THE EFFECT OF TREATING FORAGE WITH FORMALDEHYDE DURING HAYMAKING AND METHIONINE ADMINISTRATION DURING FEEDING ON THE DIGESTION AND UTILIZATION OF ENERGY AND NITROGEN BY SHEEP

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SUMMARY

Herbages (lucerne, pasture-clover mixtures) were sprayed with formaldehyde solutions during haymaking in 3 trials. After storage the hays were fed to sheep with and without intraperitoneally administered methionine. *In vivo* and *in vitro* tests showed that formaldehyde treatment protected some of the forage protein from ruminal degradation. Formaldehyde treatment caused some reduction in the apparent digestibility of nitrogen but not of energy. Responses in wool growth and nitrogen retention to hays containing protected protein, to methionine and to a combination of both treatments are given.

FORMALDEHYDE TREATMENT of pasture when made into hay offers a possible means of protecting the protein from degradation by rumen micro-organisms when later fed to animals.

This paper briefly reports on the hays made, and their digestion and utilization by sheep, with particular reference to wool growth and nitrogen retention. As the proteins in pasture plants have a content of sulphur-containing amino acids lower than in wool and which may inhibit fibre growth (McDonald, 1968), then the hays were fed with and without D-L methionine administration.

EXPERIMENTAL

The forages during haymaking were sprayed with solutions of formaldehye (CH_2O) using equipment mounted on conventional haymaking machinery. Control forages (untreated hays) were not sprayed.

EXPERIMENT 1

The herbage (75% perennial grasses, 25% white clover) was sprayed four times with either 1%, 2%, 4% or 8% CH_2O. A single application of 150 gal/acre was made into the chamber of a forage harvester at cutting with three applications each of 50 gal/acre during tedding, to give

total application rates of 0, 3.8, 7.5, 15.0 and 30.0 kg CH_2O/100 kg herbage crude protein (CP). The hays were then baled and stored for four months.

Dry matter and organic matter contents, and heat of combustion showed small increases with increasing CH_2O application rate ($P < 0.05$).

In vitro tests (Tilley and Terry, 1963) showed large decreases in nitrogen (N) digested in the microbial stage and large increases in N digested in the ensuing acid-pepsin stage in the 15 and 30 kg CH_2O-treated hays, a considerable portion of the protein in these forages thus having been protected from ruminal degradation.

The untreated, 15 and 30 kg CH_2O-treated hays were fed for a period of six weeks to non-pregnant Romney ewes aged approximately 21 months at low (400 g/sheep/day) and high (800 g/sheep/day) planes of nutriton, with and without the administration of methionine by intraperitoneal injection (2.4 g/sheep given at intervals of two days). Five animals comprised each sub-group. Wool growth and liveweight change were measured on all treatments, but digestibility and rumen fluid characteristics were measured only in the high plane groups.

Formaldehyde treatment decreased the concentration of ammonia ($P < 0.01$) and of total volatile fatty acids (VFAs:$P < 0.05$) in rumen fluid. Digestible energy (Mcal/kg DM) was increased by 6% ($P < 0.05$) and digestible N decreased by 16% ($P < 0.05$) in the CH_2O-treated hays.

The administration of methionine had no effect on rumen ammonia concentration, but decreased rumen VFA concentration ($P < 0.05$) and produced small increases in the digestibility of both energy and N ($P < 0.05$).

All treatments showed a fall in liveweight. Formaldehyde treatment caused a small reduction in the rate of liveweight loss at the high plane of nutrition only. Methionine caused a small reduction in the rate of liveweight loss, the effect being of similar magnitude at both nutritional planes.

In the absence of methionine, wool growth was not increased by CH_2O treatment. At the low plane of nutrition, methionine increased wool growth by 77%, the increase being of similar magnitude for untreated and CH_2O-treated hays. At the high plane of nutrition, the administration of methionine increased wool growth by 21% and 48%, respectively, in animals fed untreated and CH_2O-treated hays.

EXPERIMENT 2

Lucerne hay was sprayed during baling with 3%, 6% and 10% solutions of CH_2O at rates of 20 and 40 gal/acre, giving a range of application rates from 2 to 19 kg CH_2O/100 kg CP.

Examination of the hays after one month's storage showed that the incidence of mould was related to the concentration of CH_2O applied, being increased by 3% solutions and decreased by 6% and 10% solutions.

In vitro tests showed that the degree of protein protection increased rapidly with increasing CH_2O application rate up to 4 kg CH_2O/100 kg CP, but thereafter increased at a much slower rate.

After six months of storage the hays were pooled into three treatments on the basis of similar degree of protein protection. These comprised untreated, low CH_2O treatment (3.8 to 6.3 kg CH_2O/100 kg CP) and high CH_2O treatment (7.5 to 19.0 kg CH_2O/100 kg CP). Dry matter content was slightly higher and N content slightly lower in the two CH_2O treatments.

Each hay was fed to four Romney wethers (1 kg/sheep/day) for eight weeks, with a digestibility and N balance trial carried out during weeks 3 and 4 (period 1) and 7 and 8 (period 2). Intraperitoneal methionine (2.4 g/sheep/2 days) was administered to one pair of animals on each hay treatment during weeks 1 to 4 and to the second pair during weeks 5 to 8 in a crossover design.

Formaldehyde treatment decreased the concentration of ammonia ($P < 0.05$) and of total VFAs ($P < 0.05$) in rumen fluid. The digestibility of energy was not affected by CH_2O treatment, but N digestibility was depressed by 5.8 and 8.0 units, respectively ($P < 0.01$), in the low and high CH_2O treated hays, with no effect between periods. There were no differences in N retention in period 1, but N retention was higher on the treated hays in period 2 ($P < 0.05$) with no difference between levels of CH_2O treatment. The difference between periods was due to changes in urinary N excretion.

The administration of methionine had no effect on ammonia concentration but increased VFA concentration ($P < 0.05$) in rumen fluid. Methionine had no effect on the digestibility of energy or N, or on N retention.

EXPERIMENT 3

Heavily weathered hay (55% perennial grasses, 22% white clover, 23% red clover) was sprayed during baling

with 6%, 12% and 24% CH_2O at the rate of 10 gal/acre, giving application rates of 0, 1, 2 and 4 kg CH_2O/100 kg CP.

Treatment with 6% and 12% CH_2O solutions increased bale temperature during the 14-day period after baling and increased the proportion of hay classified as mould-contaminated at the end of seven months' storage. The 24% CH_2O treatment reduced bale temperature and caused a small reduction in the proportion of mould-contaminated hay.

In vitro tests showed protein protection at the two higher rates of CH_2O application, these and the untreated hay (basal hays), after removing mould-contaminated material, being offered *ad libitum* to Romney hoggets (10 animals/treatment) for a period of 4 weeks, together with a supplement of 100 g lucerne hay/day. The lucerne offered to five animals consuming each basal hay was impregnated with methionine (8 g/sheep/day) and treated with 20 kg CH_2O/100 kg CP in an attempt to protect this amino acid from ruminal degradation.

Voluntary intake increased with time up to and including Week 3, with no treatment effects being apparent. During Week 4 voluntary intake on both CH_2O-treated basal hays was 8% higher than on untreated basal hay ($P < 0.125$). Treatment of lucerne with methionine and CH_2O had no effect on voluntary intake.

Wool growth, measured over Weeks 3 and 4, was increased 11% by CH_2O treatment of the basal hays but was not increased by the methionine-formaldehye treatment of lucerne. None of the treatments increased the sulphur content of wool.

CONCLUSIONS

Formaldehyde Application Rate

A large proportion of the protein in forage was protected from ruminal degradation by spraying with CH_2O during haymaking. Protein protection resulted in a depression in the digestibility of N by 4 to 8 units but did not depress the digestibility of energy.

Approximately 15 kg CH_2O/100 kg CP was required to give protein protection in forage of low dry matter content sprayed in windrows, but rates of 4 to 6 kg CH_2O/100 kg CP gave protein protection when applied to forage of high dry matter content during baling. It is suggested that applications at baling be made using highly concentrated CH_2O solutions applied at low volumes/acre, as

this decreases mould formation, may increase voluntary feed intake, and may permit baling of hay at higher than normal moisture contents. However, further experimentation on these aspects is required.

Animal Responses to Hay Containing Protected Protein

The increased N retention from CH_2O treatment of lucerne suggests that treatment of this and perhaps other swards containing a high proportion of legumes would increase wool production. This has been shown to occur by Ferguson (1970), Hemsley *et al.* (1970) and in Exp. 3.

In the present work CH_2O treatment of forage containing a high proportion of perennial grasses (Exp. 1) increased wool production only in the presence of an increased supply of methionine at the tissue level and only when fed at the level of energy intake which was close to maintenance (high plane). Formaldehyde treatment of this type of forage is unlikely to have practical application unless it is fed with a supplement of synthetic methionine which has been protected from ruminal degradation. However, if the content of sulphur-containing amino acids in grass plants could be increased (plant breeding), then CH_2O treatment of such sulphur-enriched forage would be expected to increase wool growth.

Animal Responses to Methionine

The digestive response to intraperitoneally administered methionine differed with the type of forage fed. Methionine produced small increases in the digestibility of both energy and N in grass-dominant forage but not in lucerne.

With the forage containing a high proportion of perennial grasses, methionine was the first limiting factor for wool growth. The development of techniques for protecting dietary methionine from ruminal degradation could therefore have practical application with this type of forage. Experiment 1 showed that sheep fed at approximately 0.5 $\times$ maintenance level of energy intake (low plane) and given intraperitoneal methionine produced similar amounts of wool as sheep fed at 1.0 $\times$ maintenance energy intake (high plane) but not given methionine. It is therefore suggested that a source of protected methionine would have greatest practical application at very low planes of nutrition, permitting a large reduction in feed intake to be made without any reduction in wool production or wool quality.

Soaking methionine into forage prior to CH_2O treatment did not increase the wool parameters measured in Exp. 3, suggesting that this technique had not protected the amino acid from ruminal degradation. Other techniques for "protecting" methionine are being examined.

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REFERENCES

Ferguson, K. A., 1970: In *Feeding Protected Protein to Cattle and Sheep.* Proc. Aust. Soc. Anim. Prod. (N.S.W. Branch), Ed. D. W. Horwood.

Hemsley, J. A.; Hogan, J. P.; Weston, R. H., 1970: *Proc. 11th Int. Grassld Congr.:* 703.

McDonald, I. W., 1968: *Aust. vet. J., 44:* 145.

Tilley, J. M. A.; Terry, R. A., 1963: *J. Br. Grassld Soc., 18:* 104 .