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# PRELIMINARY OBSERVATIONS ON RUMEN FERMENTATION AND GROWTH IN CATTLE FED NaOH TREATED ELEPHANT GRASS AND *Canavalia ensiformis* FORAGE

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Mixtures of mature Elephant grass (*Pennisetum purpureum*) forage and *Canavalia ensiformis* forage were treated with NaOH and used in experiments to measure the pattern and extent of rumen fermentation in fistulated sheep, and as a basal diet for growing cattle. In the rumen of sheep pH was high (pH 6.9 - 7.5), while the pattern of VFA in the rumen was typical of a roughage diet (71 - 75 % acetate, 18 - 21 % propionate and 7 - 8 % butyrate). Dry matter (DM) fermentation of Elephant grass-*Canavalia* mixtures, measured by incubation of nylon bags in the rumen, was increased substantially by NaOH treatment; zero time solubility increased from 29 to 38 %, digestibility over 48 h from 62 to 76 %, and T 1/2 decreased from 31 to 21 h. Holstein cattle (2 treatments each of 3 animals) supplemented with either 350 g/d or 700 g/d of cottonseed meal gained 518 and 562 g/d respectively, consuming 2.9 and 3.2 kg DM/100 kg liveweight respectively with a feed conversion of 10.4 kg DM/kg liveweight gain.

Key Words: *Pennisetum purpureum*, *Canavalia ensiformis*, ovines, bovines, ruminal fermentation, growth

In the humid tropics treatment with NaOH is one method of increasing the digestibility of low-quality forages, while the legume *Canavalia ensiformis* is a promising cultivar to provide digestible energy and dietary true protein for ruminants. The following experiments were intended to provide preliminary information on production and rumen fermentation in animals fed diets based on a mixture of poor quality Elephant grass and *Canavalia* forage treated with NaOH.

## Materials and Methods

*Experiment 1:* Two mature local crossbreed sheep (21 and 29 kg liveweight) were prepared with 50 mm diameter rumen cannula and allowed 6 weeks for recovery from surgery. The sheep were housed on slatted floors in individual pens situated in an open-sided shed, were fed *ad libitum* and had free access to water. Freshly chopped mature Elephant grass forage (*Pennisetum purpureum*) (50 kg), freshly chopped entire *Canavalia ensiformis* plant (35 kg) and battery cage layer litter (12.5 kg) were mixed with 2600 g NaOH and 1300 g urea in 35 l of water. The mixture, containing approximately 7% NaOH on a dry matter (DM) basis, was stored from one to from one to three days before being fed to the sheep.

On the experimental day sheep were fed at 10:00 h, and samples of rumen digesta were obtained at 08:30, 12:00, 14:00 and 18:00 hr using a

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plastic tube that could be occluded at the lower end with a conical stopper. pH was measured inmediately, and rumen liquid was isolated by filtering the digesta through cloth. The rumen liquid was acidified (5 M $H_2SO_4$ pH < 4), and stored at -5°C pending analysis. Ammonia was determined by steam distillation, collection of the distillate into boric acid (2% w/v) and subsequent titration with 0.005 M $H_2SO_4$. VFA were determined by gas-liquid chromatography using isobutyric acid as an internal standard. Measurements with nylon bags (Ørskov et al 1980) were also made. Samples (5 g) of dried (70°C) ground (1 mm screen) pasture-*Canavalia* mixture described above with or without treatment with NaOH for 24 hr and two batches of a similar mixture where pasture was replaced by sugar cane stalk (pressed to remove about 50% of the juice) were placed in nylon bags. Bags were removed from the sheep at 4, 9, 14, 24, 33 and were then washed and dried. To measure solubility at zero time bags were soaked in 0.15 M NaCl solution for 4 h before washing and drying.

*Experiment 2:* Six Holstein cattle (4 bulls and 2 heifers, initially weights 117 - 170 kg) were paired on the basis of sex and weight and allocated to one of two dietary treatments. The basal diet consisted of freshly chopped mature Elephant grass pasture (58 kg), freshly chopped *Canavalia* plant (44 kg), NaOH (1160 g) and commercial mineral mixture (290 g). The mixture was prepared with the addition or 17 - 25 1 water and fed several hours to 2 days after preparation. *Canavalia* forage was not available for a total of 4 weeks, and during this period the proportion of pasture was increased correspondingly. Elephant grass was of 60 - 65 d regrowth, and the *Canavalia* 3 months of age at the beginning of the experiment, increasing progressively in age through the experimental period. The two dietary treatments consisted of the above mixture fed *ad libitum*, with a supplement of either 350 g/d or 700 g/d of cottonseed meal. The cattle were housed in partially-roofed individual pens with concrete floors, and water was freely available. Animals were weighed each 14 d and liveweight gain calculated by regression of liveweight and time. Feed intake was measured daily for each animal. After an initial period of 6 weeks for adaptation the experiment was continued for 15 weeks.

## Results and Discussion

*Experiment 1:* The mean intakes of the two sheep for the day of collection of rumen liquid, and for the 2 preceding days, were 587 and 303 g DM/d. Composition of the pasture-*Canavalia* mixture and sugarcane stalk-*Canavalia* mixture are given in Table 1. The somewhat lower concentration of nitrogen in the mixture than expected from the nitrogen content of the components suggested that some of the urea was hydrolized to ammonia and lost by volatilization, although the extent to which this loss occurred before consumption by the animals as opposed to during drying of the feed samples is not known. The high rumen ammonia concentrations (Table 2) suggest that the latter loss was more important.

The measurements on rumen liquid are given in Table 2. pH was maintained at a high level (pH 6.9-7.5), perhaps due to unreacted NaOH in

Table 1:
*Proximal analysis of feeds.*

| | Dry matter (%) | Organic matter (%) | Total N (%) | Neutral detergent fibre (%) |
|---|---|---|---|---|
| Experiment 1 | | | | |
| Forage - *Canavalia* (untreated) | 24.7 | 83.5 | 2.68 | 59.2 |
| Forage - *Canavalia* (NaOH treated) | - | 70.5 | 2.97 | 52.8 |
| Cane stalk - *Canavalia* (NaOH treated) | - | 83.1 | 1.78 | 60.3 |
| Experiment 2 | | | | |
| Forage - *Canavalia* mixture | | | | |
| Weeks 1-3 | 25.5 | 85.3 | 1.32 | 68.3 |
| 4-6 | 21.9 | 81.7 | 0.99 | 71.0 |
| 7-9 | 20.5 | 86.7 | 1.19 | 72.6 |
| 10-12 | 19.5 | 82.9 | 1.20 | 71.2 |
| 13-15 | 18.4 | 81.4 | 1.04 | 68.5 |
| $\bar{x}$ | 21.2 | 83.6 | 1.15 | 70.3 |
| Cottonseed meal | 91.7 | 93.7 | 6.37 | 35.8 |

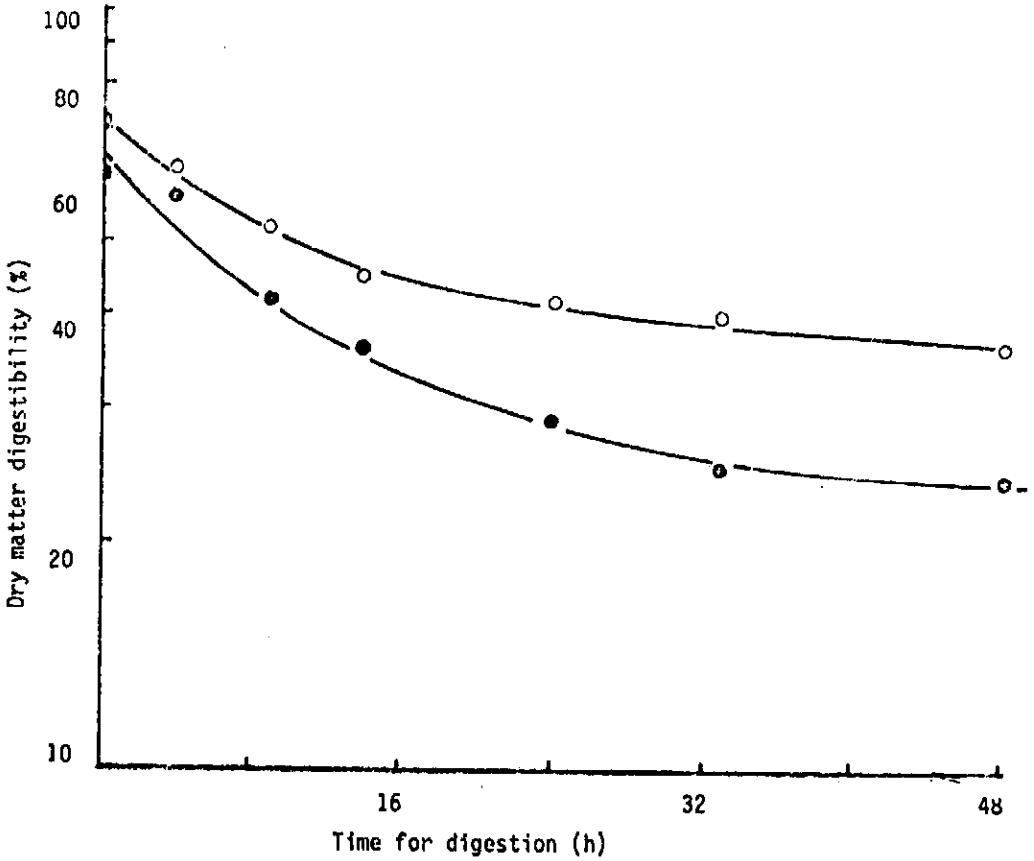
Ether extract of cottonseed meal = 7.2%.

Table 2:
*Experiment 1. Measurements of rumen fermentation in 2 sheep before, and at several times after the daily feed was given.*

| | Time of sample (h) | pH | $NH_3$ (mg N/l) | Total VFA (mm / l) | Proportions (%) Ac | Pr | Bu |
|---|---|---|---|---|---|---|---|
| Sheep 1 | -1 1/2 | 7.1 | 118 | 77 | 73 | 19 | 8 |
| | 2 | 7.5 | 606 | 73 | 73 | 19 | 8 |
| | 4 | 7.4 | 636 | 82 | 75 | 18 | 7 |
| | 8 | 7.2 | 533 | 97 | 75 | 19 | 7 |
| | Mean | 7.3 | 473 | 83 | 74 | 19 | 7 |
| Sheep 2 | -1 1/2 | 6.9 | 219 | 78 | 75 | 18 | 7 |
| | 2 | 7.3 | 544 | 63 | 71 | 21 | 8 |
| | 4 | 7.1 | 405 | 66 | 72 | 20 | 8 |
| | 8 | 6.9 | 246 | 84 | 71 | 21 | 8 |
| | Mean | 7.0 | 354 | 73 | 72 | 20 | 8 |

*Figure 1:*

*The rate of DM digestion in nylon bags in the rumen of sheep fed untreated (•) or NaOH treated (o) pasture + Canavalia.*




the feed mixture. Rumen ammonia concentration was high after feeding (246-636 mg N/l) and was expected to be in excess of the minimum requirements of ammonia N for microbial synthesis in the rumen (Satter and Roffler, 1977). The high proportion of acetate (71 - 75 %), and low proportions of propionate (18 - 21 %) and butyrate (7 - 8 %) are typical of a conventional roughage diet and are in accord with studies on treatment of straw (Horton, 1978; Garrett et al, 1979) where alkali treatment was associated with little change in proportions of VFA.

The results for the rate of disappearance of DM from nylon bags incubated in the rumen are given in Figure 1 and Table 3. It appeared that a first order kinetics equation did not provide an adequate description of the rate of DM digestion. Therefore the digestion after 48 h was considered to be the potential digestibility, and a compartment with a slope of zero and an intercept equal to the proportion of residual DM was obtained from the curves. The single compartment thus calculated was used to describe the digestion from time zero to 24 h (see Kempton, 1980). The results for DM solubility at zero time (29% and 38%), DM digestibility at 48 h (62% and 76%) and half-time (T 1/2) of DM digestion (31 h and 21 h) indicate a considerable increase in the rumen fermentation and *in vivo* digestibility of the pasture-*Canavalia* mixture due to NaOH treatment. The rate of fermentation of NaOH treated sugarcane stalk-*Canavalia* was not compared with an untreated control in this experiment; however the results do suggest

*Table 3:*

*Measurements using nylon bags of T 1/2 of DM during the first 24 h of incubation, the digestion of DM after 48 h and the solubility of DM in saline (zero time digestion) of a forage-Canavalia mixture with or without NaOH treatment, or NaOH treated cane stalk-Canavalia mixture.*

| Feed in nylon bags | Sheep | Soluble at zero time (%) | T 1/2 (h) (0 - 24 h) | Digestion after 48 h (%) |
|---|---|---|---|---|
| Forage + *Canavalia* | | | | |
| (not treated with NaOH) | 1 | 29 | 31 | 60 |
| | 2 | 29 | 30 | 64 |
| Forage + *Canavalia* | | | | |
| (treated with NaOH) | 1 | 38 | 21 | 76 |
| | 2 | 38 | 21 | 76 |
| Cane stalk + *Canavalia* | | | | |
| (treated with NaOH) | | | | |
| Batch A | 1 | 36 | 28 | 71 |
| | 2 | 36 | 35 | 72 |
| Batch B | 1 | 40 | 29 | 72 |
| | 2 | 40 | 27 | 72 |

*Table 4:*

*Experiment 2. Performance of cattle given NaOH treated Elephant grass-Canavalia forage supplemented with cottonseed meal.*

| | Cottonseed meal 350 g/d | Cottonseed meal 700 g/d | SEM | Significance |
|---|---|---|---|---|
| Nº animals | 3 | 3 | - | - |
| Initial weight (kg) | 159 | 146 | 10 | NS |
| Final weight (kg) | 211 | 200 | 15 | NS |
| Nº of days | 98 | 98 | - | - |
| Rate of gain (g/d) | 518 | 562 | 63 | NS |
| Intake DM (kg/d) | | | | |
| Forage - *Canavalia* | 5.05 | 5.05 | 0.16 | NS |
| Cottonseed meal | 0.32 | 0.64 | | |
| Total DM | 5.37 | 5.69 | 0.16 | NS |
| Intake (kg DM/100 kg liveweight) | 2.90 | 3.23 | 0.15 | NS |
| Feed conversion (kg DM/kg liveweight gain) | 10.4 | 10.4 | 1.0 | NS |

that rumen digestion of this mixture was comparable to the digestion of a forage of moderate to high quality.

*Experiment 2:* The experiment was commenced with the basal diet described for Experiment 1 where layer litter was included in the mixture. However intake of this mixture was low (approximately 2 kg DM/100 kg liveweight) possibly due to the odors and fermentation of the layer litter in the wet mixture. After 5 weeks the layer litter was excluded from the mixture; the results presented do not include this initial 5 week period or the first week with the new dietary regime.

The results for intake, liveweight gain and feed conversion are given in Table 4. There were no significant differences between the two treatments. Liveweight gain was 518 and 562 g/d and this was associated with a DM intake of 2.9 and 3.2 kg DM/100 kg liveweight, and a feed conversion of 10.4 kg DM intake/kg liveweight gain for both diets.

## Conclusions

The limited number of animals used in the experiments restricts the conclusions. However Experiment 1 demonstrated that there was a considerable effect of NaOH treatment on DM digestion of an Elephant grass - *Canavalia* forage mixture, and the rumen VFA pattern was similar to that observed with conventional forage diets. Experiment 2 demonstrated that moderate growth rates can be achieved with a diet based on NaOH treated low quality pasture and *Canavalia* forage with a low level of concentrate supplement, and demonstrates the potential of legumes such as *Canavalia* to replace concentrates. In other experiments in these laboratories with similar animals fed Elephant grass forage, supplementation with 1 - 2 kg/d of concentrate has been necessary to attain similar growth rates (F. Alvarez, unpublished results). However the relative importance of the *Canavalia* forage and the NaOH treatment in improving growth rate in the present experiment are not known.

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