Biological Forum – An International Journal **14(4): 944-951(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Influence of different Growth Substrates and their Combination on Nutritional and Mineral contents of Oyster Mushroom (*Pleurotus florida*)

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(Received 02 September 2022, Accepted 25 October, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The effect of different growth substrates on nutritional (moisture percent, vitamin-c, carbohydrate, protein & ash) and mineral (Zn, Fe & Mn) contents of oyster mushroom (*Pleurotus florida)* was studied in the present investigation. In India, rice straw is mainly used as substrate for large scale mushroom production. But there are other materials also which are cheaper than rice straw and can also enhance the nutritional quality of mushroom. Thus, to explore those cheap and easily available growth substrates other than rice straw, the effect of seven substrates including rice straw (RS), newspapers (NP), coconut husk (CH), sugarcane bagasse (SB), wood residue (WR), sal leaves (SL) (*Shorea robusta*), and *Lantana camara* (LC) were studied solely and in combinations *viz.* RS+NP, RS+ SL, and NP + SL@ 1:3, 1:1, and 3:1 ratio. The results indicated that when the oyster mushroom grown solely on different growth substrates, mushroom harvested from LC had highest moisture (96.13%) and zinc (10.42 mg/ 100gdry weight/dw), whereas RS had highest vitamin-c (11.51 mg/100 g fresh weight/fw) and manganese (3.63mg/100gdw) content. Mushroom grown on SB reported maximum carbohydrate (43.96g/ 100g dw). Highest amount of protein (29.44g/ 100g dw) was obtained from SL. Among the different substrate combinations highest vitamin-c (11.50mg /100 g fw) and manganese (3.11 mg/100g dw) were reported from RS + NP (3:1); highest carbohydrate (38.17g/ 100g dw) from RS + SL (3:1); highest protein (26.46g/ 100g dw) from RS + SL (1:3); highest ash (10.96g/ 100g dw) and iron (18.87 mg/ 100g dw) from RS + NP (1:3).

Keywords: Growth substrates, mineral content, nutritional content, oyster mushroom.

INTRODUCTION

The world's arable land resources are rapidly depleting, but food consumption is steadily rising in parallel with the growing population. This impedes the food production and increasing the demand for quality food. In this context, mushroom farming is a smart move that reduces environmental pollution, unemployment and food demand while also producing a highly valuable, protein-rich food suitable for all age grouped people with high biological value (Nongthombam *et al.*, 2021). Oyster mushrooms (*Pleurotus florida*) with its ability to grow within a short time span, less water and less space requirement has left behind other types of mushrooms in terms of production and demand (Muswati *et al.*, 2021). Oyster mushroom is becoming more well recognized as key food items because of its crucial contribution to nutrition, human health, and disease prevention. Protein, carbohydrates, minerals like Ca, P, K, Fe, and Na, vitamins like thiamine, niacin, riboflavin, vitamin-C, vitamin-D and folic acid are abundantly present in *Pleurotus florida* (Ahmed *et al.*, 2009; Manikandan 2011;Yao *et al.*, 2019). Instead of cholesterol, ergosterol the precursor for vitamin D synthesis in human body is present in mushroom making it easily digestible (Oei, 2005). In addition to its nutritional benefits, its medicinal efficacy for the treatment of cancer and diabetes has been emphasized (Sivrikaya *et al.*, 2002). Furthermore, it contains a wide range of metabolites which poses antigenotoxic, antitumor, antioxidant, antihyperglycemic, antihypertensive, antimicrobial, and antiviral properties (Chang, 2007; Davila *et al.*, 2020; Meng *et al.*, 2016). Another interesting thing is that oyster mushroom requires less amount of nitrogen and more carbon for growth. Thus, it can be grown on materials that have abundant quantity of lignin, cellulose and hemi cellulose such as different agricultural waste products including saw dust, rice straw, sugarcane baggase,

wheat straw, corncob, banana leaves etc. (Dubey *et al.*, 2019; Neupane *et al.*, 2018). In India mushroom cultivation was first started in 1943 by Thomas in Agricultural College, Coimbatore (Prakasam, 2012) but this sector's growth rate is very disappointing. This is because majority of the farmers are unaccustomed with the effectiveness and techniques of producing *Pleurotus* mushrooms using other agricultural wastes materials and are restricted to grow mushrooms using only rice straw. Thus, the objective of the study was to identify the impact of various substrates and substrate combinations on the nutritional and mineral content of *Pleurotus florida*.

MATERIALS AND METHODS

The pure culture of *Pleurotus florida* was collected from Department of Plant Pathology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, 741252, West Bengal, India and culture was maintained on Potato Dextrose Agar (PDA) media at 4°C. Sub culturing was done in every 15 days. Rice straw (RS) and guphool (*Lantana camara)*(LC) were collected from Jaguly Instructional farm, B.C.K.V. and the remaining substrates like newspaper (NP), coconut husks (CH), sal leaves (SL) (*Shorea robusta*), sugarcane bagasse (SB) and wood residue (WR) (bark of dry timber) were brought from local market. The entire process of mushroom cultivation was practiced in an isolated room within the department of Plant Pathology during 2018-2020. After harvesting of mushroom moisture percent and other nutritional parameters were analyzed. Statistical analysis was done using OPSTAT website.

Determination of moisture content

Moisture percent of fresh mushroom was estimated by the conventional method. At first weight of empty aluminum box (W1) was taken. Then the weight of box along with certain amount of fresh mushroom (W2) was taken. Thereafter the box containing mushroom was kept in hot air oven at 65°C for 2 days. Thereafter the weight of box along with dried mushroom (W3) was taken. Then moisture percentage was estimated by the following equation

Moisture (%) = {(W2-W3)/ (W2-W1)} × 100

Estimation of vitamin C content. Ascorbic acid (vitamin c) estimation was done by titrimetric analysis using 2, 6 dichlorophenol indophenol dye. At first 52 mg2, 6 dichlorophenol indophenol and 42 mg sodium bicarbonate ($NaHCO_3$) were dissolved in 50 ml water and then diluted to 200 ml. The dye solution was prepared, filtered and stored in dark place. Then, 50 mg ascorbic acid was dissolved in 250 ml of 0.6% oxalic acid to make Standard Ascorbic acid solution. Thereafter, 2g fresh mushroom was crushed with 10 ml 0.6% oxalic acid to extract juice and the volume was then made up to 100 ml. The burette was then washed and filled with dye solution until it reached the convenient mark. 10 ml standard ascorbic acid solution was pipette out and was taken in a clean conical flask. It was then titrated against the dye already taken in the burette. The development of a persistent, pale pink tint persisted for 10 minutes served as the indicator for the titration's endpoints. The titrations were repeated for 3 times and average reading was taken (V1). Then the dye equivalent of standard ascorbic acid was calculated. A clean conical flask was then filled with 10 ml of the mushroom extract solution. It was then titrated against the dye taken in the burette, until the desired, long-lasting pale pink color was developed. The titrations were repeated 3 times and average was taken (V2). The amount of ascorbic acid in the provided solution was determined using the dye equivalent of ascorbic acid.

Amount of ascorbic acid (mg.) present in 100 g of mushroom = {(0.5 × V2 × volume of mushroom solution taken for titration) / (V1 × 5 × weight of the mushroom sample)} × 100

Determination of carbohydrate concentration. The Anthrone method (1946) was followed to estimate the total carbohydrate content. Initially, 1 ml of ethanolic extracted mushroom sample was hydrolyzed with 5 ml 2.5 N Hcl in a boiling water bath for three hours and then cooled to room temperature. Then the mixture was neutralized with sodium carbonate (Na_2CO_3) and volume was made up to 100 ml. After centrifugation, 4 ml of anthrone reagent was added to the supernatant in a test tube. The test tubes were heated to a temperature of 100 to 120°C in a hot water bath for eight minutes and then cooled down to normal room temperature. The absorbance of the solution was then estimated at 630 nm in a spectrophotometer. Standard carbohydrate concentration was plotted on the X-axis and absorbance was plotted on the Y-axis to make a standard graph. From this graph carbohydrate content was calculated.

Estimation of soluble protein concentration. The soluble protein concentration of the mushroom per 100g dry mushroom powder was determined by Lowry's (1951) method. First, a 500 mg sample of mushrooms were weighed and thoroughly ground with 5–10 ml of the buffer using a pestle and mortar. The supernatant of the extract collected after centrifugation was used for estimation of protein. The two reagents *i.e.*, (i) (2% Na_2CO_3 in 0.1 N NaOH) and (ii) (0.5% $CuSO_4.5H_2O$ in 1% potassium sodium tartrate) were added together in a ratio of 50:1. Before using the Folin-Ciocalteu's Reagent-FCR was diluted thoroughly. 0.2, 0.4, 0.6, 0.8 and 1 ml of the same protein solution was taken in 5 different test tubes. Then 0.1 and 0.2 ml of the previously extracted sample was taken in two different test tubes. Distilled water was added to all the 7test-tube to make up the volume 1 ml. In each tube both the reagents (i and ii) @ 5 ml/tube was added followed by further addition of Folin- Ciocalteu's Reagent @0.5 ml/tube of FCR after 10 minutes. After 30 minutes, the absorbance of the solution was measured at 660 nm in a spectrophotometer. A standard

graph was generated by placing standard protein concentration along the X-axis and the absorbance along Y-axis. The graph is then used to calculate the amount of protein present in the mushroom sample.

Estimation of Ash content. Ash content of dried powdered mushroom was determined according to the method of A.O.A.C (1960). First, a 2 g sample of the finely crushed mushroom was taken in a crucible and heated at 550 to 600^{o} C for five hours in a carbolite muffle furnace. Thereafter it was placed in a desiccator to cool down. The ash content was determined by comparing the weights of the crucible with and without the sample before and after ashing. This was done repeatedly until the weights of two successive measurements were the same and the ash was nearly white or greyish white in colour. Then total ash was calculated in g/ 100g of dry weight.

Estimation of micronutrients. The atomic absorption spectrophotometric (AAS) method was followed to estimate the micronutrient content of the mushroom. First, 0.5 g of powdered mushroom sample was placed in a digestion tube with 5 ml nitric acid and 2.5 ml perchloric acid. After being thoroughly mixed, the solution in test tubes was heated in a boiling water bath for 10 to 12 hours at about 100°C, and then cooled to room temperature. Next, 2.5 ml of nitric acid was mixed to the mixture in each tube, and the mixture was reheated for 3–4 hours in a boiling water bath until it became transparent. After cooling, the solutions were filtered through Whatman No. 1 filter paper. The filtered volume was made up to 100 ml with de-ionized distilled water. 14 ml of each treatment's solution were pipetted into new test tubes as an aliquot. 14 ml of de-ionized distilled water was taken in a test tube as check. The concentration (ppm) of the solution was estimated using hollow cathode lamp of AAS with specification of wave length i.e., 248.3 nm for Fe, 279.5 nm for Mn and EDL lamp of AAS with specification of wave length for Zn (213.9 nm)[9]. The amount of micronutrient content in the mushrooms was calculated in mg/100g of dry weight basis from the concentrations (ppm) of the solutions.

RESULT AND DISCUSSION

Effect of different substrates on moisture and nutrition contents of oyster mushroom. Harvested mushroom from different substrates such as rice straw, newspapers, coconut husk, sugarcane bagasse, wood residue (bark of dry timber), sal leaves (*Shorea robusta*), and guphool (*Lantana camara*) was used for determination of moisture and other nutrient contents such as vitamin-c, carbohydrate, protein, ash and some micronutrient like zinc, iron and manganese. The observations of moisture and nutrient content (dry weight basis) were analyzed and presented in Table 1.

Moisture Contents. Mushroom typically has high moisture content. Fresh mushroom contains 90% moisture and 10% dry matter. In results in Table 1 indicated that highest moisture contents (96.13%) were recorded using *Lantana camara* as substrate followed by newspaper (95.15%), sal leaves (94.30%), sugarcane bagasse (94.28%), wood residue (94.04%) and coconut husk (93.15%) respectively. Lowest moisture content (92.87%) was observed when mushroom harvested from rice straw. Hoa *et al.* (2015) stated that moisture percent of *Pleurotus ostreatus* and *Pleurotus cystidiosus* varies from 89.37-91.56% and 86.95-92.45% respectively and that are close enough to our present finding. Mintesnot *et al.* (2014) also reported 85.6-93.4% moisture is present in *Pleurotus sajor-caju*.

Vitamin-C Contents. The results (Table 1 and Fig. 2) revealed that maximum vitamin-c contents (11.51 mg /100 g fresh weight) were obtained from rice straw while newspaper contained 11.29 mg/ 100g fresh weight vitamin-c followed by coconut husk (11.25 mg), *Lantana camara* (11.08 mg), sugarcane bagasse (11.08 mg), sal leaves (10.57 mg)in 100g fresh weight. Lowest vitamin-c content (10.46mg/ 100g fresh weight) was recorded from wood residue. Very little variation was observed in case of vit-c content among different growth substrates. Our finding closely matches the result of Iqbal *et al.* (2016) *i.e.*, 11.11- 11.35mg of vit-c is present in *Pleurotus florida* per 100g of fresh sample.

Carbohydrate content. Results presented in Table 1 and Fig. 1 showed that highest carbohydrate content (43.96g/ 100g of dry weight) of *P. florida* was obtained from sugarcane bagasse followed by Coconut husk (38.85g/ 100g dry weight), rice straw (38.17g/ 100g of dry weight), and sal leaves (37.86g/ 100g of dry weight). *Lantana camara* have the lowest amount of carbohydrate (31.45g/ 100g of dry weight) among all the substrates while wood residue showed comparatively better carbohydrate contents (32.44 g/100g of dry weight) than *Lantana camara*. Patil *et al.* (2010) explained that carbohydrate content of *Pleurotus ostreatus* was 50.50-55.33g grown on dry wheat straw, soybean straw and paddy straw. Sharma *et al*. (2013) also found 30.24-42.26g of carbohydrate in *Pleurotus ostreatus* grown on 100g of various dry substrates which is similar to our experiment.

Protein contents. The result indicated that sal leaves showed the highest protein content (29.44g/ 100g of dry weight) among all the substrates. It was followed by newspaper (23.93g), wood residue (22.43g), sugarcane bagasse (21.57g) and *Lantana camara* (19.13 g) per 100g of dry weight of mushroom fruit body respectively. Lowest protein content (14.01g/ 100g of dry substrate) was recorded from coconut husk. Mushroom from rice straw showed comparatively less amount of protein content (17.66g per 100g of dry weight) than other substrates (Table 1 and Fig. 1). According the experiment of Hoa *et al.* (2015) protein content of *Pleurotus cystidiosus* and *Pleurotus ostreatus* ranges from 15.68-24.54g and 19.52-29.70g respectively on 100g dry substrates that closely matches our findings.

Ash contents. The ash content of mushroom harvested from sugarcane bagasse was found highest (11.73g/ 100g dry weight) among all the substrates. Mushroom harvested from coconut husk exhibited 11.52g ash content per 100g dry weight followed by newspaper (10.83g/ 100g dry weight), rice straw (10.59g/ 100 g of dry weight) and *Lantana camara* (9.81 g/100g dry weight) respectively. Very less amount of ash content (5.70 g/100g dry weight) was recorded from wood residue while minimum was observed from sal leaves (5.50g/ 100g dry weight) (Table 1 and Fig. 1). Ash content in the experiment of Hoa *et al*. (2015) *i.e.*, 5.90-7.10g per 100g dry substrates in case of *Pleurotus ostreatus* and 6.30-7.57g per 100g dry substrates in case of *Pleurotus cystidiosus* was very much close to our result. Little variation may be due to the substrates and mushroom strain used in the experiment.

Zinc contents. From the Table 1 and Fig. 2 it is evident that *Lantana camara* hold the maximum amount of zinc (10.42 mg/ 100g of dry weight) followed by wood residue (9.62 mg), newspaper (8.89mg), sal leaves (8.64mg), sugarcane bagasse (8.26 mg) and coconut husk (8.03 mg) per 100g of dry weight. Minimum amount of zinc was estimated from rice straw (7.70 mg/ 100g of dry weight).Our finding was very much similar to the finding of Onyeka *et al*. (2018) *i.e.*, 5.2-7.5mg of zinc is present in 100 g dry mushroom.

Iron contents. Iron content of *P. florida* from different substrates were analyzed and result in Table 1 and Fig. 2 indicated that highest iron content (18.38mg/ 100g dry weight) was found from newspaper while lowest (8.85mg/ 100g of dry weight) from sal leaves. Iron content of mushroom from other substrate were recorded as rice straw (16.13mg), coconut husk (13.94 mg), *Lantana camara* (13.52 mg), wood residue (11.22 mg) and sugarcane bagasse (9.54 mg) per 100g of dry weight of mushroom. Onyeka *et al.* (2018) obtained 19.3-29.7mg of iron per 100g dry mushroom of *Pleurotus ostreatus* grown on different substrates is close to our present findings.

Manganese contents. The present study revealed that highest manganese content (3.63mg/100g dry weight) was recorded from rice straw substrate and it was followed by newspaper (2.07mg/ 100g dry weight), sal leaves (1.75mg/ 100g dry weight) and *Lantana camara* (1.32mg/ 100g dry weight).

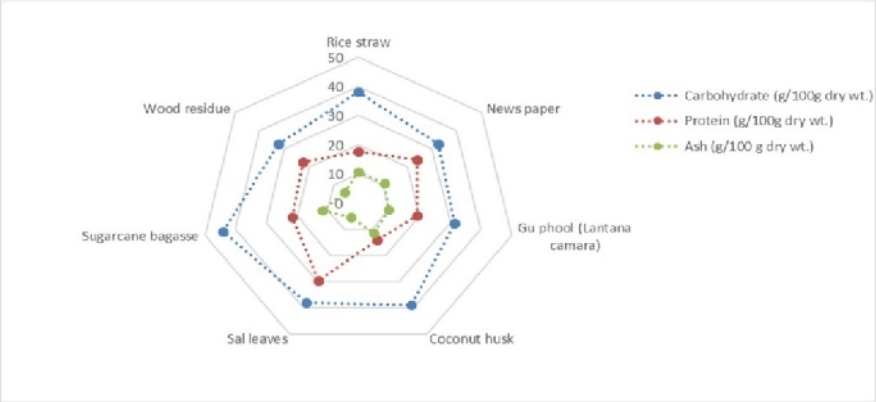

Fig. 1. Carbohydrate, protein and ash content of *P. florida* grown on different substrates.

Table 1: Moisture and nutrient content of oyster mushroom (*Pleurotus florida*) on different substrates

Substrate	Moisture (%)	Vit-c (mg/100 g fresh weight)	Carbohydrate (g/100g dry weight)	Protein (g/100g dry weight)	Ash (g/100 g dry weight)	Zinc (mg/100 g dry weight)	Iron (mg/100 g dry weight)	Manganese (mg/100g dry weight)
Rice straw	92.87	11.51	38.17	17.66	10.59	7.70	16.13	3.63
News paper	95.15	11.29	32.71	23.93	10.83	8.89	18.38	2.07
Guphool (*Lantana camara*)	96.13	11.08	31.45	19.13	9.81	10.42	13.52	1.32
Coconut husk	93.15	11.25	38.85	14.01	11.52	8.03	13.94	0.89
Sal leaves	94.30	10.57	37.86	29.44	5.50	8.64	8.85	1.75
Sugarcane bagasse	94.28	11.08	43.96	21.57	11.73	8.26	9.54	0.74
Wood residue	94.04	10.46	32.44	22.43	5.70	9.62	11.22	0.78
SEM	0.79	0.28	0.50	0.44	0.23	0.23	0.25	0.10
CD	NS	NS	1.54	1.35	0.72	0.72	0.77	0.31

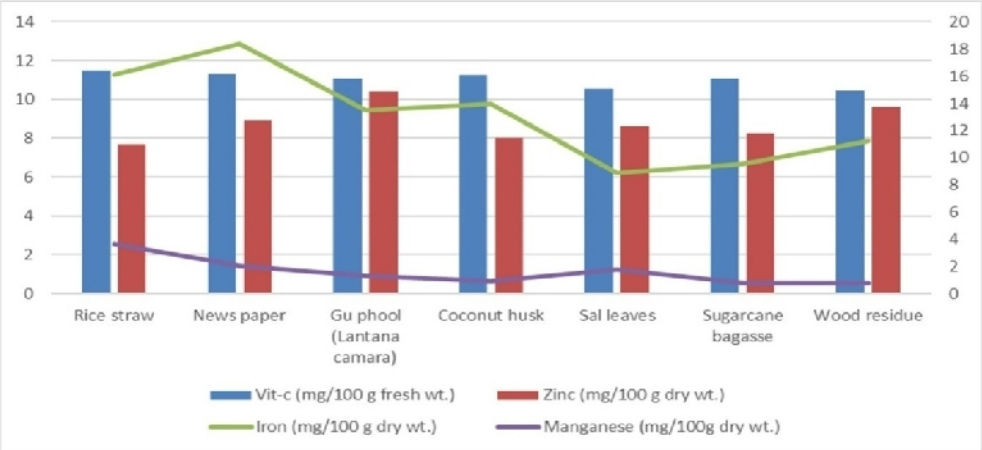

Fig. 2. Vitamin-c, zinc, iron and manganese content of *P. florida* grown on different substrates.

Lowest manganese content was obtained from sugarcane bagasse (0.74 mg/ 100g dry weight). Coconut husk (0.89 mg/ 100g dry weight) and wood residue (0.78 mg / 100g dry weight) showed low amount of manganese content. Nasiruddin *et al.* (2018) estimated 1.29 -9.33 mg of manganese /100g of dry weight of *Pleurotus* sp. resembling our present observation.

Effect of different substrate combinations on moisture and nutrition contents of oyster mushroom. In the present investigation moisture and different nutrient content of oyster mushroom grown on different substrate combinations *viz.*, rice straw + newspaper, rice straw + sal leaves, and newspaper + sal leaves @ 1:3, 1:1, and 3:1 ratio was estimated. All these substrates were mixed (dry weight basis) @ 1:3, 1:1, and 3:1 ratio among each other. Oyster mushroom (*P. florida*) was grown in each substrate combinations and after final harvest mushroom fruit body samples were analyzed. Determination of moisture content and other nutrients such as vitamin-c, carbohydrate, protein, ash and some micronutrients like zinc, iron and manganese were studied and results are presented in Table 2.

Moisture content. Result presented in Table 2 showed that maximum moisture contents (94.81%) was observed in mushroom produced from NP+SL (1:1) followed by 94.67% from RS+NP (1:3), 94.39% from NP+SL (3:1), 94.01% from RS+NP (1:1) and 93.86% from RS+SL respectively. Minimum moisture content (91.63%) was recorded from RS+SL (3:1).

Table 2: Moisture and nutrient content of oyster mushroom (*Pleurotus florida*) on different substrate combinations.

Substrate	Moisture (%)	Vit-c (mg/100 g fresh weight)	Carbohydrate (g/100g dry weight)	Protein (g/100g dry weight)	Ash (g/100 g dry weight)	Zinc (mg/100 g dry weight)	Iron (mg/100 g dry weight)	Manganese (mg/100g dry weight)
Rice straw+ Newspaper(3 :1)	92.14	11.50	36.81	18.37	10.63	7.86	17.09	3.11
Rice straw+ Newspaper(1 :1)	94.01	11.30	33.59	22.94	10.26	8.06	18.44	1.54
Rice straw+ Newspaper(1 :3)	94.67	11.38	34.08	21.81	10.96	8.43	18.87	1.73
Rice straw+ Sal leaves(3:1)	91.63	10.90	38.17	20.61	8.98	7.94	14.31	3.06
Rice straw+ Sal leaves(1:1)	93.44	11.00	38.01	23.57	8.07	8.17	12.47	2.61
Rice straw+ Sal leaves(1:3)	93.86	11.25	37.98	26.46	7.67	8.31	11.63	2.47
Newspaper+ Sal leaves(3:1)	94.39	10.81	34.78	25.31	9.41	8.77	15.86	1.89
Newspaper+ Sal leaves(1:1)	94.81	11.22	35.33	25.97	8.17	8.68	13.93	1.97
Newspaper+ Sal leaves(1:3)	93.38	10.93	35.59	26.27	8.03	8.73	13.06	1.83
SEM	0.73	0.21	0.37	0.38	0.49	0.21	0.23	0.18
CD	NS	NS	1.11	1.14	1.46	0.63	0.71	0.52

The above findings regarding moisture content of mushrooms are almost close to result as reported by Iqbal *et al.* (2016) where it was reported that highest moisture contents (93.44%) in *Pleurotus florida* obtained from sorghum straw followed by sugarcane bagasse and maize straw having the same moisture content of 90.14%. The wheat straw has the moisture content of 90.00%. The lowest (88.20%) moisture content was observed in case of rice straw.

Vitamin-C content. The results in Table 2 and Fig. 3 indicated that substrate formula RS+NP (3:1) grasped the maximum (11.50mg /100 g fresh weight) vitamin-c among all the substrate formulas. While vitamin-c content from other substrate formulas were 11.38 mg from RS+NP (1:3); 11.30 mg from RS+NP (1:1); 11.25 mg from RS+SL (1:3); 11.22 mg from NP+SL (1:1), 11.00 mg from RS + SL (1:1); 10.93 mg from NP+SL(1:3) and 10.90 mg from RS+SL (3:1) per 100 g fresh weight sample. NP+SL (3:1) contains minimum amount of vitamin-c (10.81mg/ 100g fresh weight) among all the substrate formulas. Iqbal *et al.* (2016) reported that *Pleurotus florida* cultivated in rice straw, maize straw and sorghum straw have the same vitamin c content of 11.35mg/ 100g fresh weight while the from sugarcane bagasse and wheat straw have the same vitamin c content of 11.11mg/100g. The vitamin-c content of *Pleurotus florida* in the present study on different substrate combination ranging from 10.81 - 11.50 mg/100 g of fresh weight which is confirmatory with the results reported by Iqbal *et al.* (2016).

Carbohydrate content. Carbohydrate content of mushrooms from different substrate formulas showed in Table 2 and Fig. 4 revealed that highest carbohydrate (38.17g/ 100g of dry weight) was recorded from RS+SL (3:1) while it was lowest (33.59 g/ 100g of dry weight) from RS+NP (1:1). The carbohydrate content of mushrooms from other substrate formulas were 38.01g from RS+SL (1:1); 37.98g from RS+SL (1:3); 36.81g from RS+NP (3:1); 35.59g from NP+SL (1:3); 35.33 g from NP+ SL (1:1); 34.78 g from NP+SL (3:1) and 34.08 g from RS +NP (1:3) per100g of dry weight. In the present investigation, carbohydrate content of dry mushroom samples of *Pleurotus florida* from different substrate combination was varied from 33.59-38.17 g/100 g dry weight which is almost proximate with the findings of carbohydrate content (36.74-37.69 g/100 g dry wt.) of three species of oyster mushrooms grown on different substrates as reported by Ashraf *et al.* (2013).

Protein content. Protein content of mushroom samples harvested from different substrate formulas were found ranging from 18.37g to 26.46 g/100 g dry weight (Table 2 and Fig. 4). Among the substrate formulas highest protein content (26.46g) was recorded from RS+SL (1:3) and lowest 18.37g from RS+NP (3:1). Other substrate formulas like NP+SL (1:3), NP+SL (1:1), NP+SL (3:1) and RS+SL (1:1) was recorded as of 26.27g, 25.97g, 25.31g and 23.57g of protein per 100g of dry weight respectively. Comparatively lower protein content was obtained as 22.94 g from RS+NP (1:1), 21.81 g from RS+NP (1:3) and 20.61 g from RS+ SL (3:1) respectively. Under domestic cultivation with different substrates Ashraf *et al.* (2013) reported that oyster mushrooms *Pleurotus sajor-caju*, *P. ostreatus* and *P. djmor* showed protein content of 24.83 -27.23 g/100 g dry weight that supported the present results of protein content having a range from 18.37 g-26.46 g/100 g dry weight.

Ash Content. The ash content (Table 2 and Fig. 4) of mushroom from RS+NP (1:3) substrate formula was found highest (10.96g/ 100g dry weight) followed by 10.63g from RS+NP (3:1); 10.26g from RS+NP (1:1); 9.41g from NP+SL (3:1) and 8.98 g from RS+SL per 100 g of dry weight. Ash content of remaining mushroom samples from other substrate formulas ranged from 8.03 g – 8.17 g / 100 g of dry weight. Lowest ash content (7.67g/ 100g dry weight) was observed from RS+SL (1:3). Nasiruddin *et al.* (2018) reported that the ash content of three species of *Pleurotus viz*, *Pleurotus cryngii*, *Pleurotus ostreatus* and *Pleurotus sajorcaju* found to be 4.89g, 7.78g and 5.84g/ 100g of dry weight basis. Slight variation in ash content in the present findings might be due to use of different substrates and strain of oyster mushroom.

Zinc content. It is evident from Table 2 and Fig. 3 that highest amount of zinc (8.77mg/ 100g of dry weight) in mushroom sample was found from substrate formula NP +SL (3:1) followed by NP+SL (1:3), NP+SL (1:1), RS+NP (1:3), RS+SL (1:3); RS+SL(1:1) and RS+SL(3:1) containing 8.73mg, 8.68mg, 8.43mg, 8.31mg, 8.17mg, 8.06mg and 7.94mg respectively per 100g of dry weight. Lowest amount of zinc (7.86mg/ 100g of dry weight) was estimated from RS+NP (3:1).Present findings indicated that the zinc content (7.86 mg – 8.77 mg/100 g dry wt.) in *P. florida* grown in different substrate combinations was close to the report cited by Mukhopadhyay (2019) that oyster mushrooms content zinc with a range of 5.4 -18.0 mg/100 g dry weight.

Iron content. Results presented in Table 2 and Fig. 3 indicated that mushrooms contained highest amount of iron (18.87mg/ 100g dry weight) from RS+NP (1:3) substrate formula while lowest (11.63mg/ 100g of dry weight) from RS+SL (1:3). Iron contents in mushrooms from other substrate formulas *viz.*, RS+NP (1:1), RS+NP(3:1), NP+SL (3:1), RS+SL (3:1), NP+SL (1:1), NP+SL (1:3) and RS+SL (1:1) exhibited 18.44mg, 17.09 mg, 15.86 mg, 14.31mg,13.93 mg, 13.06 mg and 12.47 mg of iron per 100g of dry weight respectively. Hoa *et al.* (2015) obtained Fe from *P. ostreatus* (14.64 and 14.85 mg/100 g) from two substrates which is also close to the present findings (11.63-18.87mg/ 100g).

Manganese content. Results from Table 2 and Fig. 3 revealed that highest amount of manganese (3.11mg/100g dry weight) in mushroom sample was obtained from substrate formula RS+NP (3:1). It was followed by 3.06mg from RS+SL (3:1); 2.61mg from

RS+SL (1:1); 2.47mg from RS+SL (1:3); 1.97mg from NP+SL (1:1); 1.89 mg from NP+SL (3:1); 1.83 mg from NP+SL (1:3) and 1.73 mg from RS+NP (1:3) respectively per 100g of dry weight. Lowest amount of manganese (1.54mg/ 100g dry weight) was obtained from RS+NP (1:1). Nasiruddin *et al.* (2018) stated that the Mn level of mushroom *Pleurotus* sp. was 12.9-93.3 mg/kg *i.e.*, 1.29 -9.33 mg/100g of dry weight which was proximate with our observation *i.e.*, 1.54--3.11 mg/100 g.

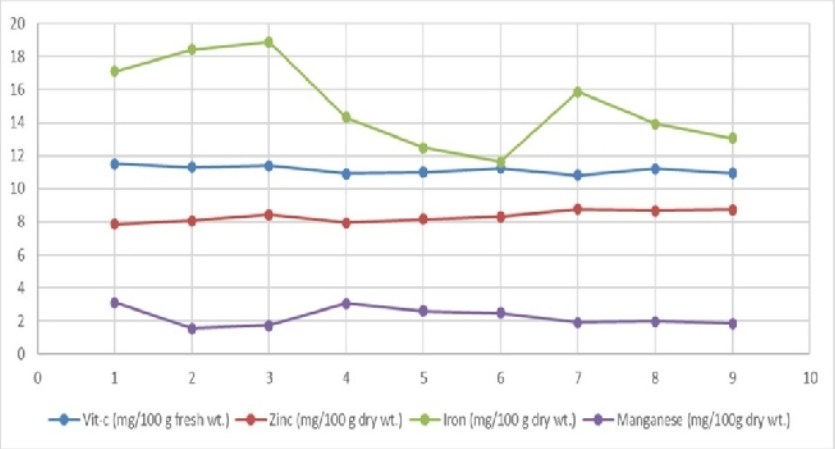

Fig. 3. Vitamin-c, zinc, iron and manganese content of *P. florida* grown on different substrate combinations.

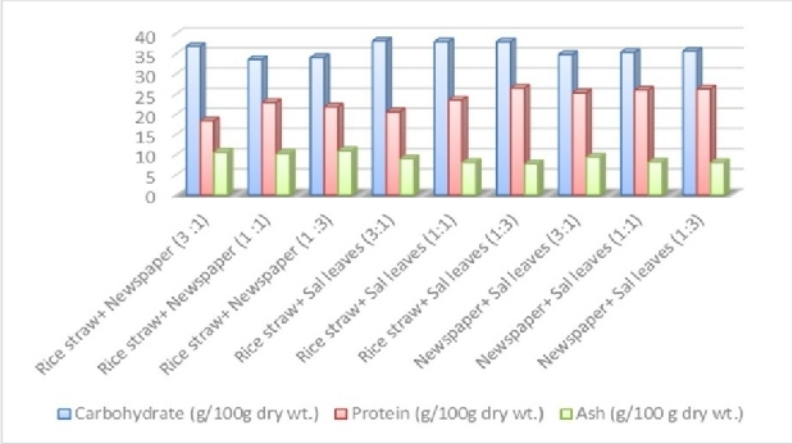

Fig. 4. Carbohydrate, protein and ash content of *P. florida* grown on different substrate combinations.

CONCLUSION

Based on the studies of the present investigation it can be recommended that apart from our traditionally used rice straw other agro-wastes like sal leaves, *Lantana camara* etc. can also be used for small- and large-scale production of oyster mushroom maintaining all its nutritional parameters as high as rice straw.

FUTURE SCOPE

Rice straw obviously the best substrate for small and large-scale cultivation of oyster mushroom in terms of availability and mushroom yield. But India being an agriculture-based country with rich biodiversity can provide different types of biological waste materials that can be used as growth substrates for mushroom production. Besides yield these waste materials can also enhance the nutritional quality of harvested mushroom. Hence further research is necessary to look for different agricultural waste materials or byproducts that can be the supplement of rice straw for production of mushroom in terms of both quality and quantity.

Acknowledgement. The authors would like to thank Department of Plant Pathology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal for providing facilities for carrying out the research.
Conflict of Interest. None.

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How to cite this article: K. Kundu, S. Patar, S. Mukhopadhyay, A. Roy Barman, S. Dutta and S.K. Ray (2022). Influence of different growth substrates and their combination on nutritional and mineral contents of Oyster mushroom (*Pleurotus florida*). *Biological Forum – An International Journal*, *14*(4): 944-951.