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Economically viable Mushroom (*Pleurotus djamor*) farming for nutritional security in Uttarakhand

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ABSTRACT

Pink oyster mushroom *(Pleurotus djamor)* owns a pleasant colour, good sensory attributes, high nutritional value, anti-oxidant, anti-microbial and medicinal properties. Cultivation of different types of mushroom has been accepted as a short-term income generating avenue under crop production for livelihood of the farmers. The present study was carried out to assess the nutritional quality, anti-oxidant activities and economic benefits of pink oyster mushroom at Research farm of G B Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during 2015–18. The fresh whole mushroom was assessed for yield and physical parameters. It was exposed to 60 ± 2^0C temperature for 8 h to prepare dried mushroom powder. The dried powder was used for proximate composition analysis and anti-oxidant activity study. The cost to benefit ratio was calculated on the basis of gross expenditure and net profit incurred in the trial field. The high contents of protein, fat and carbohydrate along with good anti-oxidant property and biological efficiency revealed the mushroom as a rich source of quality nutrients. The yield of 740.60 g/kg wheat straw with benefit to cost ratio of 2.60 depicted economical viability of mushroom farming. The study concludes that, pink oyster mushroom farming can be explored for nutritional security in alleviating the malnutrition with economic benefits to the farmers in Uttarakhand.

Keywords: Biological efficiency, Benefit to cost ratio, Nutritional security, *Pleurotus djamor*

Agriculture is the pillar of Indian economy and offers livelihood for more than 58% of its population. The focus of Indian agriculture is to enhance the production and productivity of agricultural crops per unit of land as well as doubling the farmer's income (Maji and Biswas 2018). Due to short crop cycle, mushroom farming can be a suitable secondary agricultural activity for diversification of agriculture, enhancement of farm income, nutritional security and employment generation among the rural youth. Mushroom can be grown on agro-industrial by-products, whereby efficiently converting cellulose into protein rich biomass and also reducing environmental pollution. The typical climate of Uttarakhand is favorable for cultivation of pink oyster mushroom. Abundant availability of cheap substrate attracts farmers for mushroom cultivation (Singh *et al.* 2013). In India about 20 different species of mushroom are cultivated for culinary use, and among them pink oyster mushroom *(Pleurotus djamor)* has a pleasant colour, taste, flavour, low calories, high protein, dietary fibre, carbohydrates, vitamins, minerals, anti-oxidant, anti-microbial and medicinal properties. Mushroom is one of the most vital sources of vegetable protein which can alleviate the protein deficiency in India especially in vegetarian population. FAO has recommended it as a supplementary food item in context of world protein shortage for the growing populations of the developing countries. Uttarakhand produces 10236 metric tonnes mushroom including 1228 metric tonnes (12%) oyster mushroom per annum. Compared to other vegetables the per capita consumption of mushroom in India is meager and it is less than 100 g per year (Sharma *et al.* 2017). The present research aims to study the economic benefits, physical parameters, nutritional quality, phyto-constituents and anti-oxidant activities of pink oyster mushroom.

MATERIALS AND METHODS

The spawn was prepared and pink oyster mushroom was cultivated at the Mushroom Research and Training Centre, GBPUA&T, Pantnagar (2015–18). Wheat straw was used as substrate for mushroom cultivation.

Assessment of physical parameters: Fruiting bodies of mushrooms (n=50) of different sizes were selected randomly

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from a single lot for assessment of physical characters such as pileus thickness, pileus diameter, pileus length, stipe length, stipe diameter, weight, yield, bulk density, colour, waste index and biological efficiency. The pileus thickness, stipe length and stipe diameter were measured in Vernier slide calipers and the pileus length and diameter were measured by using standard scale. The biological and economic yield was calculated according to Girmay *et al.* (2016). The biological yield (g) was determined by weighing the whole cluster of mushroom fruiting bodies without removing the base of stalks in an analytical balance, and economic yield (g) was determined by weighing all the mushroom fruiting bodies after removing the base of stalks. The bulk density was determined as:

$$\text{Bulk density} = \frac{\text{Weight of sample (g)}}{\text{Volume (ml)}}$$

The colour of the mushroom was determined using digital camera and subsequent analysis was done using Adobe Photoshop CS v.7.0 software. The L, a, b values were determined following the standard procedure where L indicates lightness, a stands for red/green coordinate and b denotes yellow/blue coordinate. The mean and standard deviation values were determined from the histogram obtained from the software. L, a, b values are not standard colour values and need to be converted to L*, a* and b*. The values for L*, a*, b* were evaluated as per the formulae given in equation 1 to 3.

$$L^* = \frac{\text{Lightness}}{255} \times 100 \quad (1)$$

$$a^* = \frac{240a}{255} - 120 \quad (2)$$

$$b^* = \frac{240b}{255} - 120 \quad (2)$$

The basal part of the stipe that includes the rhizomorph and adhered substrate was removed as a waste and the waste index was determined as:

$$\text{Waste Index (\%)} = \frac{\text{Weight of mushroom waste (g)} \times 100}{\text{Weight of mushroom (g)}}$$

The biological efficiency of the mushroom was calculated as:

$$\text{Biological efficiency (BE)} = \frac{\text{Fresh weight of mushroom (g)} \times 100}{\text{Dry weight of substrate (g)}}$$

Analysis of nutritional composition: The whole fresh mushroom was dried at 60±2°C temperature for 8 h in cabinet tray drier. After complete drying it was powdered and sieved through 60 mesh (Raman *et al.* 2020). The mushroom powder was packed in 50 µ polyethylene bag and kept in desiccator. The chemical analysis of the samples was done in three replications. The proximate composition (moisture, crude protein, crude fat, total ash and crude fibre) and minerals (calcium and iron) were estimated following the standard procedure. The physiological energy was determined and the total carbohydrate was calculated as:

Total carbohydrate (by difference)=100-[weight in grams (moisture+crudeprotein+crude fat +total ash) in 100 g of food sample]

Analysis of polyphenolic constituents and anti-oxidant activity: The methanol extract of mushroom powder was prepared by soaking 10 g of dried powder in 5 ml of methanol (2 g/ml) followed by filtration and it was processed for different and specific chemical tests for detection of polyphenolic constituents such as tannins, flavonoids, steroids, terpenoids, saponins and cardiac glycosides. Total phenol was analysed according to the method given by Singleton and Rossi (1965). Five grams of fresh mushroom sample was dissolved in 50 ml of methanol and the homogenate was centrifuged at 3000 G at 4°C for 30 min. The supernatant was filtered with WhatmanNo.4 filter paper. To the mushroom extract (200 µl), 1.8 ml distilled water and 1 ml of Folin and Ciocalteu's phenol reagent was added. After 2 min, 2 ml of 20% sodium carbonate solution (Na_2CO_3) was added. Thereafter, the reaction was allowed to proceed in the dark for 90 min and absorbance was taken at 750 nm using UV-VIS spectrophotometer. Graded gallic acid was used to calculate the standard curve and the results were expressed as mg of gallic acid equivalent (GAE) per g of sample.

The total flavonoid was estimated by using the method of Barros *et al.* (2008). The assay mixture was prepared with 250 µl mushroom extract, 1.25 ml distilled water and 75 µl 5% $NaNO_2$ and incubated for 5 min at room temperature followed by addition of 150 µl 10% $AlCl_3$. After 5 min, 500 µl of 1 M NaOH and 275 µl distilled water were mixed and the optical density of the colour was measured spectrophotometrically at 510 nm. The total flavonoid content was expressed in mg of quercetin equivalent (QE)/g of sample with reference to the quercetin standard curve.

Anti-oxidant activity or free radical scavenging of the extracts was measured by 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay following the standard procedure.DPPH (0.1 mM) solution was prepared in methanol and 1 ml of DPPH solution was added to 3 ml of methanol extracts of *Pleurotus djamor* at different concentrations (20, 40, 60, 180 µg/ml). The mixture was shaken vigorously and allowed to stand at room temperature for 30 min. The absorbance was measured at 517 nm in UV-VIS spectrophotometer. Lower absorbance of the reaction mixture indicated higher free radical scavenging activity. Inhibition of DPPH free radicals was calculated as:

$$\text{Inhibition of DPPH radical (\%)} = 100 \times (A_{control} - A_{sample})/A_{control}$$

where $A_{control}$ = Absorbance of the control solution; A_{sample} = Absorbance of the test extract

Economics of cost of cultivation and benefit to cost ratio of mushroom: Based on the total cost of production, return

and net profit of mushroom in one harvest, the benefit to cost ratio was calculated.

Statistical analysis: The data was analysed for calculation of mean and standard deviation (SD) of the samples following the suitable statistical methods.

RESULTS AND DISCUSSION

Physical parameters: The average pileus thickness, pileus diameter, pileus length, stipe length, stipe diameter and weight of fresh pink oyster mushroom grown in wheat straw substrate were 0.25 cm, 8.63 cm, 6.68 cm, 1.37 cm, 1.17 cm and 11.90 g, respectively. The biological and economic yield was 740.60 and 721.42 g/kg of substrate, respectively. The bulk density was 0.47 g/ml. The colour values were found to be L*-57.38; a*-8.02 and b*-11.26. The waste index and biological efficiency were 2.59 and 74.06%. Mishra *et al.* (2015) found that fresh pink oyster mushroom grown in wheat straw substrate had average pileus length of 4.9 cm, pileus diameter of 7.5 cm, and biological yield of 750.50 g/kg of substrate with 75.05% biological efficiency. Hasan *et al.* (2015) observed that the pileus diameter, pileus thickness, stipe length and stipe diameter of pink oyster mushroom grown in sugarcane bagasse with different levels (0–50%) of wheat bran supplementation ranged from 5.0–6.53 cm, 0.38–0.61 cm, 0.99–1.94 cm and 0.72–1.15 cm, respectively. Ibrahim *et al.* (2015) analysed the colour of the pileus of fresh pink oyster mushroom (*Pleurotus flabellatus)* cultivated on saw dust and oil palm frond (OPF) using a Minolta Chroma Meter (Model CR 200 Trimulus Colour Analyser, Minolta camera Co. Ltd., Japan). The result showed that the L*, a* and b* values for sawdust and OPF were 92.15 ± 0.79, 0.22 ± 0.73, 7.53 ± 1.74 and 90.13 ± 0.99, 3.92 ± 1.89, 10.73 ± 3.70, respectively. Oluwafemi *et al.* (2016) reported the bulk density of oyster mushroom (*Pleurotus ostreatus)* was 0.50 g/ml. Singh *et al.* (2017) observed that pink oyster mushroom grown in wheat straw substrate had average pileus length, pileus diameter and weight 9.0 cm, 9.67 cm and 29.99 g, respectively.The biological yield was 450 g/kg of substrate with biological efficiency 45%. *Pleurotus djamor* spawn treated with different types of sugar additives and grown in wheat straw substrate had pileus length, pileus diameter and weight range of 6.33–9.80 cm, 6.0–9.50 cm and 16.78–25.98 g, respectively. The biological yield increased from 400–613.33 g/kg substrate showed 40–61.33% biological efficiency reported by Singh *et al.* (2017). Singh *et al.* (2013) reported the biological efficiency of *Pleurotus djamor* (118%) on wheat straw substrate in hills of Uttarkashi (Uttarakhand).

Nutritional composition, phyto-constituents and anti-oxidant activity: The nutrient contents, phyto-constituents and anti-oxidant activity of fresh pink oyster mushroom have been presented in Table 1. The fresh pink oyster mushroom contained 87.04% moisture. The crude protein, crude fat, total ash, crude fibre and total carbohydrate contents were 23.63, 2.90, 5.49, 21.47 and 46.49 g respectively on dry weight basis. The 100 g dried mushroom powder provided 307 kcal energy, 26.66 mg calcium and 4.54 mg iron. Zurbano *et al.* (2017) observed that *Pleurotus djamor* contained 90.15% moisture. Similarly, Hasan *et al.* (2015) observed 19–31 g crude protein, 7–9.5 g ash, 33–55 g carbohydrate, 20–50 g crude fibre and 21.19–23.54 mg calcium per 100 g of *Pleurotus djamor* mushroom grown on different substrates**.**

Table 1 Nutritional composition, phyto-constituents and anti-oxidant activity of fresh dried pink oyster mushroom

Parameter	Quantity[#]
Moisture (g%)	87.04 ± 0.11
Crude protein (g%)	23.63 ± 0.26
Crude fat (g%)	2.90 ± 0.04
Total ash (g%)	5.49 ± 0.03
Crude fiber (g%)	21.47 ± 0.09
Total carbohydrate (g%)	46.49 ± 0.36
Energy (Kcal)	307.00 ± 4.59
Calcium (mg/100 g)	26.66 ± 5.57
Iron (mg/100 g)	4.54 ± 0.07
Total phenol (mg GAE/g)	7.72 ± 0.09
Total flavonoid (mg QE/g)	2.48 ± 0.04
Free radical scavenging activity, DPPH (%)	8.19 ± 0.26

[#]Values in the table are means ± SD (n=3)

Qualitative detection of phyto-constituents in methanol extract of pink oyster mushroom powder by different specific chemical tests revealed that tannins, flavonoids, terpenoids, cardiac glycoside and saponins were present except steroids. Phytochemical screening assay of the ethanol extracts of the five edible mushrooms such as *Pleurotus ostreatus*, *Pleurotus ostreatus*, *Pleurotus florida, Pleurotus sajor-caju* and *Calocybe indica* were carried out by Chatterjee *et al.* (2015). They observed that the phyto-constituents such as phenol, flavonoids, terpenoids, steroids and saponins were present except tannins.

Total phenol and flavonoid content of the fresh pink oyster mushroom was 7.72 mg GAE/g and 2.48 mg QE/g, respectively.The inhibition of DPPH free radical scavenging activity was 8.19%. Saha *et al.* (2012) found fresh *Pleurotus djamor* (Fr.) Boedijn had only 1.2–2.7 mg/g of total phenol. The beneficial properties of the phyto constituents was evident from *Geastrum saccatum* mushroom for anti-inflammatory, anti-diabetic, antioxidant and iron chelating properties (Mane *et al.* 2021).The variation between composition may be due to varietal difference and it also depends upon the quality of substrate used.

Economics of cost of cultivation and benefit:cost ratio of mushroom: The economics of cost of production of pink oyster mushroom is presented in Table 2. The gross expenditure was ₹113550.00 and gross return was ₹296240.00 with net profit of ₹182690.00 for 2500 bundles in one harvest. The calculated benefit cost ratio was 2.60. The non-recurring expenditure was one-time investment; hence in the further crop cycle the gross return would be

Table 2 Economics of cost of cultivation of pink oyster mushroom (2500 bundles)

Particular	Quantity	Amount (₹)
a. Non-recurring expenditure		
Low cost mushroom shed	1	28000.00
Sprayer pump	1	1500.00
Rack	4nos	24000.00
Cement tank	2nos	20000.00
Steel Utensils	-	1500.00
b. Total expenditure		75000.00
Recurring expenditure		
Wheat straw	10 quintal @ ₹200/q	2000.00
Spawn	160kg @ ₹100/kg	1600.00
Chemicals	-	1000.00
Polythene bag (30 × 45 cm)	2550 nos @ ₹4/bag	10200.00
Labour cost	30 days @ ₹250/day	7500.00
Miscellaneous expenditure (electricity, water, packaging etc.)	-	5000.00
Total expenditure		27300.00
Less (15%) depreciation on non-recurring items		11250.00
Gross expenditure		113550.00
Gross income		
Total mushroom harvested	37.03 q @ ₹80/kg	296240.00
Net profit		182690.00
Benefit:cost ratio		2.60

more with less expenditure and benefit to cost ratio (BCR) would be higher. The BCR of oyster mushroom was 3.47 as reported by Chitra *et al.* (2018). However, Nayak *et al.* (2019) estimated the BCR of oyster mushroom (*Pleurotus florida*) to be 2.96. The benefit to cost ratio depends upon the cost of cultivation and the total mushroom harvested with selling price of mushroom.

The pink oyster mushroom *(Pleurotus djamor)* possesses promising nutritional and antioxidant properties. The high protein and carbohydrate contents can potentially be explored for supplementation in vegetarian diet for alleviating the protein calorie malnutrition. The dietary fibre and beneficial phyto-phenols with anti-oxidant properties can decline the risk of degenerative diseases. The short-duration, high yield on wheat straw and economic benefit to cost ratio depicts oyster mushroom farming as a suitable venture for doubling the farmers' income in Uttarakhand.

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