BIODEGRADATION OF MAIZE STRAW BY FUNGI FOR USE AS RUMINANT FEED

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ABSTRACT

Biodegradation of chopped maize straw incubated at 50°C for 26 days has been investigated. *Humicola insolens* was the predominant fungus in the biodegradation. Other fungi isolated included *Mucor pusillus, Aspergillus fumigatus, Penicillium* species and yeasts. The biodegradation led to a net increase of 97.005%, 34.25% and 3.42% in total ash, crude protein and nitrogen-free extract respectively. A decrease of 21.49% in crude fibre was observed. There was an average weight gain of 1.04 ± 0.20 g/day/rat and 1.63 ± 0.65 g/day/rat in rats fed with undegraded and degraded straw respectively. Feed efficiency ratios in the two straw diets were however low, suggesting the need to further improve the palatability and reduce the fibre level.

Keywords:- Straw, fungi, biodegradation, feed, ruminant.

INTRODUCTION

Chemical analysis of cereals straw shows a high content of cellulose (Lynch, 1979) which makes cereal straw an excellent source of energy for ruminants. However, in its natural states, cereal straw is a poor-quality feed material. This is due to its low digestibility, low protein content, poor palatability and bulkiness (Han, 1978).

The nutritive value of straw, therefore, not only depends on the availability of nutrient but such attributes as lignification, salicification and crystallinity of cellulose (Han, 1978), all of which limit the digestion of cellulose and hemicellulose. Crawford & Crawford (1976) observed that digestibility of straw is inversely correlated to the amount of lignin-cellulose complex in the substrates.

The crude protein of cereals straw (about 4 -5%) is a far cry from a minimal required level of 8% for most ruminants (Han, 1978). Bogdan (1977) reported a range of 3 - 20% crude protein in the grasses and hinted that it could be more in young plants.

It is therefore desirable to modify the straw in order to make it a better feedstuff. Such modification could be chemical using NaOH (Arnason, 1979); mechanical, through extrusion and popping (Greenhalgh & Wainman, 1972) and lastly by microbial/enzymic treatment (Clark & Beard, 1977).

MATERIALS AND METHOD

Source of Straw:- Maize (Zea mays L.) straw used was collected from Forestry Research Institute of Nigeria, Jos Station in the dry months of January and February, 1996.

Biodegradation:- The straw was chopped into small cubes of roughly 0.5cm, weighed and moistened with one-quarter tap water to which antibiotics had been added (250mg

Ampicillin/litre of water final pH 8-9). The moistened straw was then incubated at 50°C for 26 days (normally attainable in the months of February through June). The straw was moistened regularly throughout the incubation period.

At weekly interval, 20g samples of straw undergoing degradation were taken, dried to constant weight, pulverised and kept for chemical analysis. Parameters analysed were moisture content, crude protein (CP), crude fibre (CF), total lipid (TL), ash, Nitrogen-free extract (NFE), calcium and phosphorus contents. Method of AOAC (1975) were used in all analyses.

Microfungi Population

This was monitored by plating straw onto specially formulated Maize Straw Agar.

Feed Trial

Male Wistar strain wean rats (average weight, 40.7 ± 9.0g) were randomly assigned, five each, to the following diets:-i. Undegraded maize straw; ii. Degraded maize straw; and iii. commercial rat diet, as control. The diets were fed to the rats for seventeen days. All the rats were allowed free access to their diets and water. A record of body weight and food consumption was kept.

Statistical Methods

For the statistical evaluation of mean difference, the Student t-test method was employed (Snedecor and Cochran, 1967).

RESULTS

Microfungi of Decomposing Straw

Table 1 shows the few thermophilic fungi isolated from the decomposing straw. *Humicola insolens* predominated while *Mucor pusillus, Penicillium* species and yeasts were present in various percentages. The relatively low occurrence of these other fungi was a result of high pH of decomposing straw. Other workers (Seal and Eggins, 1975) have shown that a combination of high temperature (50°C) and high pH (between 8 and 9) helped to keep most pathogenic fungi at bay. Thus, *Humicola insolens* can be considered as the major fungus doing the degradation.

Table 1: Frequency of Occurrence of Thermophilic Fungi Isolated From Decomposing Maize Straw

Fungal Species	%Frequency of Occurrence
Humicola insolens	90
Mucor pusillus	10
Aspergillus fumigatus	5
Penicillium species	20
Yeasts	25

Chemical Composition of Decomposed Straw

Results of chemical composition are presented in figures 1 to 4. The actual data can be found in table 2. The chemical composition in each case was given as percent dry matter content. Gradual increase in content was noticed in crude protein (CP), ash, phosphorus and calcium. While CP recorded an increase of 34.25%, calcium recorded overall increase of 76.19%. The values of ash and phosphorous doubled within the period of degradation. A stabilization in Nitrogen-Free extract (NFE) content was noticed from day 8 through day 21. By day 26, the value has risen again giving a total increase of 3.42% (Fig. 2). Total lipid (TL) recorded a very high increase in content due to the biodegradation. From as little as 0.03% DM at the beginning to 1.09% at the end, there is an increase of well 300%. Maize straw, apparently containing little or no oil , has been enriched by the growth on it of fungi which led to an increase in oil content. A gradual decline in crude fibre was observed (Fig. 1); an overall decline of 21.49% was observed, corresponding to an average loss of 0.35% per day. A very profuse utilization was noticed between Day 21 and Day 26 with an average daily loss of 0.85%. This can be regarded as period of maximal decomposition of cellulose. The period incidentally coincided with period of increased NFE content; an indication of higher level of soluble or near soluble carbohydrates such as sugar, starch, etc.

Table 2: Chemical Composition of Degraded Maize Straw

	Chemical Composition, % Dry Matter							
Period of Degradation	Moisture	Crude Protein	Crude Fibre	Lipid	Total Ash	Nitrogen Free Extract	Calcium	Phos phoru s
Day 0	5.18	8.70	42.35	0.03	4.01	39.73	0.21	0.09
Day 8	4.35	10.08	40.33	0.66	6.47	38.08	0.29	0.09
Day 17	4.31	10.64	39.32	0.56	7.00	38.17	0.29	0.12
Day 21	4.68	11.04	37.52	1.08	7.28	38.40	0.31	0.13
Day 26	4.99	11.68	33.25	1.09	7.90	41.09	0.37	0.18

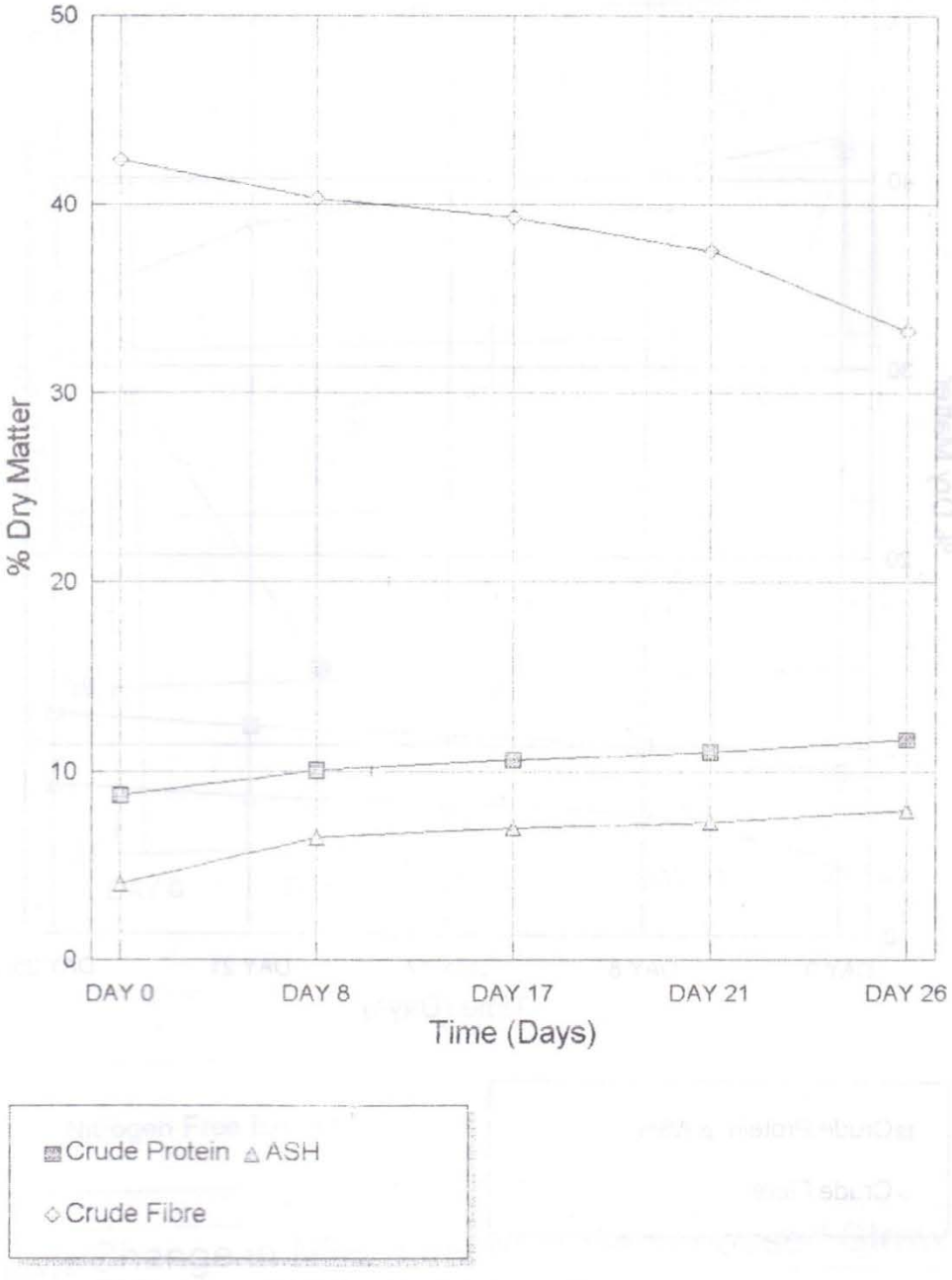

FIG.1 Change in Chemical Content of Decomposed Straw

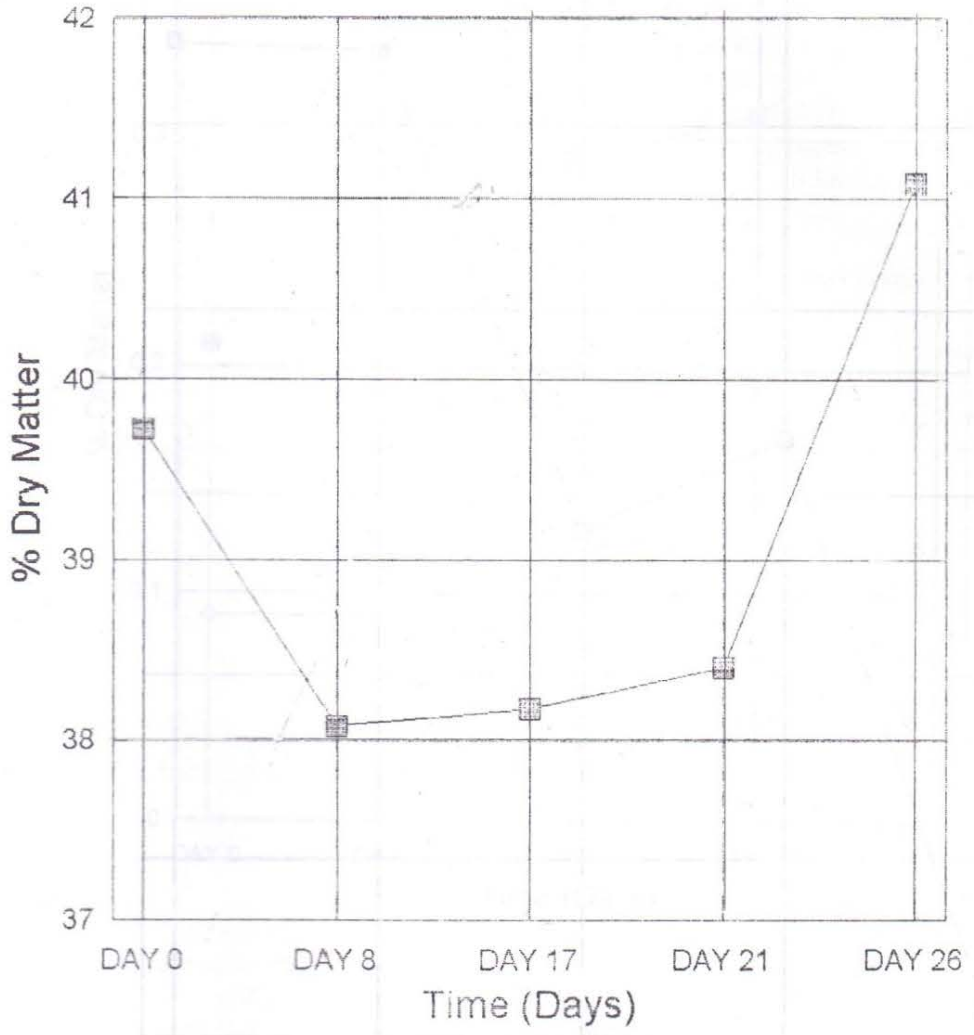

FIG.2 Change in NFE content of Decomposed Straw

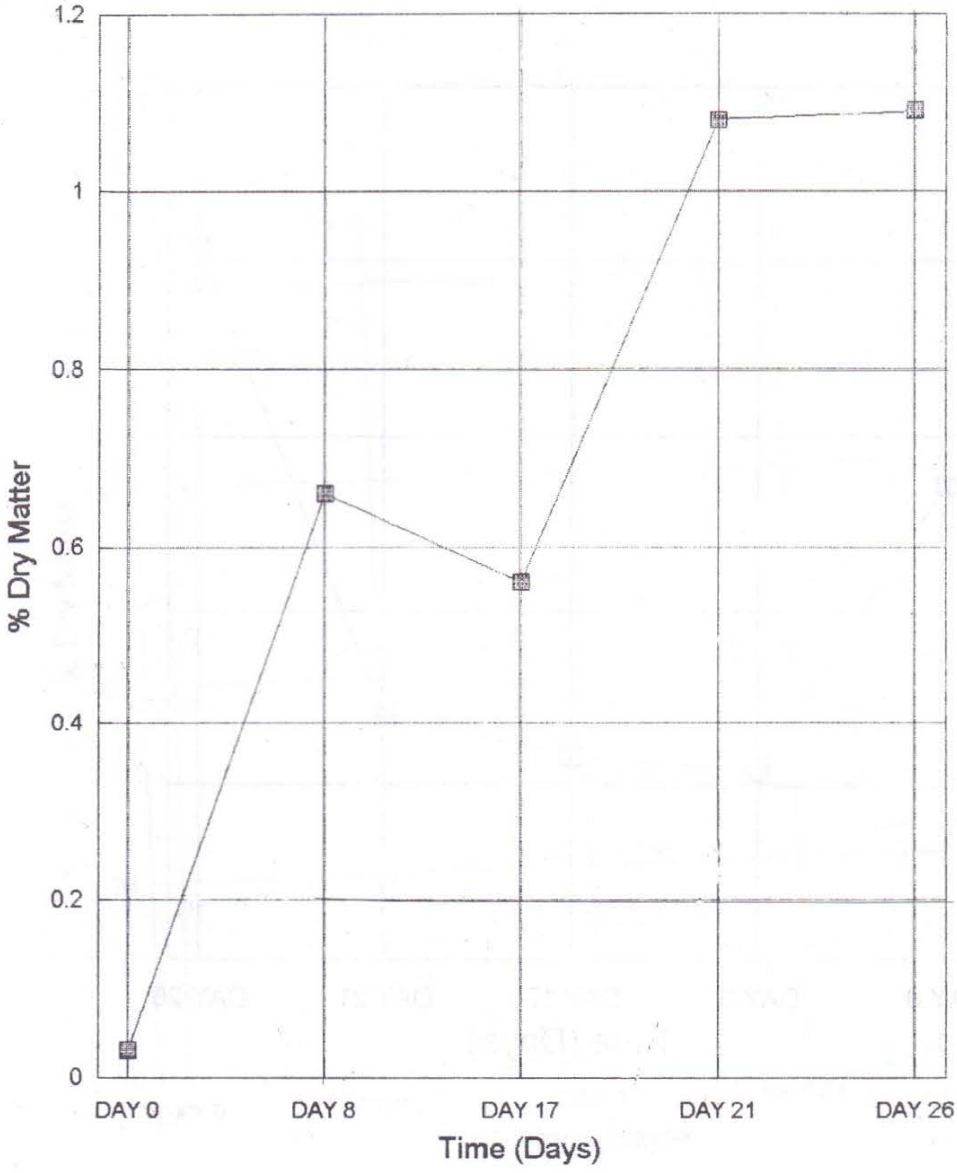

FIG.3 Total Lipid Content of Decomposed Straw

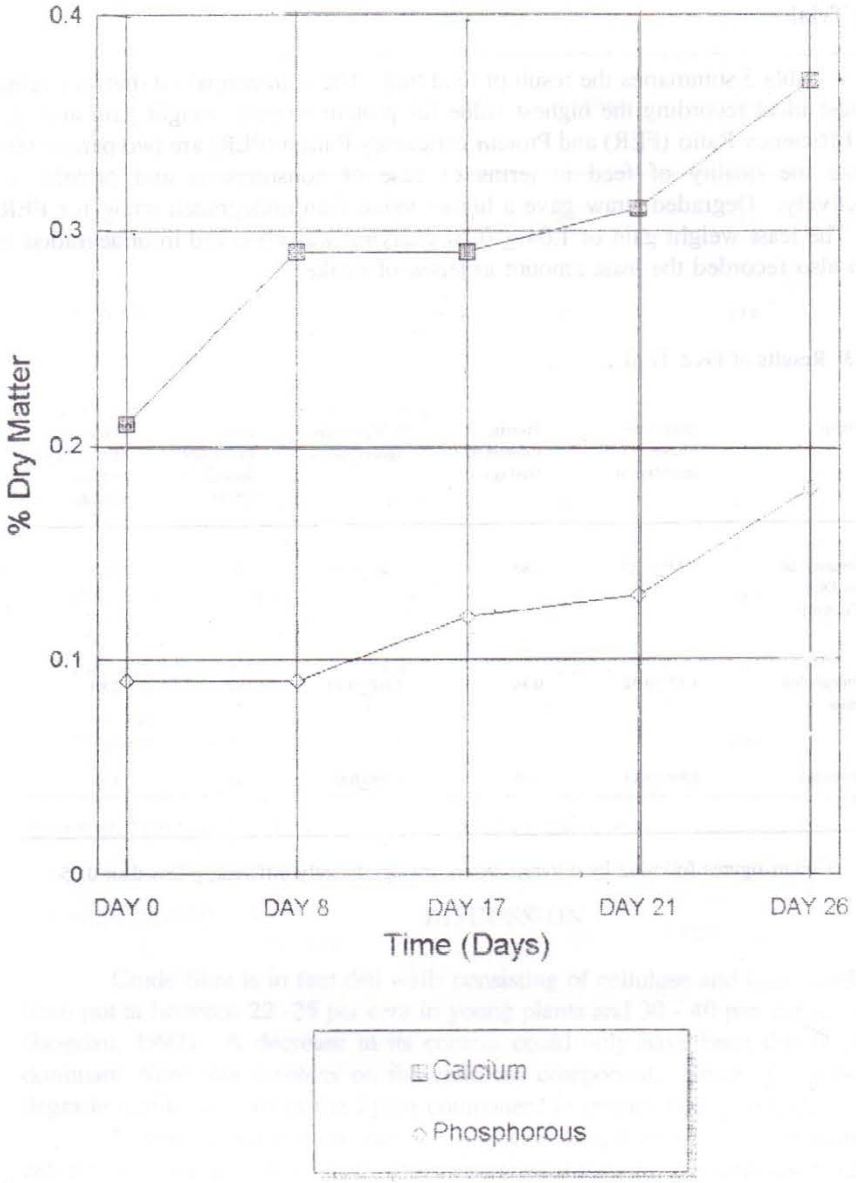

FIG: 4 Calcium and Phosphorous Content of Decomposed Straw

Feed Trial

Table 3 summaries the result of feed trail. The commercial rat diet still remained the most ideal recording the highest value for protein content, weight gain and quality. Feed Efficiency Ratio (FER) and Protein Efficiency Ration (PER) are two parameters that indicate the quality of feed in terms of ease of consumption and protein quality respectively. Degraded straw gave a higher value than undegraded straw for FER and PER. The least weight gain of 1.04 ± 0.20 g/day/rat was observed in undegraded straw, which also recorded the least amount in terms of intake.

Table 3: Results of Feed Trial

Groups	Daily feed Intake (gm/day/rat	Protein Content of feed (g)	Weight gain (g/day/rat)	Feed Efficiency Ration (PER)	Protein Efficiency Ration (PER)
Commercial Rat Diet (Control)	$5.33^{a}\pm0.23$	0.93	$3.24^{a}\pm0.64$	0.61	3.48
Undegraded Straw	$4.12^{b}\pm0.52$	0.36	$1.04^{b}\pm0.20$	0.32	2.89
Degraded Straw	$4.84^{c}\pm0.43$	0.56	$1.79^{c}\pm0.65$	0.34	3.20

Colum figures followed by different letters are significantly different, p less than 0.05.

Table 4: Composition of Maize Straw[a] compared with that of Rice Straw[b], alfalfa[b] and Nutritional Requirement of Steers[c]

Composition	Maize Undeg	Straw Degrad	Rice Straw	Alfalfa	Requirement of growing steers
Crude Protein(%)	8.70	11.68	4.5	17.0	10.00
Crude Fibe (%)	42.35	33.25	35.0	27.0	-
Total Lipid (%)	0.03	1.09	1.5	2.0	-
Nitrogen free extract (%)	39.73	41.09	42.0	40.0	-
Ash (%)	4.10	7.90	16.5	10.0	-
Calcium (%)	0.21	0.37	0.19	1.3	0.25
Phosphorus (%)	0.09	0.18	0.10	0.23	0.20

[a]Preset Work; [b]From Han (1978) [c] From Clawson *et al.*, (1970) cited by Han (1978)

DISCUSSION

Crude fibre is in fact cell walls consisting of cellulose and lignin and it value has been put at between 22 -25 per cent in young plants and 30 - 40 percent in mature plants (Bogdan, 1997). A decrease in its content could only have been due to the action of dominant *Humicola insolens* on the cellulose component. Since *H. insolens* does not degrade lignin, we expect the lignin component to remain largely intact.

Degraded maize straw (table 4) is a better feed than rice straw in terms of protein, calcium and phosphorus content. It also contains less fibre. Its contents of crude protein, calcium and phosphorous is favourable for growing steers.

Comparison of nutrient content of feeds showed that maize straw is very high in crude fibre and ash content and low in virtually all other nutrients. It should however be pointed out that the straw diet used in this work was not supplemented with anything. Even then, the feed trial result revealed that the degraded straw had a PER close to that of commercial rat diet made from groundnut. PER is inversely proportional to protein content of a feed, hence degraded straw with its low protein content and producing appreciable weight gain in rats, turned out to have a high PER. Feed efficiency ratios (PER) defined here as weight gain per feed consumed, of the diet are low compared to

that of control commercial diet. This is further indicated by the lower daily food intake, suggesting that the feed might not be very palatable for the animals. The low palatability might not be due to protein content as protein content of 11.68 percent is considered adequate for ruminant (Han, 1978). Other means of improving the palatability must therefore be exploited. Turning the feed into cubes or pellets has been suggested as one of such means (Han, 1978).

Feed trial did not show any toxic effect of the two straw feeds. The biodegradation process was such as to eliminate or reduce to a minimum the incidence of pathogenic microbes. All form of bacteria were suppressed by antibiotics and high pH (8 - 9) ensured the suppression of such pathogenic fungi as *Aspergillus fumigatus* and *Mucor pusillus* both of which are known to prefer lower pH of between 4 and 5.

In conclusion, it is clear that the biodegraded maize straw is adequate in protein and calcium for its effective usage as feed for ruminants. There is however the need to improve its palatability and hence its efficiency ration as a feed. In this work the straw was fed in powder form. It is our intention to turn the degraded straw into pellets using an appropriate level of molasses.

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