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Chemical compositions of oyster mushrooms (*Pleurotus ostreatus* and *Pleurotus pulmonarius*) under storage

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ABSTRACT

Effect of storage time on chemical compositions of *Pleurotus ostreatus* and *Pleurotus pulmonarius* (two cultivated oyster mushrooms from Nigeria) were investigated. These two edible fungi were analysed for crude protein, crude fibre, crude fat, ash content, moisture content, dry matter and mineral elements (Na, K, P, Ca, Mg, Fe, Cu and Mn)at 0day (fresh samples),35,70,105 and 140 days. The results reflected higher percentage of these nutrients in the fresh fungal samples with *P. ostreatus* and *P. pulmonarius* having 31.40 and 28.65% crude protein respectively in their fresh samples. These values however reduced drastically to 25.60 and 24.10 % in *P. ostreatus* and *P. pulmonarius* respectively after 140days of storage .Similar trends were observed in the two mushrooms for all other food components except for moisture contents. The best mineral element in the fresh samples of the two mushrooms was magnesium with 7.41 mg/g (in *P. ostreatus)* and 6.91 mg/g (in *P. pulmonarius)*. These values reduced significantly as the storage time increases ($P<0.05$).Potassium, calcium, phosphorus and sodium were also found at significant quantities in both fresh and stored mushroom samples. Similarly, micro-elements such as Fe, Cu and Mn were detected at appreciable quantities in both fresh and stored fungal samples. The implications of these findings were discussed.

KEYWORDS

Storage period;
Oyster mushrooms;
Chemical analysis;
Mineral elements.

INTRODUCTION

Pleurotus ostreatus and *P. pulmonarius* are among the species of cultivated edible mushrooms in many regions of the world .They belong to the phylum basidiomycetes, order agaricales and family tricholomataceae[2,36]. When growing naturally in the wild or cultivated on artificially prepared substrates, they usually possess oyster shaped cap. Hence, they are commonly referred to as oyster mushrooms, along with other edible Pleurotus species[13,28]. They are decomposers of wood and other agro- industrial wastes. Naturally, they can be found growing in tropical and subtropical rainforests, and can be artificially cultivated on different substrates[19,34]. Mushroom growers prefer cultivating oyster mushrooms than other species because of their flexible nutritional and environmental requirements.

Oyster mushrooms are produced at a rate of 900,000 tonnes per year with China alone producing about 800,000 tonnes per year[7,35]. Edible mushrooms

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are highly nutritious, having nutrients almost twice that of any other vegetables or fruits[31]. They are considered as healthy food as they are low in calories, fat and cholesterol,but rich in protein, carbohydrate, fibers, vitamins and mineral element[22,24]. Rashad *et al*[29] suggested that one of the significant factors that determine the nutrient contents of cultivated mushrooms is the type of substrates used for their cultivation. The texture and flavour of edible mushrooms' sporophores make them appealing but far more than this is their nutrient compositions[22,23].

Edible mushrooms do not only serve as delicacies for human consumption alone, but also used as 'neutriceuticals' that is food that could be used in the treatment of some ailments. Fruiting bodies of Pleurotus species may contain various kinds of substances that are highly valued as medicines, flavouring and perfumes[6,9,17].

Several studies that have been carried out in the past by different scientists on the nutritional properties of *P. ostreatus* and *P. pulmonarius* were focused mainly on the fresh mushrooms sporophores. Therefore, this present investigations were aimed of determining proximate and mineral elements composition of both fresh and stored samples of *P. ostreatus* and *P. pulmonarius* over a period of 140days.

MATERIALS AND METHODS

Collection of mushroom samples

Fresh samples of two oyster mushrooms (*Pleurotus ostreatus* and *Pleurotus pulmonarius* were collected from two different locations in Ibadan, Oyo State, Nigeria. Carpophores of *Pleurotus ostreatus* were obtained from the mushroom unit, Zartech Farm, Ring road, Ibadan, Nigeria, while that of *Pleurotus pulmonarius* were harvested from the growing spawn at the Plant Physiology and Biochemistry Laboratory, University of Ibadan, Ibadan, Nigeria.

Processing of the samples

The fresh mushroom samples (100g) were analysed immediately after collection, except for the portion for storage. The rest of the samples (weighing 600g) were dried for 7 days at 42^{0}C on a sterilized sheet of aluminium foil. Each of the samples was later separated into three different equal parts and each sample stored in a sterile polyethylene bags for 35, 70,105 and 140 days inside an aerated laboratory cupboard. This method of storage was selected because, it is the common way of storing mushrooms among Nigerian rural dwellers, that are exposed to natural vegetation, in which several species of wild mushrooms grow.

TABLE 1 : Proximate analysis of *Pleurotus ostreatus* and *Pleurotus pulmonarius* samples at different storage time

Nutrients	Fresh	35 days	70 days	105 days	140 days
Pleurotus ostreatus					
Crude protein (%)	31.40^a	28.68^b	27.50^c	26.83^d	25.60^e
Crude fibre (%)	06.82^a	06.10^b	05.73^c	05.23^d	04.66^e
Crude fat (%)	00.12^a	00.11$^{b, c}$	00.11^{bc}	00.10^c	00.10^c
Ash content (%)	03.11^a	02.48^b	02.45^b	02.38^c	02.33$^{c, d}$
Moisture content (%)	85.80^a	14.92^b	12.85^c	11.74^d	10.67^e
Dry matter (%)	14.20^e	85.08^d	87.15^c	88.26^b	89.33^a
Pleurotus pulmonarius					
Crude protein (%)	28.65^a	25.61^b	25.40^c	24.55^d	24.10^e
Crude fibre (%)	06.12^a	05.72^b	05.71^b	05.21^c	05.10^d
Crude fat (%)	00.12$^{a, b}$	00.11$^{b, c}$	00.10^c	00.10^c	00.10^c
Ash content (%)	03.41^a	02.36^b	02.31^c	02.23^d	02.20^d
Moisture content (%)	87.76^a	16.42^b	14.68^c	13.67^d	12.07^e
Dry matter (%)	12.24^e	83.58^d	85.32^c	87.06^b	88.11^a

Means (n=3) having the same superscript letter (s) across the row are not significantly different by Duncan's multiple range test at 5% level of probability

Nutrient analysis

The proximate composition determined were crude protein (CP), crude fibre (CF), crude fat (CFT), ash content (AC), moisture content (MC) and dry matter (DM).The moisture contents and dry matter values of different mushroom samples were determined by subtracting the final weight from the initial weight after drying the samples in the hot air oven at 80^{0}C for 24 hrs. The value obtained for the water loss formed the moisture content while the value derived after the removal of water by drying of the samples is regarded as dry matter. Crude protein was determined using the routine semi-micro Kjeldahl procedure[3]. Crude fibres and ash contents were determined using fat free extraction thimble technique and muffle furnace respectively[27]. The minerals analyzed on the mushroom samples were sodium, potassium, phosphorus, calcium, magnesium, iron, copper and manganese. They were quantified us-

ing digital flame photometer and atomic absorption spectrophotometer .The mineral element analyses were carried out at the central laboratories of Institute of Agriculture, Research and Training (IAR &T), Ibadan using the method described by Latiff *et al.*,[20].

TABLE 2 : Mineral elements composition of *Pleurotus ostreatus* and *Pleurotus pulmonarius* at different storage periods

Mineral Elements	Fresh	35 days	70 days	105 days	140 days
Pleurotus ostreatus					
Sodium (mg/g)	0.35^{a}	0.33^{b}	0.30^{c}	0.21^{d}	$0.20^{d, e}$
Potassium (mg/g)	3.82^{a}	3.77^{b}	2.66^{c}	2.61^{d}	2.60^{d}
Phosphorus (mg/g)	0.32^{a}	0.28^{b}	0.22^{c}	0.21^{d}	0.20^{d}
Calcium (mg/g)	2.34^{a}	$2.22^{b, c}$	$2.22^{b, c}$	$2.21^{c, d}$	2.20^{d}
Magnesium (mg/g)	7.41^{a}	6.27^{b}	5.94^{b}	5.70^{c}	5.41^{c}
Pleurotus pulmonarius					
Sodium (mg/g)	0.27^{a}	$0.20^{b, c}$	0.19^{c}	0.16^{d}	0.15^{d}
Potassium (mg/g)	3.26^{c}	2.84^{d}	2.41^{c}	2.35^{d}	2.31^{e}
Phosphorus (mg/g)	0.26^{a}	0.20^{b}	0.18^{c}	0.17^{d}	0.16^{d}
Calcium (mg/g)	2.29^{a}	2.28^{a}	2.25^{b}	2.24^{b}	2.21^{c}
Magnesium (mg/g)	6.91^{a}	5.93^{b}	5.91^{b}	5.91^{b}	5.91^{b}

Means (n=3) having the same superscript letter (s) across the row are not significantly byDuncan's multiple range test at 5% level of probability.

Statistical analysis

The experiment consisted of a completely randomized design with three replicates for each of the five treatments. The data generated from these studies were analyzed statistically using one way analysis of variance (ANOVA) using SPSS for windows. Significance differences were separated using Duncan's multiple range tests (DMRT) at 5% level of probability[30].

RESULTS AND DISCUSSION

TABLE 1 shows the results of proximate compositions of *Pleurotus ostreatus* and *P.pulmonarius* over different storage periods. In both mushrooms, the amounts of nutrients in the fresh fruitbodies were more than that of the stored samples. Generally, the nutrients in these two edible fungi decreased as the storage time increases. In fresh (0day), 35, 70, 105 and 140-days samples, the crude protein values in *P. ostreatus* were 31.40, 28.68, 27.50, 26.83 and 25.60% respectively while in *P. pulmonarius*, the protein contents were 28.65,25.61, 25.40,24.55 and 24.10% respectively for 0,35, 70, 105 and 140-days samples . It was reported by Ragunathan *et al.*[25] that the fruit bodies of *Pleurotus* species have a range of 26.6% to 34.1% protein contents. The values obtained for the two species studied falls within the range obtained by these researchers. The best nutrient in both mushrooms samples was found to be crude protein (TABLE 1).These findings are similar to those obtained by Kadiri[17] (for *Chlorophyllum molybditis*); Jonathan *et al*[14] (for *Phallus indusiatus*) and Fasidi and Kadiri[10] (for *Volvariella esculenta*).

The crude fibre content in *P. ostreatus* decreased from 6.82% to 4.66% as the storage time increases while in *P. pulmonarius* the decrease was from 6.12 to 5.1% respectively with storage (TABLE 1). The cell walls of higher fungi have been implicated to contain significant crude fibre but not in greater quantity as protein[12,13]. Its presence in mushrooms has been reported by other authors. The crude fibre range obtained by Bonatti *et al.*[4] was between 9.41% and 9.86% for fresh sample of *P. ostreatus* and 7.6% and 9.6% for *P. pulmonarius*, which is slightly higher than the value obtained in the present study. The difference obtained may be connected to nutritional compositions of different substrates used for their cultivation

The crude fat content in fresh *P. ostreatus* was 0.12%.This value decreased to 0.10 after140 days of storage. In *P. pulmonarius*, similar observation was obtained (TABLE 1). Fat is an insignificant part of mushroom nutrients being present in a very low quantity irrespective of the nature and type of substrates used for their cultivation[15,16,29]. Likewise, nutritional analysis carried out by some scientists on *Pleurotus* species had shown that oyster mushrooms contained low amount of fat[18,26]. The low level of fat in edible mushrooms have made them ideal food for the obsess and people with high blood pressure[10,11].

The ash content of fresh (0 day) 35, 70, 105 and 140-days samples were 3.11, 2.84,2.45, 2.38 and 2.33% respectively while in *P. pulmonarius*, the value reduced from 3.40 to 2.20% after 140 days of storage (TABLE 1). Similar observation was made by Caglarirmak[5] for P. *pulmonarius*, but the value obtained (1.13%) by this researcher was far lower than that obtained for *P. pulmonarius* samples used in the present study. The difference may be due to the sub-

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strates used for cultivation, variety of the oyster mushrooms used and, the environmental factors[12,15,16].

The moisture content of fresh (0day) *P. ostreatus* sample was 86.6%. This value reduced to 13.51, 11.20, 10.37 and 9.91% respectively after 35, 70,105 and 140days of storage (TABLE 1). Similarly, fresh sample of *P. pulmonarius* had 89.13% moisture content. This value reduced to 14.3, 11.30, 10.94 and 9.89% respectively after 35, 70,105 and 140days of storage (TABLE 1). These results are in agreement with reports of other authors that mushrooms generally comprise of high amount of moisture[4,5,8]. One of the major contributing factors to the high percentage of moisture in fresh mushrooms is the ability of the micro-organelles in their protoplasm and cell wall to hold water.

In fresh (0day), 35, 70, 105 and 140-days stored mushroom samples, the amount of sodium in *P. ostreatus* were 0.35, 0.33, 0.30, 0.21and 0.20g/100g respectively while in *P. pulmonarius*, the values reduced from 0.27g/100g (fresh samples) to 0.15g/100g after 140 days. Likewise, phosphorus content reduced in *P. ostreatus* from 0.32g/100g in the fresh samples to 0.20g/100g in 140 days old samples. While in *P. pulmonarius*, 0.26g/100g was recorded for the fresh samples which reduced significantly to 0.16g/100g after 140 days of storage (TABLE 2). Sodium and phosphorus have also been detected in moderate level in *Pleurotus tuber-regium*[1]

The content of potassium in fresh *P. ostreatus* sample was 3.82g/100g while this value reduced significantly to 2.60g/100g after 140 days of storage.Likewise, in *P.pulmonarius*, 3.26 g/100g of potassium were detected in fresh samples, but these values reduced to 2.31g/100g after 140 days (TABLE 2). The amounts stated were lower than what was found in the literatures[5,25]. The variations in nutrient values may be due to substrates used for local cultivation of these mushrooms[26].

The amount of Ca in fresh samples of *P. pulmonarius* reduced from 2.29g/100g to 2.21g/100g after 140days while in *P. ostreatus*, it reduced from 2.34g/100g in fresh samples to 2.20g/100g in 140day old samples. Similar trends were observed in the two mushrooms for magnesium and phosphorus .The calcium composition in the two studied mushrooms in these studies were more than that of Chang *et al.*[8], but fall within the range reported by Ragunathan *et al.*[25]. Likewise, the magnesium content were more than the range given by Chang *et al.* (1981) and far less than Ragunathan *et al.*[25]. The differences may also be liked to the nutrient compositions of the substrates used for growing.

The iron level of *P. pulmonarius* (ranging from 126µ/g to 155µ/g) as reported by Sivrikaya *et al.*[31] is far more than the amount obtained from *P. pulmonarius* used in this work. The same observation applied for copper (10µ/g to 14µ/g). Ragunathan *et al.*[25] reported iron compositions of between 5.1mg/g and 10mg/g in *P. pulmonarius* which was slightly higher than the level of iron in *P. pulmonarius* employed in this study. In another report on *P. ostreatus*, both the copper and iron are contained in a very low concentration ranging from 0.003mg/kg to 0.03mg/kg for copper and 0.001mg/kg to 0.042mg/kg for iron[33]. This values are far lesser to the level of these micronutrients in *P. ostreatus* samples used for the present work. The difference in values observed by different authors may be attributed to the nutrient compositions of the substrates and the variant of fungus used.

TABLE 3 : Heavy metals concentration in fresh and stored *Pleurotus ostreatus* and *Pleurotus pulmonarius* samples

Heavy metals	Fresh	35 days	70 days	105 days	140 days
Pleurotus ostreatus					
Iron (mg/kg)	4.54^{a}	4.51^{b}	4.42^{c}	4.22^{d}	4.02^{e}
Copper (mg/kg)	$4.46^{a, b}$	4.46^{b}	4.22^{c}	3.79^{d}	3.41^{e}
Manganese mg/kg)	6.58^{a}	6.50^{b}	6.40^{c}	5.62^{d}	5.21^{e}
Pleurotus pulmonarius					
Iron (mg/kg)	4.58^{a}	4.51^{b}	4.48^{c}	4.46^{d}	4.42^{e}
Copper (mg/kg)	4.48^{a}	4.44^{b}	4.21^{c}	4.01^{d}	4.00^{d}
Manganese (mg/kg)	6.92^{a}	6.40^{b}	6.31^{c}	6.28^{d}	6.22^{e}

Means (n=3) having the same superscript letter (s) across the row are not significantly different by Duncan's multiple range test at 5% level of probability.

The Mn content in fresh samples *P. ostreatus* decreased from 6.58mg/kg to5.21mg/kg after 140 days of storage while in *P. pulmonarius* it decreased from 6.92mg/kg in fresh samples to 6.22mg/kg in 140 day old samples (TABLE 3). The level of manganese in *P. pulmonarius* was similar with the amount recorded by Sivrikaya *et al.* (2002) but level of manganese in *P. ostreatus* was higher than what Yildiz *et al.*[33] ob-

served. Mushrooms generally are capable of accumulating heavy metals, translocating them into their fruit bodies. Therefore, heavy metal concentrations in mushrooms are seen to be considerably higher than those in agricultural crop plants, vegetables and fruits[32]. With the ability of mushroom to accumulate metals, several potentially toxic metals are accumulated, but *Pleurotus* species are among some cultivated mushrooms having low heavy metal content that could be tolerated by humans[32]. The toxicity level of heavy metal in cultivated mushrooms can be reduced through initial substrate analysis; and avoiding substrates containing high content of heavy metals.

The results of this studies reflected that *P. ostreatus* and *P. pulmonarius* are highly nutritious having greater amount of protein, reasonable amount of fibre, very low fat content, moderate ash content, minimal quantities of sodium and phosphorus, good amount of potassium, calcium and magnesium, and moderate proportions of iron, copper and manganese.

Likewise it was observed from the results that storage over a long period may reduce the nutritional values of *P. ostreatus* and *P. pulmonarius*. Therefore, as a consumer delight, consumption of fresh edible mushroom should be encouraged. In comparison, *P. ostreatus* is more nutritious than *P. pulmonarius*.

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