avoid any interference due to other beta-linked saccharides (e.g. cellulose).

The water activity was performed by using water activity meter (AquaLab, Decagon Devices, USA). Approximately 5 g of samples were placed in a plastic container and inserted in the instrument chamber. The water activity (a_w) of the samples was recorded in triplicate. On the other analysis, colour measurement of the samples was performed using a Minolta Colorimeter (Model CM 3500d, Minolta, Osaka, Japan). The instrument was standardized each time with a white and a black ceramic plate. Colour parameters analyzed were lightness (L), a value (redness) and b value (yellowness) intensities.

PROXIMATE ANALYSIS

All the moisture, fat, ash, protein and carbohydrate content were determined by Association of Official Analytical Chemists Methodology (AOAC 1996).

DIETARY FIBRE

The content of soluble, insoluble and total fibre was determined using AOAC 991.43 method (AOAC 1996).

STATISTICAL ANALYSIS

All analysis were performed in triplicate and averaged. Statistical analysis was conducted using Statistical package for social science (SPSS) for windows, version 18. Results were analyzed by two-ways analysis of varians (ANOVA). Differences among means were tested by the Duncan's test. Significance level was defined using $p < 0.05$.

RESULTS AND DISCUSSION

The lifetime of the bulk of fruiting body is only about 10-14 days (Kalac 2009). Thus, preserving mushroom in dried form can reduce the postharvest loss and extends their shelf life (Muyanja et al. 2012). To prolong shelf life of mushroom, appropriate drying temperature should be applied. Apati et al. (2010) suggested that the best temperature for *Pleurotus ostreatus* fruiting bodies drying process was around 40°C. On the other dehydration method, drying mushrooms under the sun yields unhygienic and poor quality product (Gothandapani et al. 1997).

It is thought that the scientific method of drying and storing will help in preserving mushroom for a long period of time. In addition, Gothandapani et al. (1997) has stressed the fact that in order to commercialize mushroom, application of the best post harvest techniques to enhance the shelf life and to maintain the quality of mushrooms plays a vital role.

Beta-glucan is a polysaccharide molecule found in many sources. For the purpose of health promotion, the primary sources of beta-glucan include oats, barley, mushrooms and yeast. Beta-glucans are the most interesting functional components in fungal cell walls other than chitin, mannan and other hemicellulose. That makes edible mushrooms are a potential source of dietary fibre (Manzi & Pizzoferrato 2000).

Researchers have studied all the various forms of beta-glucan. They are found in more than one linkage type. Linkages of (1→3), (1→4) and (1→6) are known to occur. The (1→3, 1→4) β -D-glucan are commonly referred to as β -glucan (Brennan & Cleary 2005). Beta-glucan are particularly effective in lowering blood cholesterol levels and glycemic response *in vivo* (Manzi et al. 2004).

Table 1 shows the beta-glucan content of samples which undergo SD techniques has the highest beta-glucan content (27.5%) compared to the other two methods followed by LHAB (25.8%) and the lowest when using gas LO method (24.1%). There is no significance difference ($p < 0.05$) in beta-glucan content among the three techniques used but economically, LHAB method is recommended because it is faster where the drying process is completed within 2-3 h as compared to both SD (1-2 days) and LO methods (6-10 h), respectively.

The content of beta-glucan was calculated as a difference between the total and alpha-glucans. Synytsya et al. (2008) reported that the content of beta-glucan was at 27.4 -39.2% in the pilei and 35.5- 50.0% in the stems of *Pleurotus ostreatus* in dry matter. Beta-glucan are linked with its ability to show significant immunomodulative properties, possess better antioxidant activities and exhibits scavenging capacities against free radicals (Ragunathan et al. 1996; Synytsya et al. 2008).

Meanwhile, Manzi et al. (2004) examined the effect of cooking on nutritional quality of commercial mushrooms: the beta-glucan content of oyster mushroom was 0.412 g/100g. They also found that beta-glucan levels range from 0.245 to 1.11 g/100 g of edible weight from ten samples of mushrooms. The values represent from 4% to 13% of the total dietary fibre. Furthermore, when comparing dried mushroom to fresh or frozen mushrooms, beta-glucan content of fresh mushrooms were higher than the dried mushrooms. It shows that heat treatment affected the beta-glucan content. Manzi and Pizzoferrato (2000) found that beta-glucan in the dietary fibre fractions vary according to species of mushrooms.

They reported beta-glucan concentration at 0.24-0.38 g/100 g in *Pleurotus ostreatus* species.

Water content affects food quality. It provides a medium to support microbial growth. Generally speaking, the more water that is present, the greater the opportunity for microbes to grow (Shewfelt 2009). Water activity (a_w) is a better indication of food perishability than water content (Bradley 2003). It is the term that relates to the ability of a microbe to grow in a particular environment. Removal of water by drying or concentrating will reduce its susceptibility to microbial attack, but has a profound effect on the texture of foods as well as colour and flavour (Shewfelt 2009).

The results obtained from the present study showed that LHAB drying techniques produced the lowest a_w compared to the other two techniques (Table 1). Mean triplicate data of SD and gas LO drying values are the same (0.57) but for samples dried with LHAB method, it was significantly lower (0.49) than the other two methods. It shows that the sample dried with LHAB method was better than the other methods in term of a_w value.

Mushrooms are highly perishable commodities and start deteriorating after harvesting. The development of brown colour is the first sign of deterioration and a major factor contributing to quality losses. This is due to enzymatic action of polyphenol oxidase on phenolic substances (Dunkwal et al. 2007). Sun drying method has the lightest colour compared to the others as shown in Table 2. LHAB drying techniques has the lowest colour measurement for brightness (L value). Gothandapani et al. (1997) also found that SD of oyster mushroom recorded higher values of browning index which was approximately 0.15 while the fluided bed drying (0.05) and thin layer drying (0.05) show lower browning index.

Mushrooms are liked for their delicious flavour, low calorific value and high protein, vitamins of B-groups and mineral contents. Mushroom contains proteins on a dry weight basis and has no cholesterol and is almost fat free (Walde et al. 2006). Table 3 lists the proximate composition of mushroom powders with three different drying techniques. LO drying method recorded the highest percentage of moisture (9.58%) and significantly different ($p < 0.05$) compared to the other two drying method. Besides occupying little space, mushroom keeps almost all of it taste and other features when dried. At 50°C, mushrooms risk losing protein and taste (Celen et al. 2010).

TABLE 1. Concentration of Beta-glucans and water activity value of *Pleurotus sajor-caju* among the three types of drying methods

Drying techniques	Beta-glucan content (%)	Water activity, a_w (obituary value)
Sun drying (SD)	27.50 \pm 2.08 ^a	0.57 \pm 0.02 ^a
Lab oven (LO)	24.08 \pm 0.96 ^a	0.57 \pm 0.01 ^a
Low Heat Air Blow (LHAB)	25.83 \pm 6.93 ^a	0.49 \pm 0.03 ^b

^{a,b} Mean values in the same column with different letters are statistically different ($p < 0.01$)

TABLE 2. Colour value of mushroom powder using different drying techniques

Colour values	Drying techniques		
	Low Heat Air Blow	Sun Dry	Lab Oven
L	70.99 ± 0.58 ^c	79.42 ± 0.69 ^a	73.63 ± 0.36 ^b
a	3.82 ± 0.24 ^a	1.29 ± 0.23 ^c	2.76 ± 0.25 ^b
b	25.85 ± 0.39 ^a	19.47 ± 0.19 ^b	25.98 ± 0.3 ^a

^{a-c} Mean values in the same row with different letters are statistically different ($p < 0.01$)

TABLE 3. Nutritional compositions of oyster mushroom dried using different drying techniques

Composition (%)	Low Heat Air Blow	Sun Dry	Lab Oven
Moisture	8.84 ± 0.07 ^b	9.03 ± 0.05 ^b	9.58 ± 0.16 ^a
Protein	21.01 ± 2.65 ^a	20.89 ± 0.22 ^a	23.84 ± 4.37 ^a
Fat	1.7 ± 0.2 ^a	1.33 ± 0.25 ^a	1.69 ± 0.19 ^a
Ash	7.72 ± 0.14 ^b	8.40 ± 0.08 ^a	7.48 ± 0.07 ^c
Carbohydrate	60.58 ± 2.71 ^a	60.34 ± 0.22 ^a	57.41 ± 4.36 ^a

^{a-b} Mean values in the same row with different letters are statistically different ($p < 0.01$)

No differences were found in protein, fat and carbohydrate contents between the three drying techniques. According to Yang et al. (2001), *Pleurotus ostreatus* contained higher protein (23.9%), fat (2.16%) and carbohydrate (61.1%) compared with this study. However they reported 7.59% of ash in *Pleurotus ostreatus* mushroom and within the range of 7.48 – 8.40% as in this work. Fat values in the present study are about the same as reported by Chang et al. (1981). They found that fat content in *Pleurotus sajor caju* (1.7 – 2%) are lower compared with other mushroom. Fat content in *Pleurotus sajor caju* are lower (4.99 g/100 g) compared with oyster mushroom (*Pleurotus ostreatus*) (6.32 g/100 g) (Bonatti et al. 2004).

Alam et al. (2008) also reported higher protein (24.63 g/100 g) and fat content (4.41 g/100 g) whereas lower fibre (22.87 g/100 g) and carbohydrate (39.82 g/100 g) compared with this study. They reported ash value as 8.28 g/100 g in *Pleurotus sajor-caju* which within the range of this work (7.48 – 8.4%).

Only ash value showed significant difference between the three drying method. Overall, oyster mushroom dried with LHAB drying method contains the highest fat and carbohydrate compared to the other methods. It also contains the lowest moisture content so it is confer longer life span. This is important as mushrooms are easy to depreciate within a day after harvest (Walde et al. 2006).

Mushrooms are a potential source of dietary fibres due to the presence of non starch polysaccharides. Dunkwal et al. (2007) reported that sun dried *Pleurotus sajor-caju* contains 12.59% of crude fibre compared to the oven dried mushrooms viz 12.58%.

Table 4 shows the content of dietary fibre of dried mushrooms. Among all three samples analyzed, LO recorded the highest content of total dietary fibre (37.50 g/100 g). LHAB and SD methods recorded total dietary fibre at 33.00 and 35.60 g/100 g, respectively. The same trend were also detected in insoluble dietary fibre content where

LO had 37.50 g/100 g while both LHAB and SD recorded 32.90 and 35.40 g/100 g, respectively. According to Manzi et al. (2004), dried and re-hydrated *Boletus* species showed higher levels of soluble and insoluble dietary fibre than the other mushrooms. They observed ten samples of commercial mushrooms and the content of the insoluble dietary fibre are higher than soluble dietary fibre as found in this study. Manzi and Pizzoferrato (2000) also found the same where *Pleurotus ostreatus* contain 27.1-37.8% of soluble dietary fiber compared with 62.2-72.9% of insoluble dietary fiber.

CONCLUSION

The present study revealed that drying of oyster mushrooms can lengthen their shelf life and retain their properties plus quality as close to the original sample as possible. In conclusion, LHAB method is recommended in reducing water activity and increasing proximate contents. On the other hand, LO is good in improving dietary fibre contents while SD had the highest colour intensity for brightness (L value) and good in improving beta-glucan content.

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TABLE 4. Dietary fibre content of dried mushroom using different drying techniques

Type of fibres	Low Heat Air Blow	Sun Dry	Lab Oven
Soluble dietary fibre (g/100 g)	0.10 ± 0.0 ^{ab}	0.20 ± 0.1 ^a	0.00 ± 0.0 ^b
Insoluble dietary fibre (g/100 g)	32.90 ± 0.35 ^c	35.40 ± 0.45 ^b	37.50 ± 0.4 ^a
Total dietary fibre (g/100 g)	33.00 ± 1.53 ^c	35.60 ± 0.25 ^b	37.50 ± 0.4 ^a

^{a,b} Mean values in the same row with different letters are statistically different ($p < 0.05$)

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