Sains Malaysiana 45(11)(2016): 1609–1615

Yield and Nutritional Composition of Oyster Mushrooms: An Alternative Nutritional Source for Rural People

(Komposisi Hasil dan Nutrisi Cendawan Tiram: Sumber Pemakanan Alternatif bagi Penduduk Luar Bandar)

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ABSTRACT

In recent decades, minimizing the frequency of nutrient deficiency and malnutrition in rural areas of developing countries becomes an alarming issue. Oyster mushrooms are rich source of both macro and micro nutrients. The objective of this paper was to evaluate the yield of newly introduced oyster mushroom strains viz. Pleurotus sajor-caju *(PSC),* Pleurotus flabellatus *(FLB),* Pleurotus florida *(FLO),* Pleurotus ostreatus *(PO_2 and PO_3),* Pleurotus ostreatus *(HK-51) and* Pleurotus geesteranus *(PG_1 and PG_3) and to justify their nutritional values when grown in the climatic condition of Bangladesh. Strain HK-51 produced the highest amount of fresh sporophore (197.80 g). In contrast, the highest number of fruiting body was obtained from the strain FLO (82 g) followed by strain PSC (69 g). Strain PG_1 has recorded the highest biological yield (278 g), productivity (55%) and biological efficiency (96%). Nutrient and mineral analysis of sporophore of strain PG_1 showed protein (31.80%), lipid (3.6%), potassium (1.3 mg/100 g), phosphorus (0.8 mg/100 g), calcium (32 mg/100 g), iron (43 mg/100 g), magnesium (12 mg/100 g), copper (3.5 mcg/100 g), zinc (12.5 mcg/100 g) and manganese (2.3 mcg/100 g). This study showed that the strain PG_1 performed well with regard to quality and productivity as compared to other strains. Hence, oyster mushroom strain PG_1 is a potential cheap source of nutrients and minerals to combat socioeconomic problems including malnutrition, diseases linked to malnutrition, poverty reduction and agricultural diversity.*

Keywords: Biological efficiency; mushroom cultivation; nutrient deficiency; Pleurotus *species*

ABSTRAK

Beberapa dekad kebelakangan ini, meminimumkan kekerapan kekurangan nutrien dan zat makanan di kawasan pedalaman negara membangun menjadi suatu masalah yang membimbangkan. Cendawan tiram kaya dengan sumber nutrien makro dan mikro. Objektif penyelidikan ini bertujuan untuk menilai kadar hasil bagi strain cendawan tiram yang baru diperkenalkan iaitu Pleurotus sajor-caju *(PSC),* Pleurotus flabellatus *(FLB),* Pleurotus florida *(FLO),* Pleurotus ostreatus *(PO_2 dan PO_3),* Pleurotus ostreatus *(HK-51) dan* Pleurotus geesteranus *(PG_1 dan PG_3) untuk mewajarkan nilai pemakanan apabila ditanam dalam keadaan iklim Bangladesh. Strain HK-51 menghasilkan jumlah tertinggi sporofor segar (197.80 g). Sebaliknya, bilangan tertinggi jasad berbuah telah diperoleh daripada strain FLO (82 g) diikuti dengan strain PSC (69 g). Strain PG_1 telah mencatat pulangan biologi tertinggi (278 g), produktiviti (55%) dan kecekapan biologi (96%). Analisis nutrien dan mineral sporofor strain PG_1 menunjukkan protein (31.80%), lipid (3.6%), kalium (1.3 mg/100 g), fosforus (0.8 mg/100 g), kalsium (32 mg/100 g), besi (43 mg/100 g), magnesium (12 mg/100 g), kuprum (3.5 mcg/100 g), zink (mcg 12.5/100 g) dan mangan (2.3 mcg/100 g). Kajian ini menunjukkan bahawa strain PG_1 menunjukkan prestasi yang baik daripada segi kualiti dan produktiviti berbanding dengan strain lain. Oleh itu, cendawan tiram strain PG_1 berpotensi sebagai sumber nutrien dan mineral yang murah untuk memerangi masalah sosioekonomi termasuk malnutrisi, penyakit berkaitan malnutrisi, pengurangan kemiskinan dan kepelbagaian pertanian.*

Kata kunci: Kecekapan biologi; kekurangan nutrien; penanaman cendawan; spesies Pleurotus

INTRODUCTION

Malnutrition and iron deficiency are serious health problems in developing countries and more than 80% of total populations are suffering from malnutrition. Per year specific death rate per 100000 for malnutrition is 7.77 and 11.22 in urban and rural area of Bangladesh, respectively (BBS 2010). According to Food and Agricultural Organization (FAO 2012), over 925 million people were malnourished in 2009 and over 30% of world's population were anemicdue to iron deficiency during 1993 to 2005 (WHO 2012).

Pleurotus sp., commonly known as oyster mushroom, is very attractive to the consumers for their excellent flavor and taste. Approximately 70 species of *Pleurotus* have been recorded to date and new species are discovered more or less frequently although some of these are considered identical with previously recognized species. Oyster mushroom is a good source of non-starchy carbohydrates

with high content of dietary fiber and moderate quantity of protein with important amino acids, minerals and vitamins (Croan 2004). It is also rich in Vitamin C and B complex (Randive 2012), suitable for people with hypertension (Ebigwai et al. 2012) and obesity and diabetes (Agrawal et al. 2010). The niacin content of oyster mushroom is about ten times higher than any other vegetables. The folic acid present in oyster mushrooms helps to cure anemia. Mushrooms are rare vegan sources of vitamin D and conjugated linoleic acid. Mushrooms have antioxidant property due to presence of compounds like ergothioneine (Weigand-Heller et al. 2012).

The growth habit of oyster mushroom is more flexible and can sustain under wide range of temperature than any other mushroom species (Rosado et al. 2002). Most of the agricultural byproducts and their wastes are suitable as growing media of this mushroom. Cultivation of Pleurotus is a valuable and profitable agribusiness and is gaining rapid popularity amongst the entrepreneurs (Naraian et al. 2011) because the production cost is low and easy to adopt by the marginal farmers (Banik & Nandi 2004; Pant et al. 2006).

Mushroom production in rural communities is one of the tools to alleviate poverty and brings diversification of agricultural production (Godfrey et al. 2010). More of the governments of developing countries also considers mushroom as a suitable component for a balanced diet as it comprised adequate amount of macro and micro nutrients. Tariqul et al. (2012) reported that nutrient composition of the food has to be made well known and available to the mass population for a balanced diet. Micronutrient is important for good health and taking less amount of micronutrient containing food or their bio-unavailability are the frontier cause of micronutrient deficiency. Knowing the nutrient composition of the food is also important for developing food composition database. Sometimes, commercial strains of oyster mushroom grown in several consecutive subcultures resulting in yield reduction and quality deterioration (Naraian et al. 2011). In order to make the cultivated commercial species economically attractive to the growers, continuous yield improvement practices are essential (Uhart et al. 2008). In order to overcome these constraints, cultural practices need to be optimized (Curvetto et al. 2002) through supplementation of substrate with different additives (Naraian et al. 2009). In addition, high yielding variety can be developed through hybridization and genetic modification of the existing strain may also be the option to solve this problem. Both hybridization and genetic modification are time consuming processes and require professional skills to execute. In developing countries, most of the farmers are poor and have limited knowledge. It is really a great challenge to introduce a new cultivation technique or cultural practices for mushroom production as the farmers are adopting existing cultural technique of mushroom. It is easy to introduce a new strain if the strains are economically feasible and nutritionally viable.

In Bangladesh, mushroom cultivation has been started recently and National Mushroom Development and Extension Center (NAMDEC) have introduced some new strains of oyster mushroom in Bangladesh. But the yield potentiality and the nutrient composition are unknown. Therefore, the objectives of this study were to evaluate and select strain(s) which is/are biologically efficient and could produce higher yield with sound nutritional quality.

Materials and Methods

Experimental site and strains

The experiment was conducted in Mushroom Culture House (MCH), Department of Biochemistry, Sher-e-bangla Agricultural University, Dhaka, Bangladesh (latitude 23.77° N and longitude 90.37° E).

All the eight oyster mushroom strains (*Pleurotus* sp.) used in the experiment were obtained from NAMDEC (latitude 23.85° N and longitude 90.25° E), namely *Pleurotus sajor-caju* (strain PSC), *Pleurotus flabellatus* (strain FLB), *Pleurotus florida* (strain FLO), *Pleurotus ostreatus* (strain PO_2 and strain PO_3), *Pleurotus ostreatus* (strain HK-51) and *Pleurotus geesteranus* (strain $PG_1$and strain PG_3). Among these strains, strain PO_2 is mostly cultivated and considered as control in this experiment. All the strains were supplied as pure culture of mycelium which was maintained on potato dextrose agar (PDA).

Spawn preparation

Wheat grains were cleaned to remove debris, inert matter and stubble. The cleaned grains were thoroughly washed and soaked for 2 h in tap water. Rice bran (10%) and $CaCO_3$ (1%) at dry weight basis of the grain was added and evenly mixed after removing excess water. The grain media was than filled in conical flask (200 g each) and sealed with cotton wool and neck was covered by aluminum foil. The flask was then sterilized at 121°C with 1.5 $kgcm^{-2}$ pressure for 30 min and then allowed to cool. Sterile wheat grains were immediately inoculated with pure mycelium culture.

Preparation of fruiting media and fruiting initiation

Fruiting media consists of sawdust supplemented with 10% of wheat bran (as nitrogen source) and 2% $CaCO_3$ on dry weight basis of substrate. Water (at 80% on dry weight basis of substrate) was added and thoroughly mixed. The media was then filled into polypropylene bags (500 g in each bag on an average) and sealed. The bags were sterilized at 121°C with 1.5 $kgcm^{-2}$ pressure for 60 min. The cooled sterilized bags were then inoculated separately with spawn. Inoculated bags were kept in the culture house for mycelium running. The culture room was maintained at 80 - 85% relative humidity, 22-25°C temperature and approximately 300-500 lx of light. Culture house was ventilated three to four times a day to maintain good aeration.

DATA COLLECTION

The number of sporophores (pin-head like appearance) and effective fruiting body (identified by the cural margin of the cap as described by Amin et al. (2007) were counted and recorded for consecutive three flushes of each bag. Fruiting bodies were uprootedas cluster by twisting from their base. The mean weight of three replicates of each strain was calculated for total yield (g). Fruiting bodies were weighed in order to obtain the biological and economic yield. The whole cluster of fruiting bodies was considered for biological yield (BY) and the cleaned fruiting bodies (separated from cluster by removing lower tough and dirty portion) were weighted to obtain economic yield (YE) (Sarker et al. 2007b). The biological efficiency (BE) was determined by the following formula.

BE = (g of fresh mushroom/g of dry substrate) × 100.

The productivity was determined based on wet weight of substrate.

NUTRITIONAL COMPOSITION

All the oyster mushroom strains were analyzed for proximate composition according to the Association of Official Analytical Chemists (AOAC 2005). The mean value of three replicates for each strain was calculated in all parameters, which included moisture, dry matter, protein, lipid, ash, carbohydrate, crude fiber and minerals such as nitrogen, calcium, magnesium, potassium, phosphorus, copper, zinc, manganese and iron. Nitrogen content was determined by Micro Kjeldahl methods using auto analyzer, phosphorus (P) values by spectrophotometer, Ca, Mg, Cu, Mn, Fe, Zn values using an Atomic Absorption Spectrophotometer, while potassium (K) values was determined by a flame photometer after standardizing against respective elements. The percentage of all the fractions (protein, fat, crude fiber and ash) were added together and subtracted with 100 to obtain the total carbohydrate, while the nitrogen and fat free extract (dry weight) was calculated as the percentage of the crude fiber.

STATISTICAL ANALYSIS

The experiment was performed in triplicate. The Shapiro-Wilk test and Bartlett's test were used to determine the normality and homogeneity of variance, respectively. In order to compare the means, one-way ANOVA was performed using the statistical package tool STAR (Version 1.1 2013, Biometrics and Breeding Informatics, PBGB Division, International Rice Research Institute, Los Baños, Laguna). A post-hoc Duncan's multiple range test ($p<0.05$ and $p<0.01$) was used to determine the significant differences between the means.

RESULTS

The number of sporophores, yield and biological efficiency (BE) varied significantly in different strains of oyster mushroom. The maximum number of sporophore was obtained in strain HK-51 followed by strain PG_1, both being statistically as par. The lowest number of sporophore was produced by strain PO_2. The number of sporophore differed significantly among other species (Table 1). Though the strain HK-51 produced the highest number of sporophore but the most of this sporophore did not mature fully. In terms of effectiveness of fruiting body, strain FLO was the best followed by strain PSC while strain PG_3 had the lowest (Table 1).

The highest BY was obtained from strain PG_1 followed by strain FLO, which was significantly higher compared to all other strains. Minimum BY was produced by PO_3 and PO_2. Maximum EY was also recorded by PG_1 and FLO while the minimum EY was produced by strain PO_3 and PO_2 and others produced intermediate yield. Similarly, maximum BE was recorded from strain PG_1 followed by strain FLO. On

TABLE 1. Sporophore formation, mushroom production and the productivity of *Pleurotus* strains using wheat bran supplemented sawdust

Pleurotus sp.	Total number of		Total yield (g/spawn bag)		BE (%)	Productivity (%)
	sporophore	EFB	BY	EY		
P. sajor-caju (PSC)	87.60^{b}	68.80^{b}	199.70^{c}	194.70^{c}	68.87^{bc}	38.94^{c}
P. flabellatus (FLB)	77.20^{b}	63.60^{b}	206.00^{b}	200.00^{b}	71.00^{b}	40.00^{bc}
P. florida (FLO)	102.40^{b}	81.80^{a}	230.30^{b}	227.30^{b}	79.43^{b}	45.46^{b}
P. ostreatus (PO_2)	70.80^{b}	34.40^{c}	171.40^{c}	163.20^{c}	59.10^{cd}	32.64^{d}
P. high-king (HK-51)	197.80^{a}	60.40^{b}	178.60^{c}	175.70^{c}	61.59^{c}	35.14^{c}
P. ostreatus (PO_3)	84.40^{b}	49.40^{bc}	163.80^{d}	157.80^{d}	56.48^{d}	31.57^{d}
P. geesteranus (PG_1)	191.60^{a}	30.40^{c}	278.00^{a}	273.60^{a}	95.85^{a}	54.72^{a}
P. geesteranus (PG_3)	184.60^{a}	25.00^{d}	188.50^{c}	185.20^{c}	65.00^{bc}	37.04^{c}
SEM	7.64	4.62	5.70	6.04	1.97	1.23

BE: Biological Efficiency, EFB: Effective Fruiting Body, BY: Biological Yield, EY: Economic Yield. Values are the mean of 3 replicates. Means followed by different letter (a, b, c or d) in column are significantly different at 1% level of significance

the other hand, minimum BE was obtained from strain PO_3 and PO_2 (Table 1). In this study, productivity of the strain followed a pattern similar to that of biological efficiency. The strain PG_1 showed the most productivity followed by strain FLO. A significant difference was found between the strain PG_1 and strain PO_2 while PG_1 showed identical performance regarding BE, EY and productivity.

Protein, lipid, carbohydrate, ash, crude fibre and dry matter contents of eight *Pleurotus* are described in Table 2. Moisture content and dry matter of the fruiting body ranged between 86 and 90 and 10 and 14, respectively. Significant difference was found in moisture content among all the strains. Maximum moisture content was found in FLO, PSC and PO_3 strains while that of PG_1 strain was the lowest. A reverse trend was observed in case of dry matter content among all the strains (Table 2).

The highest and the lowest protein content were found in PG_1 and FLO strains, respectively. Other strains contained intermediate and identical protein levels (Table 2). The strain PO_2 had the highest lipid content followed by strain HK-51. Strain PG_3 contained the lowest amount of lipid. The highest level of crude fibre was recorded in the strain PO_3. Minimum crude fibre was recorded from strain PO_2. Nitrogen, phosphorus, potassium, calcium, magnesium, copper, iron, manganese and zinc content in mushroom under investigation are presented in Table 3. Strain PG_1 contained the highest percentage of N and the lowest amount of N was recorded by strain FLO. Strain PG_3 contained the highest amount of K, Ca and Mg. The highest amount of Cu, Fe and Mn was recorded from the strain HK-51 (Table 3). Strain HK-51 also contained the lowest amount of Ca and Mg. The highest Zn content was found in strain PO_2. The lowest content of Cu was recorded in strain PO_2. The lowest amount of Fe, and Zn were found in strain PSC. The lowest amount of Kwas recorded in strain FLO. Strain FLB contained the highest amount of P followed by strain PO_2 and all other strains were statistically similar (Table 3).

DISCUSSION

The productivity of oyster mushroom has reduced due to the continuous culturing over the years, therefore, the selection of new strain is inevitable to ensure higher yield to meet consumers demand, especially for poor farmer who do not have facilities to control sterilization and incubation. The rate of sporophore formation by any given strain has an important implication in the production of oyster mushroom. Sporophore production of all the strains used in this experiment was significantly different. Strain HK-51 produced maximum number of sporophore compared to others. The number of sporophore was remarkable in strain PG_1 (Table 1). Islam et al. (2009) and Monadal et al. (2010) also found significantly different number of sporophore on *P. florida* and *P. flabellatus* (used different substrates of this experiment to grow mushroom), respectively, in Bangladesh.

Fruiting body is the commercial edible part of the mushroom. Among four cultivation steps of mushroom production, poor farmer or rural people can easily maintain the spawn bags for the production of fruiting bodies. Obodai et al. (2003) reported that, harvested mushroom quantity is significantly greater in composted sawdust than in any other substrate. In this study only effective fruiting bodies were considered for estimating the yield, biological efficiency and the productivity. During cultivation of mushroom, the highest number of fruiting body (in 3 consecutive flushes) was harvested from spawn bags (500 g) in strain FLO (Table 1). All sporophore did not mature to produce fruiting body. Amin et al. (2007) and Yoshida et al. (1993) has reported the similar result in case of other oyster mushroom strains by using wheat straw and paddy straw as substrates with different supplement, respectively. In this study, PG_1 produced about 50 g higher biological yields compared with the second ranked strain (FLO). The strain PG_1 produced more than twice fruiting bodies (Table 1) as compared to *P. ostreatus* (PO_2), though strain PO_2 is the mostly cultivated oyster mushroom in recent

TABLE 2. Moisture, dry matter and proximate composition of edible *Pleurotus* strains

Pleurotus sp.	Chemical components (%)						
	Moisture	DM	Protein	Lipid	Ash	CHO	CF
P. sajor-caju (PSC)	90.00^{a}	10.00^{b}	25.50^{b}	4.00^{b}	7.23^{d}	38.00^{ab}	25.20^{b}
P. flabellatus (FLB)	90.00^{a}	10.00^{b}	27.57^{ab}	$3.70c^{d}$	7.20^{d}	37.47^{ab}	24.37^{bc}
P. florida (FLO)	90.01^{a}	9.98^{b}	22.70^{d}	4.10^{ab}	8.33^{d}	39.07^{a}	25.77^{b}
P. ostreatus (PO_2)	89.40^{ab}	10.60^{ab}	28.40^{b}	4.68^{a}	8.60^{d}	35.40^{b}	21.80^{d}
P. high-king (HK-51)	87.80^{ab}	12.20^{ab}	28.00^{b}	4.14^{b}	11.53^{b}	29.20^{d}	23.60^{bc}
P. ostreatus (PO_3)	90.00^{a}	10.00^{b}	28.40^{b}	3.82^{c}	11.40^{b}	29.60^{d}	27.40^{a}
P. geesteranus (PG_1)	86.20^{b}	13.80^{a}	31.80^{a}	3.64^{cd}	12.80^{a}	33.40^{bc}	22.60^{c}
P. geesteranus (PG_3)	86.60^{b}	13.40^{a}	28.80^{b}	3.54^{d}	11.20^{c}	31.60^{c}	23.00^{b}
SEM	1.30	1.30	0.71	0.11	1.14	0.84	1.14

DM, dry matter; CHO, carbohydrate; CF, crude fibre. Values are the mean of 3 replicates. Three consecutive flushes of each replicate were mixed to determine the nutritional status. Means followed by same letter (a, b, c or d) in column are not significantly different at 1% level of significance

TABLE 3. Mineral content of different *Pleurotus* under investigation

Pleurotus sp.	Mineral content								
	mg/100 g dry weight						mcg/ 100 g dry weight		
	N	P	K	Ca	Mg	Fe	Cu	Mn	Zn
P. sajor-caju (PSC)	4.08^{c}	0.82^{b}	1.23^{c}	32.50^{b}	11.80^{b}	40.42^{c}	3.27^{c}	2.20^{c}	11.50^{cd}
P. flabellatus (FLB)	4.41^{bc}	0.92^{a}	1.29^{b}	31.10^{cd}	12.0^{a}	43.10^{bc}	3.39^{bc}	2.20^{c}	12.50^{c}
P. florida (FLO)	3.63^{d}	0.81^{b}	1.14^{d}	33.40^{ab}	11.0^{bc}	45.00^{b}	3.44^{b}	2.30^{b}	11.20^{d}
P. ostreatus (PO_2)	4.50^{b}	0.91^{a}	1.32^{b}	32.66^{b}	11.89^{ab}	42.05^{c}	3.16^{d}	2.52^{ab}	13.27^{a}
P. high-king (HK-51)	4.47^{b}	0.82^{b}	1.19^{c}	30.43^{d}	10.47^{c}	46.80^{a}	3.60^{a}	2.59^{a}	12.50^{c}
P. ostreatus (PO_3)	4.50^{b}	0.81^{b}	1.30^{b}	32.25^{bc}	10.62^{c}	46.80^{a}	3.50^{b}	2.43^{ab}	12.88^{b}
P. geesteranus (PG_1)	4.98^{a}	0.83^{b}	1.34^{b}	31.62^{c}	11.56^{b}	43.08^{bc}	3.46^{b}	2.33^{b}	12.50^{c}
P. geesteranus (PG_3)	4.61^{b}	0.84^{b}	1.43^{a}	33.77^{a}	12.19^{a}	45.60^{ab}	3.42^{b}	2.59^{a}	12.96^{b}
SEM	0.09	0.03	0.06	0.13	0.05	2.39	0.07	0.12	0.05

Values are the mean 3 replicates. Three consecutive flushes each replicate were mixed to determine the mineral content. N, Nitrogen; P, phosphorus; K, potassium; Ca, calcium; Mg, magnesium; Fe, iron; Cu, copper; Mn, manganese; Zn, zinc; mg, milligram; mcg, microgram; Means followed by different letter (a, b or c) in column are significantly different at 5% level of significance

years (Ahmed et al. 2013). Individual fruiting body weight of PG_1 was also higher than others. Our study differs with Pathmashini et al. (2008) who reported the highest biological yield for strain PO_2 in sawdust with koracan (*Eleusine coracana*) spawns. Biological efficiency is a very good standard parameter to determine the efficiency of substrate conversion in fruiting body. Productivity of the mushroom is very important because it is calculated based on the moist weight of the substrate. The strain PG_1 was biologically the most efficient and productive strain among all the strain used in this experiment. Sarker et al. (2007b) has reported similar yield for *Pleurotus ostreatus*. *Pleurotus* contains low calories and fats but high amount of good proteins with all the amino acid required for human and dietary fibres. Table 2 represents the proximate composition of *Pleurotus* species. Strain PG_1 recorded the highest protein, fat and fibre compared to strain PO_2. Chang et al. (1981) reported that the fruiting bodies of mushrooms contain 26.6-34.1% crude protein. This finding was also supported by the study of Khlood and Ahmad (2005). Strain PG_1 contained more than 5% crude protein comparing to the strain PO_2. Alam et al. (2007) reported similar data for protein (varied from 28.0-31.8% w/w) and lipid content (ranging from 4.3% to 4.4%) in case of *Pleurotus florida* Eger. and *Pleurotus sajor-caju* Fr. on different substrates. Strain PG1 contained maximum (12.8%) ash percentage followed by strain HK (11.5%). This result differed from Chang et al. (1981), but was supported by Alam et al. (2007).

FAO (2012) reported 14.9% of total population (852 million in number) living in developing countries are undernourished during 2010-2012 time period only considering dietary energy supply. Rural people (low income groups) in developing countries mainly depend on cereals, roots and tubers for daily energy (mainly comes from protein, fat and carbohydrate). This major food group production is currently declining for many reasons whereas mushroom production is increasing significantly in recent years. By including mushroom in the diet trend may raise available dietary energy. Though animal protein (meat, fish, milk, eggs) contains amino acid in wider range with micronutrients (iron, zinc & calcium), a negative concern also been developed simultaneously about it, especially about red meat because of their existing risk of heart disease, cancer, diabetes and obesity by eating animal protein (Micha et al. 2010).

All tested *Pleurotus* strains in this experiment contained significant ($p<0.01$; $p<0.05$) amounts of micro and macro nutrients. Strain PG_1 recorded the highest amount of N and moderate amount of P, K, Mg and Mn (Table 3). The results of this experiment agreed with Alam et al. (2007) and Chang et al. (1981) but Sarker et al. (2007a) found 0.97% P in oyster mushrooms grown on sawdust-based substrates. The following are the daily minimum micro and macro-nutrient requirements of an adult man: 2-3 mg copper, 10-15 mg iron, 12-15 mg zinc, 2.3 mg manganese, 1 000 mg calcium, 400 mg magnesium, 4.7 mg potassium and 700 mg phosphorus (Wildman & Medeiros 2000). Magnesium plays an important role to regulate potassium fluxes and calcium metabolism. Depletion body magnesium depresses the potassium level both in cellular and extra-cellular level. Conventional diets (plant source & vegetables) for magnesium source in rural area contain 500 mg magnesium per kg fresh weight (WHO & FAO 2004). *Pleurotus* examined in this study contains 10-12 mg of magnesiumin dry weight basis while strain PG_1 contain 1.13 mg of potassium, 33.77 mg of calcium, 2.59 mcg manganese, 12.96 mcg of zinc, 45.60 mg of iron in 100 gm dry mushroom whereas the conventional source (vegetables, cereals, fruits and animal source) of this nutrient also contained these micronutrients to some extent. The productivity of the conventional sources these

of minerals is declining due to climate change, natural disaster (flood & storm), global warming and reducing soil fertility (FAO 2012). As for mushroom production, all the above productivity declining factors have less effect as mushrooms are grown in controlled environment. The amount of macro and micro mineral contents in *Pleurotus*, to some extent, can fill the daily requirement if consumed.

CONCLUSION

Pleurotus strains are significantly productive and produce a significant number of fruiting body in sawdust, a low cost and widely used substrate for oyster mushroom production. The strain PG_1 performed the best compared with other cultivable *Pleurotus* strains. The strain $PG_1$is rich in protein, phosphorus, potassium, calcium, magnesium, iron and zinc. Using traditional cultivation procedure, PG_1 was the better *Pleurotus* strain compared with commonly cultivated *Pleurotus* strains considering sporophore productivity and nutrient status. Raising positive awareness on nutritional status and motivating rural people to include mushroom in their daily diet may improve the undernourished state in rural areas of developing countries. This may also help to protect people from diseases caused by nutrient deficiency. Increasing consumption of this mushroom and government initiative in small scale production would diversify agricultural production and may help to minimize poverty scenario in rural area.

ACKNOWLEDGEMENTS

The authors would like to thank University of Malaya for the grant Vote PPP/PV065-2012A and UMRG: RP005C/13AFR.

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Received: 7 May 2015
Accepted: 29 March 2016