Technology Section

Pakistan J.Sci.Ind.Res., Vol.26, No.1, February 1983.

SYMBIOTIC BIODEGRADATION OF CELLULOSIC RESIDUES

Part II. Biodegradation of Bagasse and Beet Pulp Feed

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(Received August 18, 1980; revised September, 1982)

Biodegradation of bagasse and beet pulp feed was studied by submerged fermentation process. Biodegradation of beet pulp feed was 36.36% and 40.30% when Penicillium and Trichoderma were employed singly. Symbiosis of Penicillium with Trichoderma degraded 48.37% of the cellulose present in beet pulp feed with 32.58% increase in nitrogen contents. In case of bagasse 25.30% increase in the degradability of cellulose was observed with the same combination. In beet pulp feed, maximum biodegradation of cellulose (70.20%) was observed due to the symbiotic effect of *Bacillus pumilus* and Streptomyces. Reduction in particle size increased the susceptibility to enzymic hydrolysis.

INTRODUCTION

Bagasse and beet pulp are the main bye-procducts of sugar industry. These bye-products contain 60-70% carbohydrate, mostly in the form of cell wall poly-saccharides and are a potential source of dietary energy for cattle. The poly-saccharides can be converted into simpler carbohydrate by growing cellulolytic microbes on them. The degradation of cellulose had been studied during the past few years. Many workers attempted to convert cellulose into simple sugars using non culture technique [1-5]. Degradation of cellulose had also been carried out by growing mixed cultures of fungi, bacteria and yeast on cellulosic materials [6, 7, 8].

The present work was undertaken to study the symbiotic effect of various microorganisms on the degradability of bagasse and beet pulp feed.

MATERIALS AND METHODS

Bagasse and beet pulp feed were used as substrates to carry out these studies. Bagasse and beet pulp feed were ground to different mesh sizes (60-200 mesh).

Biodegradation of the substrates was done by submerged fermentation technique [9].

Analytical methods for the estimation of cellulose and nitrogen were the same as reported elsewhere [10].

RESULTS AND DISCUSSIONS

The Effect of Particle Size on the Growth of Microorganisms. The effect of particle size on the biodegradation of beet pulp by molds and bacteria was initially studied for selecting the most suitable mesh size. Accordingly beet pulp was ground from 60 to 200 mesh sizes and degraded by various molds and their combinations. It was observed that the beet-pulp cellulose degradation increased with the reduction of particle size, besides an increased nitrogen content which appeared to be due to an increase in the surface area making the substrate more accessible to the action of microorganisms. For example, the degradation of cellulose by Trichoderma varied from 39.92 to 46.56% when the mold was allowed to propagate on 60 to 200 mesh beet pulp feed; combined effect of Trichoderma and Penicillium resulted in 64.36% cellulose degradation and an increase of 74.13% nitrogen. This observation supports the work carried out by other workers [11, 12, 13]. For the present study, however 100 mesh size was selected.

Biodegradation of Cellulosic Materials with Single Strains of Mold, Bacteria and Yeast. The effect of mold, bacteria and yeast on biodegradation of bagasse and beet pulp feed is given in Table 1. Maximum biodegradation of bagasse and beet pulp feed with Trichoderma was 21.74% and 40.30% respectively. *Bacillus laterosporous* was also found effective in degrading these bye-products. An increase in nitrogen content was also observed after the fermentation of bagasse and beet pulp feed with molds and bacteria. Shah *et al.* [9] had observed an improvement in the degradation of cellulose in wheat and rice straw with single strains of mold, bacteria and yeast. Many other workers had already reported an increase in the degradability of cellulose using cellulolytic microorganisms [6, 14, 15,16].

Symbiotic Biodegradation with Molds, Bacteria and Yeast. Biodegradation of bagasse and beet pulp feed due to the combined effect of molds, bacteria and yeast is given in Table 2. It is evident from these results that 48.37% of the cellulose present in beet pulp feed was degraded due to the symbiotic effect of Penicillium and Trichoderma. The increase in nitrogen content was 32.58% with the same combination. The second best results were obtained when beet pulp feed was fermented with Chaetomium and Streptomyces. Maximum biodegradation of cellulose present in bagasse was 28.85% associated with an increase in nitrogen (44.65%) with the symbiotic effect of Streptomyces and Trichoderma. Similar results were reported by Peitersen [4] using mixed cultures of fungi. Symbiotic biodegradation of rice and wheat straws had already been

Table 1. Biodegradation of cellulosic materials by single strains of molds, bacteria and yeast.

Culture	Bagasse		Beet pulp feed	
	Degradation of cellulose % age	Increase in nitrogen % age	Degradation of cellulose % age	Increase in nitrogen % age
Chaetomium	13.04	48.43	5.59	38.76
Penicillium	15.02	53.46	36.36	55.91
Streptomyces	13.84	23.27	34.46	52.16
Trichoderma	21.74	40.24	40.30	136.51
Bacillus brevis	7.89	5.66	8.61	8.43
Bacillus cereus	3.56	8.18	7.28	32.87
Bacillus laterosporous	15.02	16.35	13.91	21.35
Bacillus polymyxa	5.66	6.29	2.65	10.39
Bacillus pumilus	7.11	38.36	9.27	8.71
Bacillus sphaericus	9.88	52.83	13.25	7.58
Bacillus subtilis	9.08	6.29	3.37	22.75
S. cerevisiae	1.98	13.84	9.93	55.90

Table 2. Symbiotic biodegradation of cellulosic materials by combinations of mold, bacteria and yeast.

Culture	Bagasse		Beet pulp feed	
	Degradation of cellulose % age	Increase in nitrogen % age	Degradation of cellulose % age	Increase in nitrogen % age
Chaetomium & Penicillium	12.25	32.08	11.32	28.56
Chaetomium & Streptomyces	17.00	25.16	37.83	47.75
Chaetomium & Trichoderma	21.74	52.83	19.59	30.90
Penicillium & Streptomyces	24.51	18.23	23.84	25.56
Penicillium & Trichoderma	25.30	20.75	48.37	32.58
Streptomyces & Trichoderma	28.85	44.65	12.58	28.65

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(Table 2. Continued)

B. brevis & Chaetomium	12.25	22.01	28.48	6.74
B. brevis & Pencillium	4.63	5.03	35.10	8.99
B. brevis & Streptomyces	5.53	16.98	45.70	11.24
B. brevis & Trichoderma	4.56	6.29	35.10	8.15
B. cereus & Chaetomium	19.76	55.98	35.10	89.60
B. cereus & Penicillium	9.38	5.66	40.40	25.56
B. cereus & Streptomyces	8.70	67.92	33.11	7.87
B. cereus & Trichoderma	4.74	16.35	11.92	7.58
B. laterosporous & Chaetomium	11.86	66.67	10.38	11.24
B. laterosporous & Penicillium	6.32	77.99	25.17	11.24
B. laterosporous & Streptomyces	9.09	29.56	5.96	11.80
B. laterosporous & Trichoderma	3.95	14.47	8.22	8.71
B. polymyxa & Chaetomium	11.07	16.98	45.70	22.75
B. polymyxa & Penicillium	11.46	11.95	9.27	11.80
B. polymyxa & Streptomyces	9.88	13.21	13.91	11.24
B. polymyxa & Trichoderma	8.30	28.93	22.52	11.80
B. pumilus & Chaetomium	11.46	23.27	42.38	26.40
B. pumilus & Penicillium	7.11	8.18	31.79	9.83
B. pumilus & Streptomyces	7.11	11.32	70.20	8.71
B. pumilus & Trichoderma	3.16	15.09	13.91	8.43
B. sphaericus & Chaetomium	19.76	65.41	13.25	39.33
B. sphaericus & Penicillium	12.25	65.41	13.91	12.36
B. sphaericus & Streptomyces	16.60	40.25	11.26	10.96
B. sphaericus & Trichoderma	13.44	42.77	9.27	8.71
B. subtilus & Chaetomium	5.79	5.03	5.30	15.73
B. subtilus & Penicillium	6.32	24.52	4.64	19.10
B. subtilis & Streptomyces	1.58	14.47	9.27	8.15
B. subtilus & Trichoderma	7.77	11.95	13.25	11.80
S. cerevisiae & Chaetomium	5.14	23.27	7.28	12.36
S. cerevisiae & Penicillium	2.55	8.18	17.22	49.44
S. cerevisiae & Streptomyces	4.74	25.16	44.37	29.21
S. cerevisiae & Trichoderma	6.40	17.61	54.30	21.91

studied by Shah *et. al* [9]. Further maximum biodegradation of cellulose i.e. 70.2% was observed when beet pulp feed was fermented with a combination of *B. pumilus* and Streptomyces. The combination of *B. brevis* with Streptomyces and *B. polymyxa* with Chaetomium biodegraded upto 45.7% of the cellulose present in beet pulp feed. The maximum increase in protein nitgrogen with *B. cereus* and Chaetomium was 89.6% whereas a combination of *S. cerevisiae* and Penicillium showed 49.44% increase in protein nitrogen. Biodegradation of cellulose present in bagasse was not considerably enhanced by employing different combinations of molds, bacteria and yeast. However, the mixed culture of *B. cereus* and Chaetomium, increased the degradability of cellulose present in bagasse upto 19.76%. In all other cases the cellulolytic microorganisms showed antagonism among themselves. The maximum increase in nitrogen content i.e. 77.99% was observed when the combination of *B. laterosporous* and penicillium was employed but degradation of cellulosic contents was only 6.32%. Han *et. al*[6] had established symbiosis among 12 strains of yeasts and cellulomonas and found that none showed as good growth as the mixed culture of cullulomonas and *Alcaligenes faccalis.* Results indicated an almost five fold increase in cell density and growth rate compared to that of cellulomonas alone. Peitersen [4] also reported that becteria in combination with fungii and yeast utilized more cellulose as compared with fungus alone. Similar results were also reported by other workers [17] using mixed cultures of cellulolytic microorganisms.

REFERENCES

1. M. Mandels, L. Hontz and J. Nystram, Biotechnol. Bioeng., **16**, 1471 (1974).
2. T.K. Ghose and J.A. Kostick, Adven.Cham.Ser., **95**, 415 (1969).
3. W.D. Bellamy, Biotechnol. Bioeng., **16**, 869 (1974).
4. N. Peitersen, Biotechnol. Bioeng., **17**, 1291 (1975).
5. Y.W. Han and C.D. Callihan, Appl. Microbiol. **27**, 159 (1974).
6. Y.W. Han, C.E. Dumlap and C.D. Callihan, Food Tech. **25**, 32 (1971).
7. J.M. Harkim, D. L. Crewford and E. Mcloy, Tappi, **57**, **(3)**, 31 (1974).
8. E. W. Moore and J.M. Effland, J.Agri.Food.Chem., 20(6), 1173 (1972) CA., 283192, **78**, (1973).
9. F.H. Shah, A. Majid and Zia-ur-Rehman, Pak.J.Sci. Ind.Res., (accepted for publication).
10. R. Markam, Biochem.J., **36**, 790 (1942).
11. T. Kauser, B.A. Mahmud and F.H. Shah, Pak.J.Sci. Ind.Res., **19**, 36 (1976).
12. T.K. Ghose and J.A. Kostick, Biotech. Bioengg., **12**, 921 (1970).
13. Y.W.Han and V.R. Sirinivasan, Appl. Microbiol., **16**, 1140 (1968).
14. D.L. Crawford, E. McCoy, J.M. Harkin and P. Janes, Biotech. Bioeng., **15**, 833 (1973).
15. D. Surinder and J.K. Gupta, J.Gen.Appl.Microbiol., **23**, 155 (1977).
16. G.P. Lynch, D.F. Smith, E.D. Jackson and R.C. Cope, J.Anim.Sci., **44**, 883 (1977).
17. M. Linko, M.Pertt, B. Michael and Li. Matti, *Chem. Microb. Protein Symp. Proc. Ist* (1977).