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Comparative Study on Cultivation, Yield Performance and Proximate Composition of *Pleurotus pulmonarius* Fries. (Quelet) on Rice Straw and Banana Leaves

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Abstract: Cultivation of *Pleurotus pulmonarius* is currently gaining global attention owing to their gourmet and culinary qualities coupled with their longer shelf. In this pilot study, 10 g spawn of *P. pulmonarius* was cultivated on 300 g of different substrates namely; rice straw and banana leaves. Each substrate was supplemented with rice bran and wheat bran separately at a varying composition *viz.,* 0, 10, 20 and 30% w/w. The mixtures were prepared in triplicates and then incubated at 28±2°C for 14 days. The results showed that substrates and additive types with their percentage concentrations significantly influenced the mushroom qualities, yield and proximate composition ($P \le 0.05$). Banana leaves with wheat bran additives, irrespective of their percentage concentration, had better mushroom quality/size, yield, biological efficiency and proximate composition than rice bran and its performance in rice straw. In rice straw, 30% wheat bran had the highest stipe length of 7.1 cm at flush 1, but a slight reduction in was recorded at flush 2 with 30% rice bran best with 6.8 cm while 10% wheat bran had the highest value (7.2 cm) at flush 3. On banana leaves and 30% wheat bran had the highest stipe length of 7.3 cm at flush 1, 20% rank highest with 6.8 cm and 6.4 cm for flush 2 and 3 respectively. Also, 10% wheat bran had stipe length of 6.4 cm at flush 3. Similar trends were also observed in pileus diameter and the mushroom height. The total yield and biological efficiency of mushroom was highest at 30% rice bran in rice straw with 76.52 g and 25.51% respectively while 10% wheat bran was highest in banana leaves with 75.3 g and 25.1% respectively. In rice straw, 30% wheat bran had the highest crude protein (24.24%), lipid (7.15%) and Ethanol Soluble sugar with (12.81%) while 30% rice bran recorded the highest ash and crude fibre contents with 9.59 and 7.59% respectively. Also, the moisture content was highest at 10% wheat bran with 6.44%. On banana leaves, 30% wheat bran recorded the highest crude protein and lipid contents with 27.98 and 8.77% respectively. 10 % wheat bran recorded the highest moisture and ash content with 7.02 and 8.84 respectively. 30% rice bran recorded the highest crude fibre with 7.98% while the ethanol soluble sugar was highest in 10% rice bran with 12.66%. This empirical information will guide the farmers in the selection of substrates and additives for the successful establishment of mushroom farm with healthy and vigorous mushrooms.

Key words: *Pleurotus pulmonarius* · Total yield · Biological efficiency · Proximate composition

INTRODUCTION

Cultivation of edible mushrooms with agricultural and agro-industrial residues as substrate is an efficient and economically reliable technology for converting these materials into a valuable protein rich food and a cash crop of commercial interest [1]. The last decade has witness an empirical approach towards its cultivation for both large-scale industrial or commercial scales compared to the crude conventional method [2].

In many countries like Nigeria, *Pleurotus*, *Termitomyces*, *Tricholoma* and *Volvariella* are the most cultivated and prized edible species [3]. Among these mushrooms, *Pleurotus spp* is ranked first due to their ability in converting a huge amount of lignocellulosic substrate to fruiting bodies. Also, few environmental controls demand during their cultivation coupled with fruit bodies which are not often attacked by diseases and pests has consistently increased their popularity among cultivated mushrooms [4]. It requires a short growth time in comparison to other edible mushrooms.

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Various reports have shown the important role played by mushroom in alleviation of malnutrition due to its richness in protein contents compared to other crops. They are in low calories, unsaturated fatty acid, carbohydrates, calcium and sodium contents with large amount of vitamins such as thiamine 1.4-2.2 mg (%), riboflavin 6.7-9.0 mg (%), niacin 60.6-73.3 mg (%), biotin, ascorbic acid 92-144 mg (%), pantothenic acid 21.1-33.3 mg (%) and folic acid 1.2-1.4 mg/100g in dry weight basis but contain high proportion of unsaturated fat which are virtually not harmful lipid or cholesterol [5]. Apart from food value, its medicinal value for patients suffering from diabetics, hypertension, heart diseases and in cancer therapy has been reported [6].

P. pulmonarius has been cultivated successfully on different agricultural by-products such as chopped cocoa pods, cotton waste, dried maize straw, oil palm fibre and bunch wastes, tea leaves, rice straw, banana leaves, sugar cane bagasse and saw dust [7]. Studies on nutritional quality, yield, biological efficiency, mycelium growth, quantity and quality of fruiting bodies of oyster mushroom showed that substrates have no significant effect on these characters and are often varied [8]. Thus, variation among substrates has lead to the adoption of supplement in mushroom cultivation for improvement of nutritional quality, yield, biological efficiency, mycelium growth, quantity and quality of fruiting bodies of oyster mushroom. [9] reported that poultry manure, rice bran, wheat bran and peat moss were successfully used as food supplements to improved yield, biological efficiency and growth period via providing sufficient nitrogen and slow nutrient releasing in mushroom cultivation.

Thus, the objective of this study was mainly to assess the effect of rice bran and wheat bran as an additive at a varying percentage concentration separately, in rice straw and banana leaves as a substrate with their empirical influence on the mushroom size, total yield, biological efficiency and proximate composition of *P. pulmonarius*.

MATERIALS AND METHODS

Collection of Samples: *P. pulmonarius* was collected from the Plant Physiology Laboratory, Department of Botany, University of Ibadan. The substrates; rice straw and banana leaves were used as substrates. Freshly harvested rice straw was collected from International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria while the banana leaves was collected from Dagbolu Street, Moniya, Ibadan, Oyo State. These substrates were then air-dried in a clear open space in the Department of Botany for seven days. The rice straw and banana leaves were cut into 0.1-3 cm pieces using a guillotine.

The additive; rice bran and wheat bran were used as additives. Rice bran was obtained from Africa Rice Unit of International Institute of Tropical Agriculture while wheat bran was collected from the feed mill of the popular Bodija Market, Ibadan.

Spawn Multiplication: The pure spawn was multiplied according to the modified method of [10]. Rice straw was soaked in water one hour to moisten the straw and then squeezed using a muslin cloth until no water oozed out. 100 g of the moisten rice straw was mixed thoroughly with 10 g of wheat bran (additive) and loaded into 350 mL sterile bottles, covered with aluminum foil and autoclaved at 151bs pressure and 121°C temperature for 15mins. The bottles were later allowed to cool before inoculating with 5 g of the pure spawn and incubated at 28 ± 2°C for 3 weeks until the substrate was completely ramified to form a spawn. The spawn bottles

were stored in the refrigerator (below 10°C).

Preparation of Substrates: The culture conditions were carried out according to the method of [11] but modified as follows; 300 g of each of the each dried substrate was weighed and moisten with 75% distilled water (w/v). Calcium trioxocarbonate IV ($CaCO_3$) was mixed with each of the additives (rice bran and wheat bran) separately then thoroughly mixed with each substrate respectively at varying percentages (0, 10, 20 and 30%). The mixture is then packed into well labeled polyethylene bags, tied immediately and pasteurized in drums for 4hours. Each substrate mixed was prepared in three replicates.

Inoculation of Substrates Bags: After pasteurization, the substrate bags were allowed to cool then10g of *P. pulmonarius* was inoculated into each sterilized substrate bags. The inoculated substrate bags were incubated at 28±2°C for 5 weeks.

Spawn Run: Spawn run (mycelia extension) was observed regularly until a whitish mycelia growth (colonization) had spread to both lower and upper sides of the bags from the inoculated zone. The tied bags were opened. Three times watering per day was done on the substrate before first harvest (first flush).

Harvesting, Determination of Yield and Biological Efficiency: Harvesting was done by hand holding the stipes at the base and twisting lightly. Stipe length, pileus diameter and Mushroom height were measured in centimeters with a meter rule. Mushrooms were harvested, counted and weighed. At the end of the third flush, total yield and biological efficiency (BE) were determined.

Fresh Weight Determination: Freshly harvested mushrooms from all the supplements were weighed with an electronic weighing balance.

Yield Performance:

$$\text{Total fresh yield (g)} = \frac{\text{Total fresh weight of the mushrooms harvested per unit production for the two flushes (g)}}{\text{Substrates dry weight (g)}}$$

Biological Efficiency:

$$\text{B.E (\%)} = \frac{\text{Total fresh weight of the mushrooms harvested per unit production for the two flushes (g)}}{\text{Substrates dry weight (g)}} \times 100$$

Where: BE = biological efficiency

Proximate Analysis/Composition

Moisture Content: The harvested mushrooms were weighed and dried in the oven at 60°C for 48 hours. The dried samples were weighed and the percentage difference in weight was taken as the moisture content according to [12].

Ash Content: Powdered mushroom samples (2g) were reduced to ash in a Gallenhamp furnace in crucibles that had been ignited, cooled in a $CaCl_2$ desiccator to prevent re-absorption of water and weighed at 550°C for 6hours [13].

Protein Content: Micro-Kjeldahl automated method was used. Aliquots (0.2g) of dried mushroom were weighed with digestion tubes, 15 mL conc. H_2SO_4 and 7 kjeldahl catalyst tablets were added with the digestion pre-set at 410 °C. Digestion was done for 45min. The tube was then placed in a distilling unit and 5 mL of 40% NaOH was dispersed into it. The distillate was digested into 35 mL of 4% boric acid for 5min [11].

Crude Fibre: Crude fibre of each mushroom sample was determined according to the standard method of the Association of Official Chemists. [14].

Sugar Content: One gram of powdered sample was extracted over night with 25 mL 80% ethanol. The extract was filtered out and the filtrate made up to 100 mL with distilled water. The quantity of sugar in the extract was determined using phenol sulphuric acid method [15].

Lipid Content: Powdered sample (2 g) was extracted with 30 mL chloroform in a soxhlet extractor for 4 hours. The extract was evaporated to dryness in a pre-weighed flask was then dried at 80 °C for 2 hours, cooled in a desiccator and reweighed. The difference in final and fresh weight was taken as the lipid content of the according to [13].

Statistical Analysis: The experiment was set up using complete randomized design (CRD). Data obtained were subjected to analysis of variance (ANOVA) while the means were separated with Duncan Multiple Range Test (DMRT) at ($P \leq 0.05$).

RESULTS

The effect of substrates and additives on stipe length of *P. pulmonarius* per flush is shown in Table 1. Overall, 30% wheat bran additive had the highest stipe in substrate rice straw and banana leaves with 7.1 and 7.3 cm respectively compared to rice bran (6.7 and 6.7 cm respectively). Also, the results show that percentage concentration levels for each additive has no significant effect on both substrates at flush 1 ($p \leq 0.05$). However, at flush 2 and 3 respectively, a slight reduction in stipe length from flush 1 was recorded for both additives in each substrate. 30% rice bran had 6.8 cm stipe length advantage over other percentage concentrations of rice bran and wheat bran in rice straw respectively. In banana leaves, 20% wheat bran had a superior stipe length performance with 6.8 cm to the best and least performance observed in rice bran at flush 2. Moreover, a slight increase in stipe length from flush 2 was observed except for 10 and 20% rice bran in straw and banana leaves with 6.4 and 6.3 cm which shows no increase. The effect of substrates and additives on the pileus diameter of *P. pulmonarius* per flush is shown in Table 2. An increase in the value of pileus diameter was recorded with an increase in additive percentage composition. On rice straw; 20% wheat bran additive had the highest value of pileus diameter (7.3cm) while the control gave the lowest value of pileus diameter (5.7cm) in flush 1. However, an increase was observed in the value pileus diameter across the flushes in all the wheat bran additive level of rice straw except for 20% wheat bran additives which recorded a

Table 1: Effect of substrates and additives on stipe length per flush of *P. pulmonarius*

		Additives concentration		Stipe Length (cm)	
Substrates	Additives	(%)	Flush 1	Flush 2	Flush 3
Rice straw	Control	0	5.7^{bcde}	5.5^{cde}	5.8^{abcde}
	Rice bran	10	6.2^{bcd}	6.1^{abcd}	6.1^{abc}
	Rice bran	20	6.3^{bcd}	6.0^{abcde}	5.8^{abcde}
	Rice bran	30	6.7^{ab}	6.8^{a}	6.4^{abc}
	Wheat bran	10	6.5^{abc}	6.7^{ab}	7.2^{a}
	Wheat bran	20	6.8^{ab}	6.7^{ab}	6.9^{ab}
	Wheat bran	30	7.1^{a}	6.5^{ab}	6.7^{ab}
Banana leaves	Control	0	6.7^{ab}	6.8^{a}	7.0^{a}
	Rice bran	10	6.9^{ab}	6.3^{abc}	5.4^{bcde}
	Rice bran	20	6.5^{abc}	6.3^{abc}	6.3^{abc}
	Rice bran	30	6.7^{ab}	6.2^{abc}	6.3^{abc}
	Wheat bran	10	6.8^{ab}	6.1^{abcd}	6.4^{abc}
	Wheat bran	20	7.0^{a}	6.8^{a}	6.4^{abc}
	Wheat bran	30	7.3^{a}	6.4^{abc}	6.2^{abc}

Each value is a mean of three replicates. Values in the same column with different letters as superscripts are significantly different by Duncan multiple range test ($p \leq 0.05$).

Table 2: Effect of substrates and additives on pileus diameter per flush of *P. pulmonarius*

		Additives concentration		Pileus diameter (cm)	
Substrates	Additives	(%)	Flush 1	Flush 2	Flush 3
Rice straw	Control	0	5.7^{b}	6.0^{ab}	6.1^{ab}
	Rice bran	10	6.1^{ab}	7.0^{a}	6.8^{ab}
	Rice bran	20	6.8^{ab}	7.2^{a}	7.3^{a}
	Rice bran	30	7.0^{a}	7.3^{a}	7.1^{a}
	Wheat bran	10	6.1^{ab}	6.1^{ab}	7.0^{a}
	Wheat bran	20	7.3^{a}	7.0^{a}	6.0^{ab}
	Wheat bran	30	6.9^{a}	6.0^{ab}	7.0^{a}
Banana leaves	Control	0	7.1^{a}	6.1^{ab}	5.2^{b}
	Rice bran	10	6.7^{ab}	5.7^{b}	6.8^{ab}
	Rice bran	20	6.8^{ab}	6.8^{ab}	6.7^{ab}
	Rice bran	30	6.1^{ab}	6.0^{ab}	7.2^{a}
	Wheat bran	10	6.4^{ab}	6.1^{ab}	6.0^{ab}
	Wheat bran	20	7.0^{a}	7.3^{a}	6.8^{ab}
	Wheat bran	30	7.2^{a}	6.0^{ab}	5.7^{b}

Each value is a mean of three replicates. Values in the same column with different letters as superscripts are significantly different by Duncan multiple range test ($p \leq 0.05$)

Table 3: Effect of substrates and additives on mushroom height per flush of *P. pulmonarius*

		Additives concentration		Mushroom Height (cm)	
Substrates	Additives	(%)	Flush 1	Flush 2	Flush 3
Rice straw	Control	0	8.2^{ab}	8.2^{ab}	8.6^{ab}
	Rice bran	10	7.4^{bc}	6.1^{c}	6.0^{c}
	Rice bran	20	8.1^{ab}	8.2^{ab}	9.2^{a}
	Rice bran	30	8.2^{ab}	9.3^{a}	9.1^{a}
	Wheat bran	10	9.3^{a}	8.2^{ab}	9.3^{a}
	Wheat bran	20	9.0^{a}	8.7^{ab}	9.1^{a}
	Wheat bran	30	9.2^{a}	8.4^{ab}	7.9^{abc}
Banana leaves	Control	0	7.4^{bc}	6.4^{c}	6.1^{c}
	Rice bran	10	9.3^{a}	7.9^{abc}	9.2^{a}
	Rice bran	20	8.1^{ab}	8.2^{ab}	8.6^{ab}
	Rice bran	30	8.2^{ab}	6.0^{c}	8.7^{ab}
	Wheat bran	10	7.4^{bc}	7.9^{abc}	8.6^{ab}
	Wheat bran	20	8.1^{ab}	8.2^{ab}	8.4^{ab}
	Wheat bran	30	9.2^{a}	9.3^{a}	9.0^{a}

Each value is a mean of three replicates. Values in the same column with different letters as superscripts are significantly different by Duncan multiple range test ($p \leq 0.05$).

Table 4: Yield and Biological efficiency (B.E) of *P. pulmonarius*

Substrates	Additives	Additives Concentration (%)	(Mushroom Height cm) Flush 1	Flush 2	Flush 3	Total Yield (g)	Biological Efficiency (%)
Rice straw	Control	0	27.2	27	16.2	70.4	23.47[ab]
	Rice bran	10	21.02	20.04	20.7	61.76	20.59[cd]
	Rice bran	20	27.44	18.11	14.28	59.83	19.94[cd]
	Rice bran	30	24.61	29.01	22.9	76.52	25.51[a]
	Wheat bran	10	22.44	18.01	16.1	56.55	18.85[d]
	Wheat bran	20	20.5	19.81	17.3	57.61	19.20[cd]
	Wheat bran	30	29.4	16.68	18.2	64.28	21.43[bc]
Banana leaves	Control	0	22.01	16.93	15.01	53.95	17.98[e]
	Rice bran	10	20.44	22.53	14.72	55.69	18.56[d]
	Rice bran	20	26.13	20.1	19.25	63.48	21.16[bc]
	Rice bran	30	20.33	20.44	19.75	60.52	20.17[cd]
	Wheat bran	10	28.06	28	19.24	75.3	25.10[a]
	Wheat bran	20	27.03	26.26	16.11	71.42	23.81[ab]
	Wheat bran	30	22.92	26.1	16.01	65.03	21.67[bc]

Each value is the mean of three replicates. Mean with the same letter in the same column are not significantly different according to Duncan Multiple Range Test at ($P \leq 0.05$).

significant reduction in the value of pileus diameter across the three flushes; from 7.3cm in flush 1 to 7.0cm in flush 2 and to 6.0cm in flush 3.

On banana leaves; mushroom from 30% rice bran additive gave the lowest value of pileus diameter (6.1cm) while that of 30% wheat bran additive gave the highest value for pileus diameter (7.2cm). Nevertheless, increase of pileus diameter with increase in flush period was not observed except in mushrooms from 10% and 30%rice bran additive. 30% rice bran additive of rice straw gave the highest total mean pileus diameter of 7.13±0.26cm. The lowest total mean pileus diameter 5.93±0.21cm was recorded in mushrooms harvested from rice-straw control. The effect of substrates and additives on mushroom height of *P. pulmonarius* per flush is shown in Table 3.

On rice straw; 10% wheat bran additives gave the highest value of mushroom height (9.3cm) and 10% rice bran additive had the lowest value of mushroom height (7.4cm) in flush 1. On rice straw supplemented with rice bran, an increase in the value of mushroom height was observed from flush 1 to flush 3 except 10% rice bran additive which recorded a significant reduction from 7.4cm in flush 1 to 6.1cm in flush 2 and a slight reduction to 6.0cm in flush 3. Similar trend was recorded for 30% wheat bran additives.

On banana leaves; the control gave the lowest value of mushroom height (7.4cm) while 10% rice bran additive gave the highest value of mushroom height (9.3cm). However, significant reduction of in the value of mushroom height across the flushes was observed in banana leaves control from 7.4 cm in flush1 to 6.4cm in flush 2 and to 6.1cm in flush 3. The highest total mean mushroom height value of 9.17±0.15cm was harvested from 30% wheat bran level of banana leaves. While mushroom harvested from 10% rice bran additive of rice straw gave the lowest total mean mushroom height values of 6.50±0.78cm

Overall, wheat bran irrespective of their percentage concentrations in both substrates performs best with the highest flush number. At flush 1, 30% wheat bran concentration in rice straw had the highest flush number with 29.40 g compared to other percentage concentration levels and in banana leaves. Contrarily, at flush 2 and 3, 30% rice bran had the highest flush number with 29.01 g and 22.90 g respectively. Noteworthy, reduction in flush number were observed subsequently after flush 1.

On rice straw, 30% rice bran concentration had the highest total yield and biological efficiency with 76.52 g and 25.51% respectively compared to other percentage concentrations and that of wheat bran. On banana leaves, 10% wheat bran concentration had the highest total yield and biological efficiency with 75.3 g and 25.1% respectively compared to other percentage concentrations and that of rice bran. The biological efficiency of *P. pulmonarius* cultivated on 30% rice bran in rice straw and 10% wheat bran in banana leaves was not significantly different ($P \leq 0.05$).

The proximate composition of *P. pulmonarius* from the two substrates supplemented with two different additives at different levels in percentages is shown in Table 5. On rice straw, 10% wheat bran had the highest moisture content (6.44%) followed by 20% rice bran with 6.33%. No significant difference was observed among each additives concentration levels ($P \leq 0.05$).

Table 5: Proximate analysis *P. pulmonarius* cultivated on substrates with different additives

Substrates	Additives	Additive concentration (%)	Moisture (%)	Ash (%)	Crude Fibre (%)	Protein (%)	Lipid (%)	Ethanol - Soluble Sugars (%)
Rice Straw	Rice bran	0	5.89^{abc}	6.85^{c}	7.02^{ab}	21.06^{c}	5.22^{d}	11.81^{c}
		10	6.31^{abc}	8.86^{a}	6.69^{ab}	22.54^{cde}	5.57^{cd}	12.06^{bc}
		20	6.33^{abc}	9.19^{a}	7.01^{ab}	21.84^{de}	6.12^{bcd}	13.01^{abc}
		30	6.05^{abc}	9.59^{a}	7.59^{ab}	23.44^{cd}	6.35^{bcd}	13.62^{ab}
	Wheat bran	10	6.44^{ab}	8.99^{a}	7.29^{ab}	22.65^{cde}	5.82^{cd}	12.11^{bc}
		20	5.56^{bc}	9.22^{a}	6.97^{ab}	23.31^{cd}	6.29^{bcd}	12.58^{abc}
		30	5.11^{c}	9.24^{a}	7.22^{ab}	24.24^{c}	7.15^{abcd}	12.81^{abc}
Banana Leaves	Rice bran	0	6.50^{ab}	6.42^{c}	7.24^{ab}	23.51^{cd}	5.54^{cd}	12.01^{bc}
		10	6.06^{abc}	7.37^{c}	7.43^{ab}	25.98^{b}	6.76^{bcd}	12.66^{abc}
		20	6.17^{abc}	7.49^{c}	7.90^{a}	26.02^{b}	6.80^{bcd}	13.45^{abc}
		30	6.48^{ab}	8.39^{ab}	7.98^{a}	26.89^{ab}	7.41^{abc}	13.98^{a}
	Wheat bran	10	7.02^{a}	8.84^{a}	7.24^{ab}	27.12^{ab}	6.82^{bcd}	12.22^{bc}
		20	6.41^{ab}	7.14^{c}	7.81^{a}	27.60^{ab}	7.76^{ab}	12.45^{abc}
		30	6.20^{ab}	7.68^{bc}	7.89^{a}	27.98^{a}	8.77^{a}	12.55^{abc}

Each value is the mean of three replicates. Mean with the same alphabet in the same column are not significantly different according to Duncan's Multiple Range Test at ($P \leq 0.05$).

Also, on banana leaves, 10% wheat bran has the highest moisture content (7.02%) compared to rice bran with highest values at 30% percentage concentration (6.48%).

Overall, 30% rice bran in straw has the highest ash content with 9.59% followed by 30% wheat bran in trice straw with 9.24% compared to their contents in banana leaves. Noteworthy, the best additive with highest ash content in banana leaves was observed in 10% wheat bran with 8.84%.

Moreover, irrespective of substrate types and additive percentage concentration levels, rice bran recorded the highest crude fibre and ethanol soluble sugar. On rice straw, the highest crude fibre and soluble sugar contents were recorded at 30% rice bran with 7.59 and 13.62% respectively. Similar trend was recorded for banana leaves. Contrarily, wheat bran, irrespective of its percentage concentration levels recorded the highest protein and lipid contents. 30% wheat bran in rice straw recorded 24.24 and 7.15 5% respectively for protein and lipid contents while 27.98 and 8.77% were recorded respectively for 30% wheat bran in banana leaves.

DISCUSSION

The ability of this mushroom to grow on the substrates supplemented with different concentrations of additives (rice bran and wheat bran) agrees with the report of [16] that additive played an important role in enhancing rapid mycelia colonization of substrate through the aid of extracellular enzymes during mushroom cultivation.

The reduction in the value of stipe length, pileus diameter and mushroom length after subsequent flushes from flush 1 could be linked to temperature fluctuation during cultivation could have caused death of the surface mycelia and sclerotia [17]. Also, the larger fractions of the lignocelluloses present in the substrate could have been degraded into simpler carbon compounds which could easily be accessed by the growing mushroom mycelia at the first flush while leaving little carbon compounds for the subsequent flushes [18].

The superiority of wheat bran irrespective of its percentage concentration over rice bran in supporting stipe length, pileus diameter and mushroom length has showed it as the most suitable additive for the two tested substrates. This conforms to the reports of [19] where an increase in wheat bran levels in sawdust substrates containing millet and rye improved mushroom quality. Similarly, [20] observed the efficacy of wheat bran supplementation of substrate in improvement of sporophore yield of *Calocybe indica*. The stimulatory effect of wheat bran might have been due to abundance of carbohydrate, amino acids and mineral elements present in wheat bran [21, 22].

The reduction observed in the yield per flush of *P. pulmonarius* harvested on the substrates and additives could be linked to the differences in nutritional and physical composition of the additives in the substrates as well as microclimates of the substrates [23, 24], further explained that accumulation of CO_2 during spawn running cause reduction in mushroom productivity.

The total yield and biological efficiency of the mushroom was significantly influenced by the substrate and additives, with high percentage of rice bran concentration performing best in rice straw and low percentage concentration of wheat bran performing best in banana leaves. This is in conformity with the report of

[25], where 10% of wheat bran additive in banana leaves substrate best enhanced growth and yield of oyster mushroom (*Pleurotus ostreatus*). [26] also reported higher biological efficiencies of *L. edodes* strain Le-S on supplementation of wheat straw with wheat bran. Agreeing with the opinion of [25], the superiority of wheat bran additive at the lowest concentration compared to all concentration of rice bran in both substrates further explained that lowering quantity of wheat bran additives in substrates improves mushroom yield, sizes and their durability.

Conversely, the ability of high percentage concentration of rice bran to support mushroom yield in rice straw agrees with the report of [27], where higher productivity of *L. edodes* was obtained with the addition of 25% and 30% rice bran. However, the biological efficiency in this study agrees with that obtained by [28] where biological efficiency of 24.8 to 55.6% on wheat straw substrate. [29], found that, wheat straw-cotton straw supplemented with 20% rice bran yielded 23.2 g *P. eryngii* fruit bodies with biological efficiency of 77.2% while un-supplemented one yielded only 14.6 g/100g wet media with biological efficiency of 48.6%. Despite differences in the additive and substrates types, the proximate compositions of *P. pulmanarius* harvested is in conformity with the finding of [30] who found 17.40 to 30.31% protein; 3.90 to 6.16% lipid and 7.05 to 9.15% ash in *P. ostreatus* grown on wheat bran supplemented sugarcane bagasse. [31], also found 18.43 to 30.90% protein, 3.34 to 5.13% lipid, 33.50 to 49.58% carbohydrates and 6.33 to 8.40% ash in *P. ostreatus* grown on cowdung supplemented rice straw. [32], found 88.15 to 91.64% moisture, 18.46 to 27.78% crude protein; 1.49 to 1.90% crude fats, in oyster mushroom. The fiber content obtained in the study is slightly higher than 5.97-6.42% as reported by [33]. The high protein contents observed agrees with the theoretical prediction, stating that an increase in the availability of nitrogen might enable increase protein contents of plants, animals and fungi [34].

CONCLUSION

From the data, it was evident that banana leaves supplemented with wheat bran irrespective of their percentage concentration was linked to better mushroom size, total yield, biological efficiency and proximate composition compared to rice straw. This observation underscores the importance of selection of appropriate substrate-additive for mushroom production in a mushroom farm establishment.

REFERENCES

1. Zhang, R., X. Li and J.G. Fadel, 2002. Oyster mushroom cultivation with rice and wheat straw. Bioresour. Technol., 8: 277-284.
2. Mwita, L.N., S.L. Lyantagaye and A.M. Mshandete, 2011. Cultivation of Tanzanian *Coprinus cinereus* (sisal compost mushroom) on three non-composted sisal waste substrates supplemented with chicken manure at various rates Int. J. Biol. Chem. Sci., 5(3): 968-978.
3. Amuneke, E.H., K.S. Dike and J.N. Ogbulie, 2011. Cultivation of *Pleurotus ostreatus:* An edible mushroom from agro base waste products J. Microbiol. Biotech. Res., 1(3): 1-14.
4. Kues, U. and Y. Liu, 2000. Fruiting body production in basidiomycetes. Appl. Microbiol. Biotech., 54: 141-152.
5. Hossain, M.S., N. Alam, S.M.R Amin, M.A. Basunia and A. Rahman, 2007. Essential Fatty Acid Contents of *Pleurotus ostreatus, Ganoderma lucidum* and *Agaricus bisporus*. Bangl. J. Mushroom, 1(1): 1-7.
6. Sharma S., R. Kailash, P. Yadav and C.P. Pokhrel, 2013. Growth and yield of Oyster mushroom (*Pleurotus ostreatus*) on different substrates J. New Biol. Reports, 2(1): 03-08.
7. Banjo, N.O., E.T. Abikoye and A.O. Kukoye, 2004. Comparison of three nutrient supplements used as additive to sawdust during the cultivation of oyster mushroom (*Pleurotus pulmonarius*). Niger. J. Microbiol., 18: 335-336.
8. Mandeel, Q.A., A.A. Al-Laith and S.A. Mohamed, 2005. Cultivation of oyster mushrooms (*Pleurotus spp.*) on various lignocellulosic wastes. World J. Microbiol. Biotechnol., 21: 601-607.
9. Loss, E., A.R. Royer, M. Barreto-Rodrigues and A.C. Barana, 2009. Use of maize wastewater for the cultivation of the *Pleurotus* spp. mushroom and optimization of its biological efficiency. J. Hazardous Materials, 166: 1522-1525.
10. Okhuoya, J.A., E.O. Akpaja and O. Abbot, 2005. Cultivation of *Lentinus squarrosulus* (Mont.) Singer on sawdust of selected tropical tree species. Int. J. Med. Mushroom, 7: 213-218.
11. Lawal, R., C.O. Adenipekun and O.S. Isikhuemhen, 2011. Effect of additives on the cultivation of *Auricularia auricula* (St. Amans) on *Mansonia altissima* (A. Chev) Chev. sawdust. Advances in Food Sci., 33(4): 199-204.

12. Campbell, D.J., S. Stothers, M. Vaisey and B. Berck, 1986. Gamma irradiation influence on the storage and nutritional quality of mushrooms. J. Food Sci., 33: 540-542.
13. Parent, G. and D. Thoen, 1977. Food value of edible mushrooms from upper Shaba Region. Econ. Bot., 31: 436-44.
14. AOAC, 2005. Association of Official Analytical Chemists. new edition., Association of analytical chemists, Washington D.C., pp: 1105-1106.
15. Dubois, M., A.K. Gilles, J.K. Hamilton, A.P. Revers and F. Smith 2003. Colorimetric method determining of sugar and related substances. Analytical Chemists, 28(2): 350.
16. Martínez-Carrera, D., 2002. Mushroom. McGraw-Hill Encyclopedia of Science and Technology, 9th Edition. McGraw-Hill, Inc., New York, pp: 4.
17. Oei, P., 2003. Mushroom cultivation; appropriate technology for Mushroom growers.3rd edn. Backhnys Publication, Leiden Netherlands, pp: 426.
18. Onyango, B.O., C.A. Otieno and V. Palapala, 2013. Effect of wheat bran supplementation with fresh and composted agricultural wastes on the growth of Kenyan native wood ear mushrooms [*Auricularia auricula* (L. ex Hook.) Underw.] Afri. J. Biotechnol., 19: 2692-2698.
19. Shen, Q., 2001. Molecular Phylogenetic Analysis of *Grifola frondosa* (Maitake) and related species and the influence of selected nutrient supplements on mushroom yield. The Pennsylvania State University. pp: 144.
20. Tandan, G. and V.P. Sharma, 2006. Yield performance of *Calocybe indica* on various substrates and supplements. Mushroom Res., 15(1): 33-35.
21. Fasidi, I.O. and M. Kadiri, 1993. Use of agricultural wastes for the cultivation of *Lentinus subnudus* (Polyporales: Polyporaceae) in Nigeria. Rev. Biol. Trop., 41: 411-415.
22. Isikhuemhen, O.S., J.A. Okhuoya, E.M. Ogbo and E.O. Akpaja, 1999. "Effect of substrates supplementation with Nitrogen, Phosphorous, Potassium (NPK) Fertilizer on sporophore yield in *Pleurotus tuberregium*." Micol Neotropol. Appl., 12: 9-21.
23. Amin, S.M.R., C.S. Nirod, M. Moonmoon, J. Khandaker and M. Rahman, 2007. Officer's Training Manual (National Mushroom Development and Extension Centre, Savar, Dhaka, Bangladesh, pp: 7-17.
24. Shen, Q. and D. Royse, 2001. Effect of nutrient supplement on biological efficiency, quality and crop cycle time on maitake (*Grifola frondosa*). Appl. Microbiol. Biotechnol., 57: 74-78.
25. Earnshaw, D.M., B.E. Dlamini and M.T. Masarirambi, 2012. Growth and Yield of Oyster Mushroom (*Pleurotus ostreatus*) Grown on Different Substrates Amended with Varying Levels of Wheat Bran. Inter. J. Life Sci., 1(4): 111-117.
26. Kaur, N., 2010. Studies on genetic variability and biomolecules production in *Lentinus edodes* strains. M.Sc. Thesis, Punjab Agricultural University, Ludhiana, India.
27. Rossi, I.H., A.C. Monteiro, J.O. Machado, J.L. Andrioli and J.C. Barbosa, 2003. Shiitake (*Lentinula edodes*) production on a sterilized bagasse substrate enriched with rice bran and sugarcane molasses. Braz. J. Microbiol., 34: 66-71.
28. Gaitan, H. and G. Mata, 2004. Cultivation of the edible mushroom *Lentinula edodes* (shiitake) in pasteurized wheat straw-alternative use of geothermal energy in Mexico. Eng. Life Sci., 4(4): 363-367.
29. Kirbag, S. and M. Akyuz, 2008. Evaluation of agricultural wastes for the cultivation of *Pleurotus eryngii* (DC.ex Fr.) Quel. var. ferulae Lanzi. Afr. J. Biotechnol., 7(20): 3660-3664.
30. Ali, M.R., M.S. Hoque, K.U. Ahmed and M.H. Rahman, 2010. Effect of Wheat Bran Supplements with Sugarcane Bagasse on the Yield and Proximate Composition of Oyster Mushroom (*Pleurotus ostreatus*). Bangladesh J. Mushroom., 4(2): 21-26.
31. Nuruddin, M.M., M.H. Rahman, K.U. Ahmed, A. Hossain and N. Sultana, 2010. Effect of Cow Dung Supplements with Rice Straw on the Yield and Proximate Composition of Oyster Mushroom (*Pleurotus ostreatus*). Bangladesh J. Mushroom, 4(2): 45-52.
32. Moni, K.H., R. Ramabardan and A. Eswaran, 2004. Studies on some physiological, cultural and post harvest aspects of Oyster mushroom *Pleurotus ostreatus* (Berk). Trop: Agric. Res., 12: 360-374.
33. Wang, D., A. Sakoda and M. Suzuki, 2001. Biological efficiency and nutritional value of *P. ostreatus* cultivated on spent beet grain. Biores Technol., 78(3): 293-300.
34. Chandel, G., S. Banerjee, S. See, R. Meena, D.J. Sharma and S.B. Verulkar, 2010. Effects of different nitrogen fertilizer levels and native soil properties on rice grain Fe, Zn and protein contents. Rice Sci., 17: 213-227.