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SPENT MUSHROOM SUBSTRATE: A TREASURE OF NUTRIENTS

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Abstract– *Pleurotus* mushrooms are the second most popular species used worldwide. The enzymes in mushrooms have the ability to degrade readily available agricultural wastes under solid state fermentation. Two *Pleurotus* species viz. *P. sapidus* and *P. sajor-caju* were grown on different agrowastes like wheat (*Triticum aestivum*), Mung (*Phaseolous radiatus*), Tur (*Cajanus cajan*), Soybean (*Glycine max*) and their 15 combinations. The nutritional analysis of plain agrowaste and different SMS were done. There is increase in crude protein contents in both the varieties. The crude fibre contents were found to be decreased with increase in total carbohydrates. In mineral contents, Na was increased with decrease in K and Ca. Thus, along with other uses, the SMS can be used as better animal feed and it can be a way to pollution control.

INTRODUCTION

Spent mushroom substrates are the substrates that remain after harvesting of mushrooms. The genus *Pleurotus* is a group of basidiomycetes, some species are produced as human food and have a great economic importance because their cultivation is not complicated and has become a common practice around the world. For the past decades, in many parts of the world, much interest has been evident in new techniques for bioconversion of lignocellulosic materials. In this regard, production of edible mushrooms has been industrially developed in more than 80 countries (Spencer, 1985). The worldwide production of edible *Agricus biosporus* was estimated to be about 2 million tons in 1997 (Chang, 1999). Then at least more than 10 million tons of spent *Agaricus biosporus* substrates are annually produced in the world. Langer *et al.* (1982) reported that spent *Agaricus biosporus* substrate could be used as sources of minerals for animals, as they are rich in major and trace minerals. China produces more that 4 million tons of SMC annually. In contrast to Holland, spent mushroom compost (SMC) is not considered a waste in China. A vegetable grower will spend RMB 100 (about Euro 10) to buy one ton SMC from the mushroom farm (Oei *et al.*, 2007). Although traditionally spent mushroom substrates have been used as a fertilizer for plants, they have been studied also for their use as a feed source for animals. The present study was performed for estimating the potential increase in feeding values of spent mushroom substrates in comparison to control agrowastes.

MATERIALS AND METHODS

1) Spent Mushroom straw preparation

The spawns of different varieties of mushrooms viz *Pleurotus sapidus*, *Pleurotus sajorcaju* were obtained from Agriculture College, Pune and P.K.V., Akola. The different agrowastes *viz* wheat (*Triticum aestivum*), Mung (*Phaseolous radiatus*), Tur (*Cajanus cajan*), Soybean (*Glycine max*) were collected from local farms. The substrate straw and beds were prepared according to the procedure described by Bano and Nagarajan (1976) in 15 different combinations. The spent mushroom substrate was collected after each flush. It was sun dried and oven dried for further estimations.

2) Estimation of crude fibers

Crude fibre contents in SMS were estimated according to Maynard (1970).

3) Estimation of proteins

Protein content in SMS was measured by Bradford method (Bradford, 1976).

4) Estimation of minerals (Na, K, Ca)

Estimation of sodium, potassium and calcium was done by Flame Photometric Method (Kapur and Govil, 2000).

5) Estimation of total carbohydrates

Total carbohydrates in SMS were estimated by Anthrone Method (Hedge and Hofreiter, 1962).

RESULTS AND DISCUSSION

It was observed that the maximum decrease in crude fibre (%), the maximum increase in crude protein (%) and total carbohydrates (%) in SMS of *P. sapidus* and *P. sajor-caju* were recorded as [44.00% (W), 5.46% (W+T), 10.90% (W+M)], [23.50% (S), 7.36% (T+S+W), 7.60% (W+M+T)] respectively.

The extra cellular ligninolytic enzymes viz. LiP, MnP, laccases and cullulolytic enzymes viz. cellulases may be responsible for reduction in cell wall components and increase in protein and carbohydrate contents in SMS and also the reduction in crude fibre contents. With respect to plain untreated control substrates, the cultivation of mushroom by *P. sapidus* and *P. sajor-caju* increased crude protein contents in [(0.006% to 5.46%), *P. sapidus*; (5.47% to 7.36%)], *P. sajorcaju* and decreased crude fibre content (3.0% to 44.0%), *P. sapidus* (2.0% to 23.50%), *P. sajorcaju*. Also, the carbohydrate contents were increased in the range (1.37% to 10.90%), *P. sapidus*; (0.20% to 7.60%), *P. sajor-caju*.

There is slight decrease in Na contents and increase in K and Ca contents in all the SMS combinations compared to agrowaste.

According to the Patil *et al.* (2010), *P. ostreatus* spent straw *viz.* soybean straw, paddy straw, wheat straw and their combinations presented similar results to our study as an increase in crude protein content (4.9% to 9.9%) decrease in crude fibre content (16.20% to 22.07%). In contrast to our study, the similar study depicted the decrease in carbohydrate in *P. ostreatus* SMS. The increased carbohydrate contents in our study may be due to much lignocellulose biodegradation of agrowaste. The same study presented slight increase in Na content. Also, the K and Ca levels are increased marginally. In our study, increasing levels of Na and decreasing levels of K may be due to their respective decreased and increased levels in mushroom fruiting body. Jafri *et al.* (2007) studied the effect of *Pleurotus* spp. fungi on chemical composition and in vitro digestibility of rice straw. According to them, there is increase in crude protein content of *P. ostreatus*, *P. florida*, *P. sajorcaju*, *P. dijamor* SMS (0.01%, 0.95%, 0.7%, 1.53%) respectively. The increase is much less compared to our study. Similar to our study decrease in fibre content ADF and NDF in the range of (2.46% to 5.56%) and (7.89% to 13.83%) respectively was recorded in all the four SMS varieties.

CONCLUSION

The study suggests that both the *Pleurotus* species can upgrade the agrowastes by fermentation. As both the varieties increase the protein, carbohydrate contents and decrease the crude fibre contents of agrowastes, the SMS can be used as value added

Table 1. Nutritional contents in Plain Agrowaste

Sr. No.	Plain Agrowaste	Crude Fibre %	Protein %	Carbohydrate%	Minerals % Na	K	Ca
1	W	74.50 ± 0.16	1.2 ± 0.005	6.0 ± 0.12	0.024 ± 0.002	0.6125 ± 0.03	0.2968 ± 0.03
2	M	68.00 ± 0.01	1.155 ± 0.02	6.6 ± 0.02	0.012 ± 0.009	0.6294 ± 0.18	0.2155 ± 0.11
3	T	38.50 ± 0.05	1.120 ± 0.08	6.8 ± 0.25	0.013 7 ± 0.12	0.5034 ± 0.05	0.2358 ± 0.05
4	S	68.50 ± 0.038	1.155 ± 0.18	7.8± 0.009	0.01497 ± 0.002	0.4906 ± 0.65	0.2358 ± 0.21
5	W + M	67.10 ± 0.36	1.315 ± 0.32	7.9 ± 0.11	0.01686 ± 0.6	0.5120 ± 0.8	0.2516 ± 0.71
6	W + T	46.50 ± 0.086	1.137 ± 0.022	8.8 ± 0.020	0.0186 ± 0.15	0.6318 ± 0.25	0.2765 ± 0.13
7	W + S	75.50 ± 1.30	1.208 ± 0.26	6.4 ± 0.12	0.0188 ± 0.002	0.7101 ± 0.12	0.2663 ± 0.09
8	T + S	35.00 ± 0.40	1.332 ± 1.16	6.0 ± 0.025	0.0159 ± 0.007	0.6125 ± 0.05	0.2460 ± 0.08
9	T + M	48.00 ± 0.50	1.315 ± 0.20	5.8 ± 0.15	0.0144 ± 0.08	0.6382 ± 0.01	0.2358 ± 0.31
10	S + M	45.50 ± 0.65	1.324 ± 0.24	9.2 ± 0.32	0.014 ± 0.01	0.6318 ± 0.09	0.2053 ± 0.06
11	W + M + T	76.50 ± 0.16	1.324 ± 0.005	7.0 ± 0.11	0.01546 ± 0.02	0.6651 ± 0.01	0.1850 ± 0.05
12	W + M + S	51.50 ± 0.18	1.015 ± 0.64	7.4 ± 0.12	0.0159 ± 1.12	0.6767 ± 0.18	0.2155 ± 0.11
13	M + T + S	50.00 ± 0.35	1.306 ± 0.78	7.6 ± 0.005	0.01253 ± 0.18	0.3108 ± 0.12	0.1850 ± 0.21
14	T + S + W	40.50 ± 0.38	1.20 ± 0.29	6.8 ± 0.6	0.0176 ± 0.17	0.3044 ± 0.10	0.1850 ± 0.03
15	W + M + T + S	39.50 ± 0.42	1.315 ± 0.62	7.4 ± 0.25	0.0164 ± 0.03	0.3429 ± 0.11	0.1545 ± 0.12

Table 2. Nutritional contents in *P. sapidus* SMS

Sr. No.	SMS	Crude Fibre % I	Crude Fibre % II	Protein% I	Protein% II	Carbohydrate% I	Carbohydrate% II	Minerals % Na	Minerals % K	Minerals % Ca
1	W	64.00 ± 0.12	30.50 ± 0.31	1.6 ± 0.12	1.80 ± 0.15	13.40 ± 0.14	16.59 ± 0.16	0.0244 ± 0.18	0.902 ± 0.10	0.195 ± 0.13
2	M	58.00 ± 0.01	40.50 ± 0.12	1.33 ± 0.11	1.93 ± 0.17	11.60 ± 0.12	17.20 ± 0.18	0.0232 ± 0.15	0.0669 ± 0.11	0.185 ± 0.14
3	T	36.00 ± 0.08	33.00 ± 0.10	1.55 ± 0.09	2.22 ± 0.19	8.20 ± 0.10	13.40 ± 0.20	0.0242 ± 0.14	0.0861 ± 0.12	0.215 ± 0.16
4	S	60.00 ± 0.11	42.00 ± 0.16	1.20 ± 0.07	1.33 ± 0.21	8.20 ± 0.09	9.70 ± 0.02	0.0200 ± 0.11	0.02839 ± 0.006	0.185 ± 0.17
5	W + M	59.00 ± 0.15	39.50 ± 0.05	4.10 ± 0.05	4.80 ± 0.23	14.10 ± 0.11	18.80 ± 0.05	0.0257 ± 0.09	0.105 ± 0.16	0.205 ± 0.19
6	W + T	41.00 ± 0.09	33.50 ± 0.1	4.00 ± 0.05	6.60 ± 0.02	13.90 ± 0.12	15.80 ± 0.07	0.0264 ± 0.08	0.0797 ± 0.17	0.225 ± 0.11
7	W + S	68.00 ± 0.05	43.00 ± 0.03	1.155 ± 0.02	2.90 ± 0.30	7.00 ± 0.14	7.77 ± 0.09	0.0276 ± 0.06	0.1375 ± 0.19	0.225 ± 0.18
8	T + S	33.00 ± 0.03	30.00 ± 0.02	1.10 ± 0.30	1.11 ± 0.25	8.80 ± 0.16	12.40 ± 0.25	0.0276 ± 0.12	0.0604 ± 0.21	0.225 ± 0.21
9	T + M	38.50 ± 0.11	28.50 ± 0.10	1.15 ± 0.16	1.20 ± 0.27	9.80 ± 0.20	12.80 ± 0.22	0.0244 ± 0.11	0.0348 ± 0.23	0.215 ± 0.22
10	S + M	39.00 ± 0.10	35.50 ± 0.08	1.244 ± 0.02	1.33 ± 0.4	11.00 ± 0.19	11.20 ± 0.23	0.0222 ± 0.13	0.0219 ± 0.25	0.205 ± 0.23
11	W + M + T	65.50 ± 0.42	43.00 ± 0.12	1.20 ± 0.04	1.39 ± 0.02	8.20 ± 0.15	12.40 ± 0.11	0.0257 ± 0.10	0.05407 ± 0.25	0.205 ± 0.18
12	W + M + S	43.00 ± 0.21	27.50 ± 0.11	1.11 ± 0.12	2.12 ± 0.05	10.20 ± 0.12	11.40 ± 0.18	0.0266 ± 0.09	0.03814 ± 0.27	0.246 ± 0.19
13	M + T + S	41.50 ± 0.17	38.50 ± 0.15	1.244 ± 0.22	2.32 ± 0.7	7.20 ± 0.13	12.40 ± 0.7	0.0232 ± 0.15	0.02197 ± 0.29	0.195 ± 0.22
14	T + S + W	36.00 ± 0.16	32.50 ± 0.26	1.315 ± 0.12	2.66 ± 0.09	10.00 ± 0.22	10.20 ± 0.15	0.0249 ± 0.22	0.0476 ± 0.22	0.195 ± 0.24
15	W + M + T + S	37.00 ± 0.12	36.50 ± 0.4	2.40 ± 0.10	3.21 ± 0.25	10.00 ± 0.25	14.40 ± 0.25	0.0264 ± 0.23	0.0500 ± 0.19	0.205 ± 0.21

Table 3. Nutritional contents in *P.sajorcaju* SMS

Sr. No.	Plain Agrowaste	Crude Fibre % I	Crude Fibre % II	Protein% I	Protein% II	Carbohydrate% I	Carbohydrate% II	Minerals % Na	Minerals % K	Minerals % Ca
1	W	67.50 ± 0.11	56.00 ± 0.15	5.248 ± 0.14	7.52 ± 0.12	8.40 ± 0.10	12.60 ± 0.10	0.0244 ± 0.09	0.1696 ± 0.17	0.2155 ± 0.12
2	M	68.00 ± 0.16	58.00 ± 0.18	5.28 ± 0.11	7.44 ± 0.16	7.60 ± 0.01	9.80 ± 0.09	0.025 ± 0.25	0.15 ± 0.16	0.25 ± 0.10
3	T	37.00 ± 0.20	36.50 ± 0.16	7.11 ± 0.13	7.36 ± 0.11	7.00 ± 0.03	8.20 ± 0.08	0.025 ± 0.09	0.21 ± 0.16	0.20 ± 0.16
4	S	68.00 ± 0.22	45.00 ± 0.18	5.92 ± 0.20	7.44 ± 0.10	6.20 ± 0.15	9.40 ± 0.10	0.027 ± 0.07	0.14 ± 0.11	0.23 ± 0.21
5	W + M	65.00 ± 0.24	61.00 ± 0.17	6.40 ± 0.19	7.52 ± 0.09	9.20 ± 0.12	10.00 ± 0.11	0.028 ± 0.01	0.79 ± 0.10	0.23 ± 0.22
6	W + T	44.00 ± 0.23	40.00 ± 0.19	6.32 ± 0.17	8.48 ± 0.15	10.20 ± 0.13	14.20 ± 0.12	0.027 ± 0.03	0.28 ± 0.09	0.27 ± 0.25
7	W + S	71.00 ± 0.28	65.50 ± 0.16	6.56 ± 0.10	7.52 ± 0.18	9.60 ± 0.22	13.40 ± 0.13	0.021 ± 0.05	0.15 ± 0.08	0.20 ± 0.16
8	T + S	33.00 ± 0.26	30.00 ± 0.12	6.56 ± 0.09	7.60 ± 0.19	11.20 ± 0.25	13.40 ± 0.14	0.029 ± 0.09	0.34 ± 0.16	0.31 ± 0.17
9	T + M	42.50 ± 0.12	31.00 ± 0.09	6.88 ± 0.08	7.52 ± 0.22	7.60 ± 0.02	12.40 ± 0.16	0.028 ± 0.08	0.79 ± 0.18	0.26 ± 0.09
10	S + M	42.50 ± 0.15	40.50 ± 0.07	6.80 ± 0.14	7.36 ± 0.17	9.20 ± 0.2	9.40 ± 0.18	0.025 ± 0.11	0.15 ± 0.10	0.22 ± 0.08
11	W + M + T	71.00 ± 0.16	46.50 ± 0.11	6.88 ± 0.13	8.40 ± 0.12	14.00 ± 0.6	14.60 ± 0.20	0.027 ± 0.10	0.54 ± 0.11	0.23 ± 0.07
12	W + M + S	50.00 ± 0.18	44.00 ± 0.22	6.83 ± 0.12	8.40 ± 0.16	5.40 ± 0.12	10.20 ± 0.21	0.026 ± 0.12	0.99 ± 0.12	0.25 ± 0.11
13	M + T + S	43.00 ± 0.22	29.00± 0.10	6.81 ± 0.16	8.48 ± 0.12	10.20 ± 0.10	11.00 ± 0.23	0.025 ± 0.10	0.14 ± 0.13	0.25 ± 0.10
14	T + S + W	38.50 ± 0.21	36.00 ± 0.19	6.64 ± 0.17	8.56 ± 0.10	7.40 ± 0.11	11.20 ± 0.24	0.026 ± 0.16	0.86 ± 0.12	0.26 ± 0.09
15	W + M + T + S	38.00 ± 0.23	36.50 ± 0.12	6.88 ± 0.19	8.64 ± 0.09	8.20 ± 0.19	11.20 ± 0.16	0.028 ± 0.19	0.21 ± 0.11	0.37 ± 0.08

animal feed. Thus, decreasing the use of food grains for animal feed and helping the economy as well as pollution control. It will be viable for the benefit of society by mushroom cultivation as alternative protein rich food source for human beings and SMS as alternative food source for animals.

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