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BIOCONVERSION OF SUGARCANE BAGASSE WITH WHITE ROT FUNGI

Neelam Kewalramani, D.N. Kamra, D. Lall and N.N. Pathak
Animal Nutrition Division
Indian Veterinary Research Institute
Izatnagar-243122, India

SUMMARY

Four cultures of white rot fungi were screened for their ability to degrade lignin and carbohydrates of sugarcane bagasse and their effect on changes in in vitro digestibility. Polyporus hirsutus 534 degraded maximum lignin and carbohydrates accompanied with the highest increase in digestibility, but increase in nutrient availability was maximum with Pleurotus sajorcaju (Z-6) due to lower dry matter loss during the process of fungal treatment. All the fungi tested except Polyporus caperatus Berk. degraded lignin more selectively than the other components of sugarcane bagasse.

INTRODUCTION

Agricultural byproducts like cereal straws and sugarcane bagasse are rich in lignocellulose. Cereal straws constitute a staple animal feed in India and other developing countries of the world, but sugarcane bagasse is very rarely utilized. It is readily available and is commonly used as fuel. Bagasse contains more than 60% of its dry matter in the form of cellulose and hemicellulose (Sen et al., 1978) but its digestibility is very poor. One of the main reasons for this depression in digestibility is the presence of lignin which shields carbohydrates from attack by the rumen microbes. White rot fungi are well known for their ability to degrade lignin (Kirk and Moore, 1972, Zadrazil, 1980, Reade and McQueen, 1983 and Rolz et al., 1986), but this may not increase the digestibility of fermented lignocellulose, except when the lignin is degraded more selectively than the other feed components. Keeping this in view, various white rot fungi have been screened to assess their efficiency in the process of bioconversion.

MATERIALS AND METHODS

Pleurotus sajorcaju (Z-6) was procured from Dr. F. Zadrazil of the Institut fur Bodenbiologie, Braunschweig, Federal Republic of Germany; P. sajorcaju (Solan) from the Director, National Centre for Mushroom Research and Training, Solan, Himachal Pradesh; Polyporus hirsutus 534 from the Director, Forest Research Institute and Colleges, Dehradun and P. caperatus Berk. was isolated in our laboratory. Cultures were maintained on solid medium containing: maltose 10 g., yeast extract 2.5 g, peptone 8.0 g, agar 20 g, water 1000 ml, pH adjusted to 5.0. The same medium without agar was used for the preparation of liquid inocula . Five day old cultures diluted four times with autoclaved physiological saline were used as inocula.

For screening, 10 g of milled sugarcane bagasse (to pass 1 mm sieve) was taken in 250 ml Erlenmeyer flasks with 20 ml of tap water. These flasks were autoclaved at 121°C for 45 minutes and after cooling 10 ml of diluted inoculum was added aseptically to each. The flasks were incubated at 25°C and were taken out in triplicate after 10, 20, 30 and 40 days of fermentation. The samples were dried at 80°C for 48 h and loss in weight was expressed as dry matter loss. The dried material was milled again and pooled for chemical analyses. Untreated sugarcane bagasse and the fermented product were analysed for cellulose, hemicellulose, lignin, and in vitro dry matter digestibility (IVDMD) according to the methods described by Goering and Van Soest (1970). The change in IVDMD was expressed as positive or negative in comparison to the untreated sugarcane bagasse for which the IVDMD was 30 percent.

The efficiency of a fungus was calculated as follows:

$$N_t = \frac{(100 - DML)\, D_t}{100} \quad \text{and} \quad \Delta N = \frac{N_t - N_o}{N_o} \times 100$$

Where ΔN = Change in nutrient availability on fungal treatment.

D_t = In vitro dry matter digestibility of treated bagasse.

D_o = In vitro dry matter digestibility of untreated bagasse.

N_t = Nutrient availability from treated bagasse.

N_o = Nutrient availability from untreated bagasse = D_o

DML = Dry matter loss during fungal treatment

ΔN will tell how much increased or decreased nutrients are available after fungal treatment as compared with untreated bagasse.

RESULTS AND DISCUSSION

Sugarcane bagasse contains around 50% cellulose, 27.9% hemicellulose, 9.8% lignin and 11.3% cell contents. Degradation of various substrate fractions by the four fungi and corresponding changes in the IVDMD of bagasse are presented in Table 1. Both strains of Pleurotus sajorcaju and Polyporus hirsutus 534 degraded hemicellulose and lignin more selectively than cellulose and there was a significant increase in the IVDMD. P. sajorcaju (Z-6) was also reported to increase the IVDMD of wheat straw (Kamra and Zadrazil, 1986), but the degradation of wheat straw was slightly faster, perhaps because of the higher crystallinity and lignification of bagasse. P. sajorcaju (Solan) showed similar characteristics, except that the rates of degradation of dry matter, cellulose, hemicellulose and lignin were a little faster. The highest increase in IVDMD of bagasse and the highest loss of lignin was observed with Polyporus hirsutus 534, but a simultaneous higher loss of dry matter (27.5%) makes the process of biodelignification uneconomical. P. caperatus Berk. also degraded a considerable amount of lignin, but the IVDMD was not improved very much. This might be due to relatively higher loss of carbohydrate in comparison to lignin degradation.

In all the fungi tested, there was a depression in IVDMD during the first 10 days of fermentation as compared with untreated bagasse, and afterwards there was a constant increase in IVDMD as the fermentation

Table 1 : Fermentation of sugarcane bagasse with white rot fungi

Time (Days)	Loss (% DM)				Changes in IVDMD (Dt - Do)
	Dry matter	Cellulose	Hemi cellulose	Lignin	
Pleurotus sajorcaju (Z-6)					
0	0	0	0	0	+8
10	7	6	14	0	-3
20	10	2	35	9	+15
30	11	8	30	8	+19
40	12	6	37	14	+17
Pleurotus sajorcaju (Solan)					
10	10	9	18	0	-5
20	10	10	20	5	+10
30	10	9	28	15	+15
40	17	12	42	26	+19
Polyporus hirsutus 534					
10	3	2	14	0	-7
20	16	15	38	7	+6
40	28	21	51	28	+23
Polyporus caperatus Berk.					
10	4	6	8	0	+1
20	10	16	9	9	-1
30	13	17	20	9	+3
40	17	19	26	10	+3

proceeded. A similar trend was also found by Zadrazil (1977) and Kamra and Zadrazil (1985) in fermentation of wheat straw with white rot fungi. Dry matter loss starts from the very first day of inoculation, whereas lignin degradation starts at a later stage. The fungus utilizes soluble carbohydrates in the initial stages, as a result of which the IVDMD of sugarcane bagasse decreases. After primary growth of fungus lignin degradation starts and cellulose is freed from lignocellulosic complex and the digestibility increases continuously.

The efficiency of a fungus can be assessed only when we consider the improvement in IVDMD of feed, along with the losses that occur during the process of fungal treatment. Keeping the same fact in view a formula for calculation of change in nutrient availability is suggested which tells how much additional nutrients will be available on treatment with fungi. Maximum degradation of lignin and increase in IVDMD of bagasse is observed with *Polyporus hirsutus* 534, but the improvement in nutrient availability is not as good as with *P. sajorcaju* (Z-6) or *P. sajorcaju* (Solan) (Table 2). Fungi which show preference for hemicellulose and lignin degradation are able to increase the nutrient availability from the fermented product as also reported by Rolz *et al.* (1986). Therefore, only those cultures should be selected for further studies which are able to increase the nutrient availability to the maximum possible extent.

Table 2

Comparison of white rot fungi for improvement in nutrient availability

Fungus	Dry matter loss (%)	L/C loss[1] ratio	H/C loss[2] ratio	ΔN[3]
Pieurotus sajorcaju (Z-6)	12.14	2.27	6.04	37.90
P. sajorcaju (Solan)	17.02	2.20	3.51	34.43
Polyporus hirsutus 534	27.54	1.31	2.40	27.17
P. caperatus Berk.	17.03	0.52	1.34	-8.00

[1]percent lignin loss divided by percent cellulose loss, [2]percent hemicellulose loss divided by percent cellulose loss, [3]change in nutrient availability.

REFERENCES

Goering, H.K. and Van Soest, P.J. (1970). Forage fibre analysis. Agriculture Handbook No. 379. Agriculture Research Service, US Deptt. of Agriculture.

Kamra, D.N. and Zadrazil, F. (1985). Biotechnol. Letters 7, 335-340.

Kamra, D.N. and Zadrazil, F. (1986). Agric. Wastes. 18, 1-17.

Kirk, T.K. and Moore, W.E. (1972). Wood Fibre. 4, 72-79.

Reade, A.E. and McQueen, R.E. (1983). Can. J. Microbiol. 29, 457-463.

Rolz, C., DeLeon, R., DeArriola, M.C. and DeCabrera, S. (1986). Appl. Environ. Microbiol. 52, 607-611.

Sen, K.C., Ray, S.N. and Ranjhan, S.K. (1978). Nutritive value of Indian cattle feeds and the feeding of animals. Indian Council of Agricultural Research, New Delhi. p. 88.

Zadrazil, F. (1977). European J. Appl. Microbiol. 4, 291-294.

Zadrazil, F. (1980). European J. Appl. Microbiol. Biotechnol. 9, 243-248.