percentage as compared to control (27.83) and these mutants also showed higher starch percentage. An improved cooking quality was observed in many of the mutants except in CPM 49 and 61, as against the control. Microscopic observation on starch grain size presented in Table 2., also showed variability and the maximum starch grain size observed was 15.0 u in CPM. 46 and against 10.8 u in control. Data presented on reducing sugar showed both increasing and decreasing trends in mutuant as compared to their control.

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BIOCONVERSION OF RICE STRAW INTO PROTEIN RICH FEED

A. THANIKACHALAM and M. RANGARAJAN

ABSTRACT

Three cellulolytic fungi were inoculated on alkali hydrolysed rice straw and untreated rice straw. **Asperquillus** sp. (AS.3) exhibited maximum straw conversion (80.0%) followed by **Fusarium** sp. (Fs.4) and **Trichoderma** sp. (T.3) Fungal biomass yield ranged from .82 to 1.06 g/50 ml depending upon the fungi. Crude protein content of rice straw after

1. Centre of Advanced Studies in Agricultural Microbiology Tamil Nadu Agricultural University, Coimbatore 641 003

fermentation varied from 15.6 to 25.0% irrespective of the type of rice straw and the fungi. Soluble protein of the fermented rice straw was maximum (42.5 mg/100 ml) in *Aspergillus* sp. (As.3) insulated substrate. The results showed the possibility of obtaining protein enriched rice straw employing efficient cellulosic fungi.

Availability of rice straw as a large cellulosic waste (Vander Wal, 1979) has led to the development of suitable fermentation process to convert waste materials into protein rich food or feed. Production of fungal protein from sugar-cane bagasse and groundnut shell with *Aspergillus niger* (5 strains), *Penicillium chrysogenum* (S.T.F.38) and *Pastalotia* sp. was reported (Sitaram *et al.*, (1978). Semisolid fermentation of rice and wheat straw acid hydrolysates with *Penicillium funiculosum* and *Candida utilis* resulted in 37-180% increase include protein content within 5-7 days at room temperature. Bioconversion of alkali treated rice straw with *Myrothecium varrucaria* gave the maximum yield of 32.1% crude protein (Dhillon *et al.*, 1981). We recently reported the possible protein enrichment of rice straw through fermentation with *Cellulomonas* sugar release from rice straw inoculated with certain fungi (Thanikachalam and Rangarajan, 1986 a & b) and scaling up of single cell protein from rice straw by bacterial fermentation (Thanikachalam and Rangarajan, 1987). The present study deals with the bioconversion of rice straw into protein rich fee by three cellulolytic fungi.

MATERIALS AND MEHTODS

Three cellulolytic fungi viz., *Trichoderma* sp. (T.3), *Aspergillus* sp. (Ag.3) and *Fusarium* sp. (Fs.4) isolated from decomposing rice straw, farm yard manure and compost respectively, were used in the present study. The cultures were maintained on potato dextrose agar (PDA) at 10°C.

(i) Preparation of Pre-treated Rice straw : Rice straw was dried, milled (powdered) and pre-treated as follows : A quantity of 40 g of powdered rice straw was boiled with 750 ml of alkali mixture (5% NaOH and 1% H_2O_2 in 2:1 ratio v/v) for an hour at 100°C. The powder was washed to free the alkali, and sieved (710).

(ii) Preparation of Inoculum : Fungi were grown under static conditions on Czapek's medium with 0.5% glucose and 0.5% lactose as described by Thanikachalam and Rangarajan (1986 b). After 8 days of growth, fungal mat was homogenised in waring blender and diluted with sterile distilled water to contain 4 x 10^6 spores/ml. Each flask was inoculated with 2 ml inoculum per 100 ml of medium.

(iii) Rice Straw Fermentation : Fungi were cultivated in 50 ml. of the broth medium (Reese and Mandels, 1959) dispensed in 500 ml. Erlenmeyer flask with 1% straw powder as carbon source. The flasks were inoculated as mentioned above and were incubated at static condition for 25 days. Per cent conversion of straw into biomass was estimated as follows : Fungal mycelium along with undigested rice straw powder, was filtered and were transferred to silica crucible. The residue was dried at 60°C and weighed. Then the fungal mat was digested with 100 ml of 5-10% NaoH by keeping in shaker for 6 days and then neutralised by adding con. $H_2 SO_4$ drop by drop. The unutilized straw residue was filtered, dried and weighed as mentioned earlier. Control without inoculation was treated similarly and value deducted. In another set of experiment fungi were grown in 100 ml of same medium dispensed in 500 ml conical flask for 25 days under static condition. The residue consisting of fungal mat and unutilised straw, was separated, dried and weighed.

Analytical Methods : The crude protein content of the residue was estimated by micro-Kjeldahl's method (Humphries, 1956). Soluble protein (Lowry *et al.* (1951) and Cellulase (C_x) activity were determined in the culture filtrate.

RESULTS AND DISCUSSION

Increased conversion of rice straw and biomass yield were observed when treated straw was grown with any one of the three fungi (Table 1) *Aspergillus* sp. (Ag.3) exhibited maximum per cent of conversion (80.0) followed by *Fusarium* sp. and *Trichoderma* sp. (78.0% and 76.0% respectively. But in untreated straw, *Fusarium* sp. (Fs.4) followed by *Trichoderma* sp. (T.3) and *Aspergillus* sp. (Ag.3) recorded maximum conversion of 74.0%, 62.0% and

TABLE 1. Per cent conversion of rice straw and biomass yield by cellulolytic fungi

Cellulolytic fungus	Percent of Straw conversion		Biomass yield (g/50 ml)	
	Treated	untreated	treated	untreated
Trichoderma sp.(T3)	76.00	62.00	0.82	0.66
Aspergillus sp.(Ag.3)	80.00	52.00	1.06	0.75
Fusarium sp. (Fs.4)	78.00	74.00	0.93	0.80

TABLE 2 Growth and activity of cellulolytic fungi on treated and untreated rice straw

Cellulolytic Fungus	Soluble Protein[1]		Cellulolytic, activity[2]C		Residue[3]		Crude protein in residue (%)[4]	
	T	UT	T	UT	T	UT	T	UT
Trichoderma sp. (T.3)	31.80	39.70	78.00	48.00	1.63	1.73	21.80	17.50
Aspergillus sp. (Ag.3)	42.50	43.90	81.00	78.00	1.52	1.61	18.75	15.60
Fusarium sp. (Fs.4)	24.50	39.50	54.00	45.00	1.67	1.89	25.00	19.40

1 = Soluble protein in culture filtrate mg/100 ml. 4 = Crude protein content of residue
2 = Per cent loss in viscosity at 30 minutes T = Treated Straw
3 = Undigested straw + mycelial mat g/100 ml UT = Untreated Straw

52.0% respectively. Residue yield containing both fungal mat and undigested straw was found to be more in *Fusarium* sp. (Fs.4) followed by *Trichoderma* sp. (T.3) and *Asperquillus* sp. (Ag.3) Regarding crude protein content of residue, no significant difference between treated and untreated straw as well as among the three fungi was observed (Table 2).

Similar observation was also made for *Aspergillus* sp, grown on pretreated paddy straw (Ghose, 1981). Maximum crude protein content of 25.0% in treated straw grown with *Fusarium* sp. (Fs.4) was in agreement with earlier reports (Christias *et al.* 1975). All the three fungi gave more C_x activity in treated straw than in untreated straw.

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