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RESEARCH ARTICLE

Influence of supplements on productivity, proximate principles, vitamin C and tryptophan content of syster mushroom

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SUMMARY

Protein malnutrition is wide spread in developing countries and stresses a profound need to search alternate or non-conventional sources of protein. The mushroom is one such promising source as it produces a significant amount of protein of higher biological value. The spawn of *Pleurotus sajor-caju* and *Pleurotus florida* was obtained from All India Co-ordinated Mushroom Improvement Project, College of Agriculture, Pune-5 (M.S.). The paddy straw and supplements *viz.*, wheat bran, rice bran, gram flour, neem cake, urea, cellulose powder and potassium dihydrogen phosphate (KH_2PO_4) were purchased locally. The maximum fresh yield of mushroom obtained was 841 g per kg dry substrate with maximum biological efficiency of 84.10 per cent. The oven dried mushroom contained maximum of 29.53 per cent protein, 8.70 per cent crude fibre, 1.70 per cent fat, 8.32 per cent ash, 63.14 per cent carbohydrate and 347.63 Kcal of energy per 100 g of mushroom. The gram flour treatment (T_4) was superior in respect of iron content (13.9 mg/100g). The comparison of treatments revealed that the fertilizer treatment (T_6) was adjudged as superior in respect of yield and biological efficiency, ash content on dry weight basis and content of phosphorus, potassium and calcium.

Key Words : Mineral element, Paddy straw, Proximate principle, Supplements tryptophan, Vitamin C, Yield, Biological efficiency

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Mushrooms are regarded as non-conventional source of protein having good amount of protein with high digestibility. Its capacity to convert carbohydrates into protein is 65% as against 25% of pork, 15% of milk and 5% of poultry (Madan *et al.*, 1994). The mushroom protein is rich in lysine and tryptophan, the two essential amino acids which are deficient in cereal protein. They contain good amount of vitamin C and B group of vitamins, rich in K, P, and Na, and contain low but available form of Iron. Mushroom is a low calorie food with very little fat. Potassium: sodium ratio is very high which is desirable for patients of hypertension. Considering the amino acid index, biological value, *in vitro* digestibility, nutritional index and protein score they fall between high-grade vegetables and low grade meats. Fractions of water-soluble polysaccharide are reported to posses anti-tumor activity (Bano and Rajarathnam, 1988).

Natural plant wastes or agro-wastes are the basic substrate for production of all edible mushrooms, capable of utilizing high C/N ratio organic matter such as lignin, cellulose and hemicelluloses, require minimum space and low investment cost and has short gestation period. They can be cultivated even by villagers and can serve as means of higher net returns *i.e.* net profit of Rs. 21,929.00 per season from two crops (Suman, 2003). They are eco-friendly, less labour

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intensive, safe from natural calamities and cost effective. Almost all the high quality hotels, even at taluka level are serving delicious dishes prepared out of mushrooms and people are relishing them even after paying higher cost. The information on the effect of enriched substrate on productivity and nutritive value of mushroom is not available. The effect of different supplements on productivity and nutritive value of two varieties of oyster mushroom grown under Konkan agro-climatic condition is, therefore, proposed to study the effect of different supplements on productivity and nutritive value of *Pleurotus species.*

MATERIAL AND METHODS

The oyster mushroom (*Pleurotus species*) was cultivated on paddy straw beds prepared with and without supplements in a room previously disinfected with 2 per cent formalin. The paddy straw was pasteurized by dipping in hot water at 82^0C for one hour. The supplements *viz.*, wheat bran, rice bran, gram flour, neem cake and inorganic fertilizers were sterilized in autoclave at 1 kg/cm^2 pressure for one hour. The polypropylene bags (35 cm × 55 cm) were sterilized by dipping them in 2 per cent formalin solution, and filled with pasteurized wet paddy straw (approx. 3.5 kg wet weight), spawn and supplements. The spawn and supplements were added along the periphery of the bed in five layers. The paddy straw (1 kg dry or about 3.5 kg wet weight) and spawn @ 3% wet weight of paddy straw were common to all the treatments. The supplements were added on dry weight basis as per the treatment details given in Table A.

Table A : Treatment details

Treatments	Description
T_1	Control
T_2	10 % rice bran
T_3	10 % wheat bran
T_4	5 % gram flour
T_5	2 % neem cake
T_6	Fertilizer mixture (Urea 1.15 g + KH_2PO_4 4.38 g + Cellulose powder 94.47 g)

The treatments were replicated three times and were same for both the species *viz*., *Pleurotus sajor-caju* and *Pleurotus florida*. The first flush of fruiting body was harvested between 14th and 17th October, 2nd flush during 1st and 4th November and last flush was harvested between 14th and 17th November 2005. All the three flushes were pooled weighed and the mushroom yield is expressed in gram on fresh weight basis. The *Pleurotus sajor-caju* was ready for harvest one to two days earlier than the *Pleurotus florida*. However, the size and weight of individual sporophores of *Pleurotus florida* was almost twice that of *Pleurotus sajor-caju*. The fruit bodies (sporophores) were kept for drying in oven at 70^0C temperature until complete drying. The dried mushrooms were ground to powder in a waring blender. This powder was used for analysis of proximate principles, amino acid content and vitamin C.

RESULTS AND DISCUSSION

The data on the effect of different supplements on productivity and biological efficiency in *Pleurotus sajor-caju* and *Pleurotus florida* are presented in Table 1.

The yield of *Pleurotus* species ranged from 650 g to 841 g per kg dry substrate with a mean value of 730 g on fresh weight basis. The fertilizer treatment (T_6) recorded the highest yield of 828 g per kg dry substrate and appeared to be significantly superior to all other treatments. The increase in yield was highest (24.1%) with fertilizer supplement (T_6) followed by wheat bran (15.1%) and the lowest increase in the yield (6.5%) was seen with rice bran (T_2). Similar beneficial effects of supplements on *Volvariella diplasia* mushroom yield has been reported by Kumar and Singh (2002). They observed that the neem cake, wheat bran, rice bran and gram flour with paddy straw as substrate produced significantly higher yield as compared with control. The finding of Sangeetha *et al*. (2004) that the fertilizer treatment showed the maximum beneficial effect on sporophore yield is also in accordance with the finding in present study. Similar beneficial effect of NPK supplementation on sporophore yield has also been reported by Isikhuemhen and Okhuoya (1998). The differences in sporophore yield due to species were not significant. Similarly, the interaction of species with supplement was also found to be non-significant.

Mathew *et al*. (1996) reported that the yield of mushroom was 865 g per kg dry substrate, which is in accordance with yield obtained in present investigation. Hazarika (1998) concluded that the yield of *Pleurotus sajor-caju* was 1685 g per 2 kg dry substrate which is also in close agreement with the findings in present study. The flush wise analysis of data revealed that the first harvest constituted more than 50 per cent (54.40%) of the total yield. The second harvest gave 32.80 per cent yield and in the third harvest, the mushroom yield was only 12.80 per cent.

The biological efficiency of the *Pleurotus species* grown on paddy straw with and without supplements varied from 65.0 per cent to 84.1 per cent with a mean value of 73.0 per cent. The species differences in respect of biological efficiency were significant. The fertilizer treatment (T_6) recorded significantly higher biological efficiency over rest of the treatments. The species and interaction differences were not significant.

The biological efficiency values (68.7 to 88.4 %) reported by Eswaran *et al*. (1998) were in close agreement with the values in present investigation. While the biological efficiency values reported by Dhanda *et al*. (1996), Pathak *et al*. (1998), Jain and Vyas (2002) and Kumar and Singh (2002) were lower than the values in present study. The biological efficiency values reported by Hazarika (1998); Gogoi and

Table 1 : Effect of different supplements on productivity (g/kg substrate) and biological efficiency (%) of *Pleurotus species*

Treatments	Total			Biological efficiency		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1 – Control	650	681	667	65.0	68.1	66.6
T_2 - Rice bran	711	711	711	71.1	71.1	71.1
T_3 - Wheat bran	794	742	768	79.4	74.2	76.8
T_4 - Gram flour	675	697	686	67.5	69.7	68.6
T_5 - Neem cake	730	715	723	73.0	71.5	72.3
T_6 – Fertilizer	815	841	828	81.5	84.1	82.8
Mean	729	731	730	72.9	73.1	73.0
S.E.± (T)		10.9			1.1	
C.D. (P=0.01)		43.3			4.3	
S.E.± (V)		6.3			0.6	
C.D. at 1%		NS			NS	
S.E.± (V×T)		15.4			1.5	
C.D. (P=0.01)		NS			NS	

NS=Non-significant

Adhikary (2002) and Periasamy and Natarajan (2004) were higher than the biological efficiency values in present study.

Proximate principles

The oyster mushrooms are consumed both in fresh as well as dry forms. The data on proximate composition of oven dried *Pleurotus species* are therefore presented in Table 3.

The protein content on dry weight basis ranged from 19.00 to 29.53 per cent with a mean value of 24.19 per cent. The gram flour treatment (T_4) recorded the highest protein content of 25.92 per cent followed by wheat bran treatment (T_3). The neem cake treatment (T_5) and fertilizer treatments (T_6) resulted in significant decrease in protein content of *Pleurotus* species as compared with control (T_1). The species differences with respect to protein content were also significant. The *Pleurotus florida* recorded significantly higher protein content (27.28%) as compared with *Pleurotus sajor-caju* (21.09%). The interaction of species with treatments revealed that the protein on dry weight basis was significantly decreased in all the treatments except V_2T_3 and V_2T_4 treatments. Singh and Mishra (2006) reported that the protein content of mushroom ranged from 20 to 35 per cent. The values are in close agreement with the protein content values in present investigation. Similar results have also been reported by several workers (Anonymous, 1972; Ogundana and Fagade, 1982; Sivaprakasam, 1983; Periasamy and Natarajan, 2002 and Singh *et al*., 2003).

The crude fibre content ranged from 7.98 to 8.70 per cent with a mean value of 8.37 per cent on dry weight basis. The rice bran treatment (T_2) showed the highest crude fibre content of 8.63 per cent and appeared to be significantly superior to all other treatments except fertilizer treatment (T_6) which was at par with it. The gram flour and neem cake treatments were statistically at par with control (T_1). The differences in crude fibre content due to species or species and treatment- combinations were not significant. Khydagi *et al.* (1998) and Bande (2004) reported that the crude fibre content values ranged from 7.4 to 8.8 per cent and 7.94 to 8.94 per cent, respectively which are in close agreement with the crude fibre content values in present investigation. Similar results have also been reported by Anonymous (1972) and Singh *et al*. (2003). However, the crude fibre content values reported by Upadhyay and Rai (1999) and Rathore and Thakore (2004) were slightly on higher side (8.05 to 11.76%).

The crude fat content of *Pleurotus species* ranged from 0.65 to 1.70 per cent with a mean value of 1.36 per cent. The crude fat content was decreased significantly due to different treatments. The effect due to species on crude fat content was significant. The *Pleurotus sajor-caju* recorded significantly higher crude fat content (1.51 %) as compared with *Pleurotus florida* (1.22%). The interaction effect was also significant. The interaction of species with treatment revealed that the crude fat content on dry weight basis was significantly decreased in all the treatments except V_1T_4, V_1T_5, V_2T_1 and V_2T_6 treatments. Hadwan *et al*. (1993) reported that the crude fat content of *Agaricus bisporus* mushroom was in the range from 1.2 to 1.6 per cent, which is in close agreement with the crude fat content values in present investigation. However, the crude fat content values (1.80 to3.15%) reported by Khydagi *et al*. (1998), Ude *et al*. (2001), Bande (2004) and Rathore and Thakore (2004) were about two times more than the crude fat content values observed in present study.

The ash content of *Pleurotus species* ranged from 7.06 to 8.32 per cent with a mean value of 7.53 per cent on dry weight basis. The fertilizer treatment (T_6) recorded the highest ash content of 8.26 per cent and appeared to be significantly superior to all other treatments. The effect due to species was not significant. The interaction effect was also not significant.

Table 2 : Effect of different supplements on proximate composition of *Pleurotus* species

Treatment	Protein (%)			Crude fibre (%)			Crude Fat (%)			Ash (%)			Carbohydrate (%)			Energy (Kcal/100 g)		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1 - Control	19.73	29.53	24.63	8.21	7.98	8.10	1.70	1.55	1.63	7.22	7.06	7.14	63.14	53.88	58.50	346.77	347.63	347.20
T_2 - Rice bran	22.75	25.73	24.23	8.55	8.70	8.63	1.33	1.22	1.28	7.47	7.49	7.48	59.90	56.86	58.38	342.60	341.73	342.17
T_3 - Wheat bran	21.50	29.07	25.28	8.25	8.42	8.34	1.43	0.65	1.04	7.36	7.40	7.38	61.46	54.46	57.96	344.77	339.83	342.30
T_4 - Gram flour	22.77	29.07	25.92	8.31	8.25	8.28	1.58	1.37	1.48	7.26	7.50	7.38	60.08	53.81	56.94	345.63	343.83	344.73
T_5 - Neem cake	20.80	24.83	22.82	8.41	8.22	8.31	1.58	1.00	1.29	7.57	7.46	7.51	61.64	58.49	60.07	344.00	342.20	343.10
T_6 - Fertilizer	19.00	25.47	22.23	8.43	8.65	8.54	1.40	1.53	1.47	8.32	8.19	8.26	62.85	56.16	59.50	339.97	340.17	340.07
Mean	21.09	27.28	24.19	8.36	8.37	8.37	1.51	1.22	1.36	7.53	7.52	7.53	61.51	55.61	58.55	343.96	342.57	343.26
S.E.± (T)		0.43			0.06			0.04			0.07			0.41			0.78	
C.D. (P=0.01)		1.72			0.23			0.14			0.29			1.63			3.11	
S.E.± (V)		0.25			0.03			0.02			0.04			0.24			0.45	
C.D. at 1%		1.00			N.S.			0.08			N.S.			0.94			1.80	
S.E.± (V×T)		0.61			0.08			0.05			0.10			0.58			1.10	
C.D. (P=0.01)		2.44			NS			0.20			NS			2.31			NS	

NS=Non-significant

Pathak *et al.* (1998) and Bande (2004) reported that the ash content of *Pleurotus species* ranged from 6.2 to 9.2 per cent, which is in accordance with the ash content values in present investigation. However, the ash content values (9.0 to 12.6%) reported by Anonymous (1972), Hadwan *et al.* (1993), Singh *et al.* (1996) and Rathore and Thakore (2004) were slightly on higher side.

The carbohydrate content of *Pleurotus species* ranged from 53.81 to 63.14 per cent with a mean value of 58.55 per cent on dry weight basis. The carbohydrate content was highest (60.07%) in neem cake treatment (T_5) followed by fertilizer treatment (59.50%). However, the increase in carbohydrate content due to neem cake or fertilizer treatment was not significant as it was statistically at par with control. Among the treatments, none of the treatments was found to be statistically significant over control with respect to carbohydrate content of mushroom. Between the species, *Pleurotus sajor-caju* recorded significantly higher carbohydrate content (61.51 %) as compared with *Pleurotus florida* (55.61 %). The interaction effect was significant. The *Pleurotus sajor-caju* alone had the highest carbohydrate content (63.14 g/100 g) and appeared significantly superior to all other treatment combinations except V_1T_3, V_1T_5 and V_1T_6. The carbohydrate content values (41.8 to 61.9%) reported by Anonymous (1972) and Hadwan *et al.* (1993) were in close agreement with the carbohydrate content values observed in present investigation. However, Khydagi *et al.* (1998); Pathak *et al.* (1998); Bande (2004) and Rathore and Thakore (2004) reported carbohydrate content values ranging from 34.6 to 53.4 per cent, which were lower than the carbohydrate content values obtained in present study.

The energy content, which represents physiological fuel value, ranged between 339.83 to 347.63 Kcal per 100 g with a mean value of 343.26 Kcal per 100 g on dry weight basis. The energy content was decreased significantly due to different treatments except gram flour treatment (T_4) which was statistically at par with control. The species *Pleurotus sajor-caju* observed to contain significantly higher energy content (343.96 Kcal/100 g) as compared with *Pleurotus florida* (342.57 Kcal/100 g). The interaction effect on energy content is not significant indicating that the data do not revealed definite evidence of differential response of *Pleurotus* species to the different treatments. The energy content values ranged from 247 to 347 Kcal per 100 g of mushroom reported by Bulinski *et al.* (1981) are in accordance with the energy content values observed in present investigation. However, the energy content values (293 to 301 Kcal/100 g) reported by Bande (2004) were much lower than the energy content values observed in present study.

Vitamin C and tryptophan:

The data on the effect of different supplements on vitamin C and tryptophan contents of *Pleurotus* species are presented in Table 4.

Table 3 : Effect of different supplements on vitamin C and tryptophan content of *Pleurotus* species

Treatments	Vitamin C (mg/100 g)			Tryptophan (g/100 g protein)		
	V_1	V_2	Mean	V_1	V_2	Mean
T_1 - Control	53.0	51.3	52.2	1.04	1.17	1.11
T_2 - Rice bran	61.0	54.7	57.8	1.09	1.11	1.10
T_3 - Wheat bran	61.0	57.7	59.3	1.13	1.32	1.22
T_4 - Gram flour	64.7	69.0	66.8	1.07	1.34	1.21
T_5 - Neem cake	70.3	66.7	68.5	1.03	1.24	1.14
T_6 - Fertilizer	65.3	62.3	63.8	1.01	1.13	1.07
Mean	65.6	60.3	61.4	1.06	1.22	1.14
S.E.± (T)		1.1			0.05	
C.D. (P=0.01)		4.5			NS	
S.E.± (V)		0.7			0.03	
C.D. (P=0.01)		NS			0.12	
S.E.± (V×T)		1.6			0.07	
C.D. (P=0.01)		NS			NS	

NS=Non-significant

The vitamin C content of *Pleurotus species* ranged from 51.3 to 70.3 mg per 100 g with a mean value of 61.4 mg per 100 g on dry weight basis. The neem cake treatment (T_5) produced the highest amount of vitamin C (68.5 mg/100 g) in *Pleurotus* species which was significantly higher than all other treatments except the treatment of gram flour (T_4) which was at par with it.

Similarly, the differences in vitamin C content of two species were also substantial. These differences between two species and among different treatment- species combinations were, however, statistically not significant. The vitamin C content values ranging from 15.88 to 66.20 mg per 100 g reported by Singh *et al*. (1999) and Upadhyay and Rai (1999) were in close agreement with the vitamin C content values obtained in present study. However, the vitamin C content value (98.28 mg/100 g) reported by Singh *et al*. (1996) was on higher side.

The tryptophan content of mushroom ranged from 1.01 to 1.34 g per 100 g protein with a mean value of 1.14 g per 100 g protein on dry weight basis. The wheat bran treatment (T_3) and gram flour treatment (T_4) recorded much higher tryptophan content (1.21 to 1.22 g/100 g protein, respectively) as compared with other treatments (1.07 to 1.14 g /100 g protein, respectively). The differences in tryptophan content due to species were, however, significant. The *Pleurotus florida* contained 1.22 g tryptophan per 100 g protein which was significantly higher than *Pleurotus sajor-caju* (1.06 g/ 100 g protein). However, the differences in tryptophan content of different treatment-species combinations were not significant. The tryptophan content value (1.109/100 g protein) reported by Thakur and Yadav (2006) is in close agreement with the tryptophan content values obtained in present study.

Conclusion:

The species *Pleurotus florida* was found to be superior in respect of content of protein content on dry weight basis, tryptophan content, while *Pleurotus sajor-caju* was superior to *Pleurotus florida* in respect of crude fat content, carbohydrate content and energy. The two species, however, did not differ in respect of crude fat and ash contents on dry weight basis and content of vitamin C.

The comparison of treatments revealed that the fertilizer treatment (T_6) was adjudged as superior in respect of yield and biological efficiency, ash content on dry weight basis. The gram flour treatment (T_4), on the other hand, was found to be superior in respect of protein content. From the results of the study, it could be concluded that the species *Pleurotus florida* is superior to *Pleurotus sajor-caju* not only in yield and nutrient contents but also in its physical outlook as it had attractive bright white large sporophores of an average size of 13.5 cm diameter.

Since yield is the main criterion for net higher returns, use of 1.15 g urea, 4.38 g potassium dihydrogen phosphate and 94.47 g cellulose powder along with paddy straw as substrate (T_6) could be recommended for cultivation of *Pleurotus florida*. The gram flour treatment (T_4) may be tried along with fertilizer treatment (T_6) to improve nutritionally important nutrient-protein. The temperature and humidity in Konkan region are quite favourable for growth and fruiting body formation of the oyster mushroom.

The cultivation of oyster mushroom at farmer's level in villages therefore, need to be encouraged, in addition to regular farming. There is also a dire need of commercialization and establishing the organized 'mushroom production and processing' industries in Konkan region.

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