International Food Research Journal 18: 249-254 (2011)

Influence of rice husk on biological efficiency and nutrient content of *Pleurotus ostreatus* (Jacq. ex. Fr.) Kummer

[1]Frimpong–Manso, J., [1]Obodai, M., [1]Dzomeku, M. and [2]Apertorgbor, M. M.

[1]*CSIR-Food Research Institute, P.O. Box M20, Accra, Ghana.*
[2]*CSIR-Forestry Research Institute of Ghana, University Box 63, Kumasi, Ghana*

Abstract: Rice husk was evaluated as a possible additive to composted sawdust of *Triplochiton scleroxylon* to ascertain its contribution to the biological efficiency (BE) and nutrient content of *Pleurotus ostreatus* (Jacq. ex. Fr.) Kummer. Mycelial growth rate, spawn run period and mean number of fruit body per flush were the other parameters studied. The BE values on the different rice husk concentrations (2, 5, 10, 15 and 20%) were 75.2, 64.0, 49.6, 43.3 and 40.7% respectively indicating an 11% increase over the control at 2% concentration. The mean mycelial growth rate and the spawn run period on the substrate showed an increasing trend with increasing rice husk concentration. Major mineral constituents of fruit body of the mushroom such as Ca and P and proximate analysis of fat, ash and carbohydrate content also showed significant increases ($P<0.05$) over the control. Based on these increases in both the BE and proximate composition of *Pleurotus ostreatus* strain EM-1, rice husk at 2% concentration can be used as an alternate additive for producing more nutritious mushrooms.

Keywords: rice husk, biological efficiency, *Pleurotus ostreatus*, mushroom

Introduction

Rice is one of the world's most important food crop consumed by more than half of the world's population. Nearly all the people who depend on it as part of their meal live in Asia and Africa. Yearly production of it's by products such as rice straw is about ~ 573 million tons worldwide (Shashirekha et al., 2005). Rice husk which is another by product of rice production accounts for 23% of total paddy weight. In Thailand, about 4,000,000 tons of rice husk are produced every year (Internet). Also, in Ghana, 164,726 metric tons of rice straw and 14,475 metric tons of rice bran were produced in 1994 (Sawyerr, 1994). This figure has increased steadily over the years. The disposal of this husk causes significant problems for the rice mill owners. Different ways have been adopted to utilize rice husk. In Thailand, for instance it is used as biomass fuel to help reduce global climate change and reserve fossil fuel resource (Shashirekha et al., 2005). However, rice straw and rice husk have been identified as rich in cellulose (Datta and Chakravarty, 2001; Obodai et al., 2003).

Mushrooms are grown on a great variety of substrates. The choice of substrate depends on availability and cost. Mushrooms have been recognized as a high potential converter of cheap celluloses into valuable protein (Poppe, 2000). The rapid growth and the ability to utilize various lignocellulosic substances, make *Pleurotus* species cultivation possible in different parts of the world. *Pleurotus* species have been grown on different kinds of sawdust, straw and many other agricultural and industrial wastes (Hadder et al., 1993). Substrates may also be obtained from various plant remnants without enrichments by expensive additives. In almost all cases the efficiency of these waste-constituting substrates is considerably enhanced when supplemented with protein-rich materials such as bran of rice and wheat.

In Ghana, *Pleurotus* species are cultivated on composted sawdust of *Triplochiton scleroxylon* supplemented with rice bran and lime (Obodai et al., 2002). The unavailability of sawdust in some regions of Ghana makes it imperative that other sources of substrates and additives be utilized for *Pleurotus* species cultivation. Rice straw and/ or rice husk are used for the cultivation of *Volvariella volvacea* and *Pleurotus ostreatus* (Mahmoud and El-Kattan, 1989) and these are available in large quantities. Although,

*Corresponding author.
Email: *mobodai@fri.csir.org.gh, obodaime@yahoo.com*
Tel: +233(0)207930703, Fax: +233(0)21777647/500331

rice straw has been recommended as the growth substrate for the economic production *of Pleurotus species*, a 17% increase in yield has been observed when composted sawdust of *T. scleroxylon* was mixed with rice straw (Narh and Obodai, unpublished data). The study was therefore carried out to investigate the influence of rice husk as an additive on composted sawdust of *T. scleroxylon*, with a resultant effect on the biological efficiency and nutrient content of P. *ostreatus* (Jacq.ex.Fr.) Kummer.

Materials and Methods

Spawn and compost preparation

Cultures of *P. ostreatus* (Jacq.ex.Fr.) Kummer strain EM -1 originally from Mauritius and maintained on Potato Dextrose Agar slants were used to prepare sorghum grain spawn (Oei, 1991). Compost was prepared by the outdoor single-phase solid waste fermentation. Fresh sawdust of *T. scleroxylon* K. Schum (wawa) obtained from Timber Market, Accra was mixed with rice bran and lime and composted as described by Obodai et al. (2002). The mixture was then stacked into a heap of about 1.5m high and 1.5m wide at the base and left to compost for 28 days with regular turning every 4 days.

Preparation of substrate mixtures

At the end of the composting period, varying concentrations of rice husk (2%, 5%, 10%, 15% and 20% w/w) were added at bagging. Controlled experiments without rice husk supplements and 100% rice husk were also set up. Each mixture was then supplemented with rice bran (Obodai et al., 2002) and adjusted to approximately 68-70% moisture (Buswell, 1984). The mixtures were bagged, sterilized and inoculated with 5g of spawn and incubated till total spawn run.

Determination of biological efficiency

Fresh mushrooms were harvested and the biological efficiency determined as the percentage of weight of fresh mushrooms to dry weight of substrate at spawning as described by Mueller et al. (1985).

Chemical analyses of fresh mushrooms

Proximate analyses for crude fat and fibre, protein and ash content of the fresh fruit bodies were performed according to standard methods (AOAC, 1990). The 6.24 factor was used to convert nitrogen to crude protein. Total carbohydrate was determined by subtracting the amount of ash, protein and fat from total dry matter while energy values were calculated using Atwater's procedure i.e. the sum of protein x 4, carbohydrates x 4 and fat x 9 (AOAC, 1990). Calcium was determined by permanganate titration (Pearson, 1970) while phosphorus analysis was determined using the molybdovanate method (AOAC, 1990). All analyses were carried out in four replicates.

Data analysis

The flushes and biological efficiencies were subjected to a one-way analysis of variance and their means separated by the Duncan's multiple range tests (SPSS 10 for Windows).

Results and Discussion

Mycelial growth on different concentrations of rice husks as an additive to sawdust

The results of the mycelia growth rate on the different rice husk concentrations used as an additive on composted sawdust of T*riplochiton scleroxylon* are presented in Table 1. In general, increasing the concentration of rice husk within the sawdust substrate decreased the surface mycelial density, but accelerated spawn running and therefore increased the mycelia growth rate (Table 1). The highest mean mycelial growth rate was recorded for 100% rice husk. This could be attributed to the physical nature, high porosity and how aerated the rice husk are causing the mushroom mycelia to run through the substrate as observed by Song, 1986; Saxena and Rai, 1992; Salmones, 1999. Due to the fact that rice husk dries up very fast it is advisable to use it as an additive to sawdust rather than using it alone at 100% concentration.

Mushroom production

Among the different concentrations of rice husk used as additive for the cultivation of *P. ostreatus*, rice husk at 2% supplementation supported the best growth and yield of the fungus. The mycelium density was very thick and dense. This is in accordance with Thomas et al. (1998) who reported that the yield of the mushroom is directly related to the spread of mycelium into the substrate. Although 100% rice husk gave the fastest mycelial growth, the mycelia were not able to utilize the substrate and thus did not correspond with yield (Table 2). This also indicates that mycelial growth and yield of mushrooms have different requirements (Oei, 1991). Supplementation at 2% gave the best biological efficiency (BE) of 75.3%. This was followed by the control (no rice husk) with a BE of 68.2% showing a significant difference ($P \leq 0.05$) of 11% increase. Other studies carried out in Ghana showed that groundnut testa at 15% supplementation gave an overall increase of 57% over the control (Obodai and Johnson, 2002). Thus the composition of the substrate used greatly

Table 1. Mycelial growth rate of *P. ostreatus* on different concentrations of rice husk

Concentration of rice husk (%)	Surface mycelial density	Average mycelial growth (cm/week)	Spawn run period	pH
0	+++	4.8	46	5.9
2	+++	4.3	47	5.6
5	++	4.4	47	6.0
10	++	4.4	46	6.3
15	+	4.9	45	6.2
20	+	4.5	45	6.2
100	+	5.8	20	6.5

Degree of mycelial density when mycelia fully colonize the substrate
+++ Mycelium totally grows through the bag and is uniformly white
++ Mycelium totally grows through the bag but not uniformly white
+ Poor patchy growth

Table 2. Total yield and Biological efficiency of *P. ostreatus* on different concentrations of rice husk

Concentration of rice husk at bagging (%)	Period of bag opening to first flush (days)	Yield/ Flush (g)				Total yield (g)	Biological Efficiency (%)
		First	Second	Third	Fourth		
0	2	81.2d	45.8b	44.7b	32.9b	204.6de	68.2de
2	3	85.8d	60.7c	41.8b	37.8c	226.1e	75.3e
5	3	86.2d	41.9ab	34.4a	29.6b	192.1d	64.0d
10	2	62.9c	30.3a	31.8a	23.9a	148.9c	49.6c
15	1	41.8bc	32.8ab	33.9a	24.6a	133.1bc	43.3bc
20	1	35.4b	34.6ab	28.0a	24.0a	122.0b	40.7b
100	4	23.3a	0.0	0.0	0.0	23.3a	7.8a

Values in the same column followed by a common letter do not differ significantly ($P \geq 0.05$)

Table 3. Mean number of fruit body per flush

Concentration of rice husk (%)	Mean number of fruit bodies per flush				
	First	Second	Third	Fourth	Total number of fruit bodies
0	9	6	4	4	23
2	13	9	4	4	30
5	13	4	5	4	26
10	9	4	5	4	22
15	10	4	4	3	21
20	7	4	3	5	19
100	3	0	0	0	3

Table 4. Chemical composition of additives used

Additive	Moisture	Ash	Nitrogen	Protein	Carbon	C:N	pH
Rice bran	9.19	15.85	1.17	7.31	45.6	39.97	6.71
Rice husk	7.39	17.41	0.2	1.25	40.86	204.3	6.32

Source: Youri (2004), MPhil thesis

Table 5. Some major and minor mineral contents of fruit body of *P. ostreatus*

Additive	Major mineral constituents (mg/100g)		Minor mineral constituents (mg/100mg)
	Ca	P	Fe
Rice bran alone	43.1	939	42.6
Rice bran and 2% rice husk	1567	1447	15.0

Table 6. Proximate composition of *P. ostreatus* mushroom on different additives (per 100g sample)

Additive	Initial moisture	Crude protein	Fat	Ash	Total carbohydrate	Energy value
Rice bran alone	90.9	20.0	2.0	7.6	49.9	279.9
Rice bran and 2% rice husk	86.6	19.2	3.3	9.2	54.9	326.0

influences the BE values obtained (Chang Ho and Yee, 1977; Chang and Miles, 1982).

Across all strains, flush 1 gave the highest mean yield (59.5g) and flush 4 the lowest mean yield (24.7g) (Table 2). Flush 2 produced the second highest mean yield (35.2g). Significant differences ($P \leq 0.05$) were found between flushes 1, 2 and 4. Although by flush 2 more than 60% of the total yield of the fruit body had been obtained, the proportional weight of mushrooms obtained per flush shows the importance of continuously harvesting till flush 4 (Table 2).

In general, the number of fruit bodies per flush recorded decreased from flush to flush (Table 3) indicating that the nature and amount of nitrogen available in a substrate after each flush influence the degree of cellulose degradation which in turn affects the yield (Zadrazil and Brunnert, 1980). Thus, the high C/N ratio of 100% rice husk determined as 204.3 by Youri (2004) (Table 4) greatly affected the yield of the mushrooms. The major mineral constituents of the fruit body such as Ca and P were significantly increased ($P \leq 0.05$) at 2% supplementation of rice husk (Table 5) as was also recorded for its fat, ash and carbohydrate content (Table 6). There was however a slight decrease in protein content of the fruit body.

Conclusion

The use of agricultural by-products and additives to improve the biological efficiency and nutrient content of the oyster mushroom *Pleurotus ostreatus* (Jacq. ex. Fr.) Kummer has been an area of continuous research in Ghana. Rice husk identified as a possible additive showed an 11% increase in the biological efficiency over the control at 2% supplementation with subsequent increases in some proximate analysis and mineral contents such as calcium and phosphorus. It is therefore recommended that it be used as an additive in the rice growing areas for production of mushrooms.

Acknowledgement

The technical assistance of Messrs Richard Takli and Godson Agbeley is greatly appreciated

References

AOAC, 1990. Official Methods of Analysis of the Association of Official Analytical Chemists. 15th edition. Virginia, USA. Association of Official Analytical Chemists, p 69-80.

Buswell, J. A. 1984. Potentials of spent mushroom substrates for bioremediation purposes. Compost 2: 31-35.

Chang, S. T. and Miles, P. G. 1982. Introduction to mushroom science. In: Chang, S. T and Quimio, T.H. (Eds). Tropical mushrooms: biological nature and cultivation methods p. 3-10. Hong Kong: Chinese University Press.

Chang-Ho Y and Yee, N. T. 1977. Comparative study of the physiology of Volvariella volvacea and Coprinus cinereus. Transaction British Mycological Society 68: 167-72.

Datta, S and Chakravarty, D. K. 2001 Comparative utilization of lignocellulosic components of paddy straw by Tricholoma lobayense and Volvariella volvacea. Indian Journal of Agricultural Sciences 71 (4): 258-260.

Hadder, Y., Kerem, Z. and Gorodecki, B. 1993. Biodegradation of lignocellulosic agricultural wastes by Pleurotus ostreatus. Journal of Biotechnology 30: 133-139.

Internet: Prasara-A. J. 2006. Life cycle assessment of rice husk utilization in Thailand. International conference on green and sustainable utilization. November 29th – December 1st, 2006 Chiangmai Thailand. Downloaded from http://www.energybased.nrct.go.th/Article/Ts3%20life%20cycle%20assessment%20of%20 rice%20husk%20utilization%20in%20thailand.pdf on 08/07/09

Mahmoud, B. H. and El-Kattan, M. H. 1989. Edible oyster mushroom cultivation on rice straw. Mushroom Journal for the Tropics 9: 37-42.

Mueller, J. C., Gawley, J. R. and Hayes, W. A. 1985. Cultivation of the shaggy mane mushroom (Coprinus comatus) on cellulosic residues from pulp mills, Mushroom Newsletter for the Tropics 6: 15-20.

Obodai, M., Cleland-Okine, J., Awotwe, B., Takli, R. and Dzomeku, M. 2002. Training manual on mushroom cultivation in Ghana. pp 16-19. Technical manual of the CSIR-Food Research Institute

Obodai, M. and Johnson P-N. T. 2002. The effect of nutrient supplements on the yield of Pleurotus ostreatus mushroom grown on composted sawdust of Triplochiton scleroxylon. Tropical Science 42: 78-82.

Obodai, M., Cleland-Okine, J. and Vowotor, K. A. 2003. Comparative study on the growth and yield of Pleurotus ostreatus mushrooms on different lignocellulosic by-products. Journal of Industrial Microbiology and Biotechnology 30 (3): 146-149.

Oei, P. 1991. Manual on mushroom cultivation-techniques, species and opportunities for commercial application in developing countries. CTA, Netherlands.

Pearson, D. 1970. Chemical analysis of food. 7th ed. London: J and A Churchill, p. 18-19.

Poppe, J. 2000. Use of agricultural waste material in the cultivation of mushrooms. Mushroom Science 15: 3-23.

Salmones, D., Gerardo, M., Ramos, L. M. and Waliszewski, K. N. 1999. Cultivation of shiitake mushroom, Lentinula edodes in several lignocellulosic materials originating from the tropics. Agronomie 19:13–19

Saxena, S. and Rai, R. D. 1992. Effect of nitrogen on production of extracellular degradative enzymes by Pleurotus sajor-caju (Fr) Singer on wheat straw. Mushroom Research 1: 45-48.

Sawyerr, L. C. 1994. Utilization of agricultural and agro-Industrial by-products in the cultivation for edible and medicinal mushrooms in Ghana. In: Proceedings of Food Research Staff Association Seminars Accra, Ghana. 1994. p. 22.

Shashirekha, M. N., Rajarathnam, S and Bano, Z. 2005. Effect of supplementing rice straw growth substrate with cotton seeds on the analytical characteristics of the mushroom, Pleurotus florida (Block and Tsao). Food Chemistry 92(2): 255-259.

Song, F. 1986. Management of growing shiitake in sawdust-filled plastic bags. Youth Commission, Taiwan (in Chinese). Mushroom Journal for the Tropics 9: 91.

SPSS for Windows (1999), Chicago, Illinois, USA.

Thomas, G. V., Prabhu, S. R., Reeny, M. Z and Bopaiah, B. M. 1998. Evaluation of lignocellulosic biomass from coconut palm as substrate for cultivation of Pleurotus sajor-caju (Fr.) Singer. World Journal for Microbiology and Biotechnology 14: 879–882

Youri, M. 2004. Formulation of media for the production of Pleurotus ostreatus using agro-processing waste: University of Ghana. MPhil thesis.

Zadrazil, F. and Brunnert, H. 1980. The influence of ammonium nitrate supplementation on degradation and in-vitro digestibility of straw colonized by higher fungi. European Journal of Applied Microbiology and Biotechnology 9: 37-44.