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# Effects of Mimosa bark extract containing condensed tannins on rumen metabolism in sheep and milk production by grazing cows

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## ABSTRACT

A Mimosa bark extract (MB) was given to sheep and cattle to provide condensed tannins (CT) at levels which increased growth in lambs. The effects on rumen metabolism in sheep and milk production in grazing cows were studied in two experiments during spring 1994. MB contained 507 g CT/kg bark and was administered as a water suspension (280 g/litre). In Experiment 1, six rumen fistulated wethers were offered fresh pasture for two periods of 10 and 14 days, during which each sheep was drenched twice daily with 12.5 ml of either water or MB suspension (4.1 g CT/kg pasture DM intake), in a cross-over design. MB did not significantly affect DM intake, *in sacco* DM disappearance or apparent digestibility of DM or nitrogen (N), but ruminal ammonia-N and plasma urea concentrations were significantly decreased ($P<0.05$). In Experiment 2, 30 Friesian cows grazing mixed pasture were allocated to one of three treatments: undrenched control (C) or twice daily drenching with 90 (L) or 180 (H) ml of MB suspension (1.8 or 3.6 g CT/kg pasture DM intake) for three weeks. No significant differences in yields of milk or milk constituents were observed. Live weight and condition score changes did not differ significantly. Plasma urea concentrations were significantly lower ($P<0.05$) in treatment H than in treatment C. These results indicated that drenching with MB at daily rates of approximately 4 g CT/kg pasture DM intake reduced ruminal protein degradation in sheep and cattle, but did not increase milk production.

**Keywords:** Condensed tannins; mimosa bark; pasture; dairy cows; protein digestion; milk yield; rumen ammonia; plasma urea.

## INTRODUCTION

Crude protein (CP) concentrations in excess of 250 g/kg DM have been reported for New Zealand dairy pastures in spring and autumn (Moller *et al.*, 1996). This is well above the 170-180 g/kg DM suggested as the requirement of high producing dairy cows (NRC 1989). However, high degradabilities of pasture proteins in the rumen and low concentrations of non-fibrous carbohydrates can result in low flows of amino acids to the small intestine and high urinary urea excretion (Muller *et al.*, 1995).

Condensed tannins (CT), found in a restricted range of forages, can bind plant proteins and protect them against microbial degradation in the rumen. In comparison with lucerne (*Medicago sativa*), *Lotus corniculatus* containing 34-45 g CT/kg DM increased liveweight gain in lambs (Wang *et al.*, 1996a) and milk production in ewes (Wang *et al.*, 1996b). Barry (1989) suggested that 20-40 g CT/kg DM was ideal for ruminant diets. However, Montossi *et al.*, (1996) reported that swards based on Yorkshire fog (*Holcus lanatus*) and containing 4.2 g CT/kg DM produced significantly higher liveweight gains and wool growth in lambs than swards based on annual ryegrass (*Lolium multiforum*) and containing 3.7 g CT/kg DM.

Responses to increasing the amount of undegraded protein reaching the small intestine in dairy cows fed pasture are variable, with higher milk yields reported in some instances (Rogers *et al.*, 1980, Minson 1981) but not in others (Brookes 1984, Penno *et al.*, 1995). There have been no reports of the effect of feeding CT-containing plants on milk production by grazing cows, but Waghorn and Jones (1989) examined the inclusion of dock (*Rumex obtusifolius*) in dry cows fed lucerne/grass diets. The inclusion of 10% dock resulted in CT concentrations of 1.3-2.3 g/kg DM in the herbage consumed and reduced the concentration of soluble protein in rumen fluid.

The present study investigated the effects of a CT-containing extract of Mimosa bark (*Acacia spp*) on rumen metabolism in sheep and milk production by grazing cows. The extract was administered by drenching a water suspension in amounts estimated to provide 2-4g CT/kg DM intake daily.

## MATERIALS AND METHODS

Two experiments were conducted in the spring of 1994 at Massey University, in which the effects of MB on rumen metabolism in sheep (Experiment 1) and milk production by grazing dairy cows (Experiment 2) were measured. MB (Wattle Bark Industry of S.A., Pietermaritzburg, South Africa) was suspended in water at a concentration of 280 g/litre and administered as an oral drench.

### Experiment 1

Six mature rumen fistulated wethers (55.9-79.5 kg live weight) were housed in metabolism crates and offered freshly cut pasture twice daily in amounts calculated to meet energy requirements for maintenance. Following a seven day adjustment period, the sheep were randomly allocated to one of two treatment groups and drenched twice daily at feeding (08.00 and 15.30 hours) with 12.5 ml of either water (C) or MB suspension (MB) for 10 days. The treatments were then crossed over and continued for a further 14 days.

Samples of pasture offered and refused were weighed and DM concentrations determined at each feeding. Daily samples (200 g) of pasture offered in each treatment period were pooled, frozen and stored for laboratory analysis. During the last five days of each period, total faecal collections were made and the faeces stored at -20°C for further analysis. On days 3 and 4 of the faecal collections, 50 ml rumen fluid samples were taken through the rumen fistula immediately prior to (0 hours) and 2, 4 and 6 hours after the morning feeding. Samples were deproteinised and stored at -20°C for rumen ammonia nitrogen ($NH_3$-N) determination. Blood samples were taken according to the same schedule from the jugular vein, using ethylenediaminetetraacetate (EDTA)- vacutainers (Nipro Industries, Japan), placed in crushed ice until the plasma could be separated by centrifugation at 3000 rpm for 20 minutes. Plasma was stored at -20°C prior to determination of urea concentrations. On day 5 of the faecal collections, five polyester bags (Estal-mono, 7 x 14 cm, 47 µm pore size, Swiss Screens, Sydney, Australia) containing approximately 40 g of freshly minced pasture (Waghorn and Caradus 1994) and a 5 g weight were placed in the rumen of each sheep at the morning feeding. One bag was removed from each sheep after 1, 2, 4, 8 and 24 hours. Four further bags were prepared as zero time controls. The bags were rinsed with tap water until the rinse water was clear. Fresh pasture and the rinsed samples were dried at 60°C for 48 hours to determine *in sacco* DM losses during rumen fermentation.

### Experiment 2

Thirty Friesian cows (3-9 years of age) in the first month of lactation were assigned to blocks of three according to milk yield. A preliminary period of one week was followed by a three week experimental period in which the cows were allocated at random within blocks to the following treatments: an undrenched control (C) or drenched twice daily with either 90 (L) or 180 (H) ml of MB suspension. The experimental cows were fed, managed and milked as part of the 120 cow herd at the Dairy Cattle Research Unit, Massey University. Pasture on offer consisted of predominantly perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*). Daily milk yields were recorded on two consecutive days each week and the composition of the combined evening and morning milks for each day was measured using a Milkoscan 140 A/B (Foss Electric, Denmark). Cows were weighed and condition scored (using the 1-10 scale of Scott *et al.*, 1980) after the morning milking at the beginning and end of the experimental period. Mean values (± SEM) for live weight (kg) and condition score at the start of the experimental period were 461 ± 6.4 and 4.22 ± 0.06, respectively. During the morning milking on one day of each week, blood samples were taken by venipuncture from the tail of each cow, using EDTA - vacutainers, place in crushed ice until centrifuged and stored at -20°C for urea analysis.

### Laboratory Analyses

CT concentrations in MB were determined by the method of Terrill *et al.*, (1992a). Pasture samples were freeze dried, ground through a 1mm sieve and analysed for total nitrogen (N) by the Kjeldahl method, organic matter (OM) by ashing samples at 500°C, and *in vitro* digestibility by the enzymic method of Roughan and Holland (1977). Faecal samples were thawed, mixed and subsamples taken for DM and N determinations. Deproteinised rumen fluid samples were analysed for $NH_3$-N by steam distillation from sodium tetraborate using a Kjeltec Auto 130 Analyser (Tecator Ltd, Sweden). Plasma urea concentrations were determined using a Cobas Fara II autoanalyser (Hoffman La Roche Ltd, Switzerland).

### Statistical Analyses

All data were analysed by a statistical computing package (SAS 1985) using the general linear model. In Experiment 1, analysis of variance for a cross over design was used, with repeated measures through time for the analysis of rumen $NH_3$-N and plasma urea concentrations. In Experiment 2, analysis of variance was used to assess treatment differences. Repeated measures through time were used for milk yields, milk composition and plasma urea concentrations and data from the preliminary period served as covariates.

## RESULTS

The Mimosa bark extract contained 507 g extractable CT/kg. No detectable amounts of fibre-bound or protein-bound CT were present.

### Experiment 1:

Pasture offered contained on average 170 g DM/kg, 864 g OM/kg DM, 273 g CP/kg DM and had a mean *in vitro* organic matter digestibility (IVOMD) of 0.768. No significant differences ($P < 0.05$) were observed between treatments (C v MB ± SEM) for DM intake (0.96 v 0.87 ± 0.05 kg/day), DM digestibility (0.820 v 0.794 ± 0.010), N digestibility (0.872 v 0.857 ± 0.008) or DM disappearance *in sacco* (0.77 v 0.76 ± 0.02 after 24 hours). Ruminal $NH_3$-N and plasma urea concentrations after drenching are presented in Table 1. MB significantly ($P < 0.05$) depressed ruminal $NH_3$-N concentrations 2 hours after drenching and plasma urea concentrations 4 and 6 hours after drenching.

**TABLE 1:** Effects of twice daily drenching with 12.5 ml of water (C) or a suspension of Mimosa bark extract (MB) on ruminal ammonia-N (mg/l rumen fluid) and plasma urea (mM/l ) concentrations (Mean ± SEM).

| Time after drenching (hours) | Ruminal Ammonia-N | | | Plasma Urea | | |
|---|---|---|---|---|---|---|
| | C | MB | SEM | C | MB | SEM |
| 0 | 179[a] | 162[a] | ±10 | 7.41[a] | 7.13[a] | ±0.21 |
| 2 | 340[a] | 232[b] | ±23 | 7.86[a] | 7.29[a] | ±0.24 |
| 4 | 314[a] | 229[a] | ±37 | 7.98[a] | 7.33[b] | ±0.15 |
| 6 | 219[a] | 171[a] | ±17 | 7.86[a] | 7.18[b] | ±0.15 |

[ab] For each measurement means within rows having superscripts with letters in common are not significantly different ($P > 0.05$).

## Experiment 2:

The effects of drenching dairy cows with a suspension of MB on milk yields and composition, live weight and condition score changes, and plasma urea concentrations, are presented in Table 2. Milk yields and composition for cows receiving MB did not differ significantly from the controls, although lactose concentrations were greater ($P < 0.05$) for L than H treatments. Live weight and condition score changes during the experimental period were not significantly different. The H treatment significantly ($P < 0.01$) depressed plasma urea concentrations.

**TABLE 2:** Effects of twice daily drenching with 90 ml (L) or 180 ml (H) of a suspension of Mimosa bark extract compared with an undrenched control (C) on daily yields (kg/cow) of milk, fat, protein and lactose, concentrations of fat, protein and lactose in milk (%), changes in live weight (kg) and condition score, and plasma urea (mM/l) concentrations. (Covariate adjusted means ± SEM)

| | C | L | H | SEM |
|---|---|---|---|---|
| **Yields** | | | | |
| Milk | 25.39[a] | 25.35[a] | 25.78[a] | ±0.28 |
| Fat | 1.11[a] | 1.11[a] | 1.09[a] | ±0.02 |
| Protein | 0.84[a] | 0.85[a] | 0.86[a] | ±0.01 |
| Lactose | 1.26[a] | 1.26[a] | 1.27[a] | ±0.01 |
| **Concentrations** | | | | |
| Fat | 4.29[a] | 4.41[a] | 4.29[a] | ±0.06 |
| Protein | 3.31[a] | 3.35[a] | 3.35[a] | ±0.01 |
| Lactose | 4.95[ab] | 5.01[a] | 4.91[b] | ±0.01 |
| Live weight change | -6.1[a] | -18.8[a] | -12.1[a] | ±3.7 |
| Condition score change | +0.06[a] | +0.00[a] | +0.13[a] | ±0.06 |
| Plasma urea | 10.75[a] | 10.92[a] | 9.93[b] | ±0.16 |

[ab]Means within rows having superscripts with letters in common are not significantly different ($P > 0.05$).

## DISCUSSION

Condensed tannins (CT) at low dietary concentrations (2-4 g CT/kg DM) have been shown to reduce the concentration of soluble protein in the rumen (Waghorn and Jones 1989) and to improve animal performance (Montossi *et al.,* 1996). MB contained 507 g CT/kg bark and daily drenching supplied 7 g MB/sheep (MB) and 50 g MB (L) and 100 g MB (H)/cow. Daily DM intakes were measured directly for the sheep, and were estimated to be 14 kg DM/cow from live weight change and milk production data (ARC 1980). MB supplied CT concentrations of 4.1, 1.8 and 3.6 g/kg pasture DM intake for treatments M, L and H respectively.

Decreases in ruminal $NH_3$-N and plasma urea concentrations indicated that the higher levels of MB administration were effective in reducing rumen protein degradation. DM disappearance form polyester bags suspended in the rumen was not affected by MB. This agrees with the observation of McNabb (1990) that DM disappearance and protein solubilisation in *Lotus pedunculatus* were not affected by CT, but that degradation rates of soluble proteins in the rumen were substantially reduced.

In this study, it was not possible to directly attribute the protection of proteins to the CT component of MB. However, CT have been shown to decrease rumen $NH_3$-N concentrations in animals fed forages containing 2-5 g CT/kg DM (Terrill *et al.,* 1992b, Montossi *et al.,* 1996). Montossi *et al.,* (1996) concluded that CT concentrations of 5 g/kg DM were probably required to significantly improve wool production and liveweight gain in lambs.

The dose rates given to cows (1.8-4.1 g CT/kg DM) were low and no increases in yield of milk constituents resulted from MB drenching, despite the reduction in plasma urea concentrations. CT added as peanut skins to a total mixed ration have been shown to increase milk yields and reduce rumen $NH_3$-N and plasma urea concentrations but this was at dietary concentrations (40 g CT/kg DM) ten times those used in the present study (West *et al.,* 1993). The increase in non-ammonia N (NAN) flow to the small intestine has been estimated to increase by 0.0046 g/g CT for *Lotus spp* (Barry *et al.,* 1986, Waghorn *et al.,* 1987). If this relationship holds true for MB, 100 g MB/day would only increase NAN flow to the small intestine by 0.23 g/day. It is not known whether increasing the dose of MB would result in increased milk yields. Penno *et al.,* (1995) dosed grazing cows with a fishmeal slurry estimated to provide 150 or 300 g undegraded dietary protein (UDP) daily and did not observe any changes in milk yields or cow live weight. They concluded that cows grazing spring pasture are not limited by UDP levels.

## CONCLUSION

MB provided a degree of protection for dietary proteins against rumen degradation, as evidenced by a depression in ruminal $NH_3$-N and plasma urea levels in both sheep and cattle. However, at the MB concentrations provided (1.8-4.1 g/kg pasture DM intake), the increases to be expected in NAN flowing to the small intestine would be small, and no increases in yields of milk and milk constituents were observed. Recent evidence (Penno *et al.,* 1995) suggests that milk production by cows grazing spring pasture may not be limited by undegraded dietary protein intakes, so that increasing the dose rate of MB may not be effective in increasing milk yield.

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## REFERENCES

ARC 1980: The nutrient requirements of ruminant livestock. Technical review by an agricultural research council working party Farnham Royal, UK, Commonwealth Agricultural Bureaux.

Barry, T.N. 1989: Condensed tannins: Their role in ruminant protein and carbohydrate digestion and possible effects upon the rumen

ecosystem. *In:* The roles of protozoa and fungi in ruminant digestion, Nolan, J.V., Leng, R.A., Demeyer, I.D. ed Armidale, Australia, Penambul Books.

Barry, T.N., Manley, T.R., Duncan, S.J. 1986. The role of condensed tannins in the nutritional value of *Lotus pedunculatus* for sheep .4. Sites of carbohydrate and protein digestion as influenced by dietary reactive tannin concentration. *British journal of nutrition.* **55:** 123-137.

Brookes, I.M. 1984. Effects of formaldehyde-treated and untreated casein supplements on performance of dairy cows offered ryegrass - clover pasture. *New Zealand journal of agricultural research* **27:** 491-493.

McNabb, W.C. 1990. Digestion and metabolism of sulphur containing amino acids in sheep fed fresh forage diets. Ph.D. thesis, Massey University.

Minson, D.J. 1981. The effects of feeding protected and unprotected casein on the milk production of cows grazing ryegrass. *Journal of agricultural science, Cambridge.* **96:** 239-241.

Moller, S.N., Parker, W.J., Edwards, N.J. 1996. Within year variation in pasture quality has implications for dairy cow nutrition. *Proceedings of the New Zealand Grassland Association* **57:** 173-177.

Montossi, F., Hodgson, J., Morris, S.T., Risso, D.F. 1996. Effects of condensed tannins on animal performance in lambs grazing Yorkshire fog (*Holcus lanatus*) and annual ryegrass (*Lolium multiflorum*) dominant swards. *Proceedings of the New Zealand Society of Animal Production* **56:** 118-121.

Muller, L.D., Kolver, E.S., Holden, L.A. 1995. Nutritional needs of high producing cows on pasture. *Proceedings 1995 Cornell Nutrition Conference for Feed Manufacturers.* 106-120.

NRC 1989. Nutrient requirements of dairy cattle - Sixth revised edition. Washington DC., National Academy Press.

Penno, J.W., Bryant, A.M., Carter, W.A., Macdonald, K.A. 1995. Effects of fishmeal supplementation to high genetic merit cows grazing temperate spring pastures in early lactation. *Journal of dairy science* **78 (Supplement 1):** 295.

Rogers, G.L., Porter, R.H.D., Clarke, T., Stewart, J.A. 1980. Effect of protected casein supplements on pasture intake, milk yield and composition of cows in early lactation. *Australian journal of agricultural research* **31:** 1147-1152.

Roughan, P.G., Holland, R. 1977. Predicting in-vivo digestibilities of herbages by exhaustive enzymic hydrolysis of cell walls. *Journal of the science of food and agriculture* **28:** 1057-1064.

SAS 1985. SAS users guide: statistics, version 5 edition. Cary, N.C: SAS Institute Inc.

Scott, J.D.J., Lamont, N., Smeaton, D.C., Hudson, S.J. 1980: Sheep and cattle nutrition. Agricultural Research Division, Hamilton, New Zealand, Ministry of agriculture and fisheries.

Terrill, T.H., Rowan, A.M., Douglas, G.B., Barry, T.N. 1992a. Determination of extractable and bound condensed tannin concentrations in forage plants, protein concentrate meals and cereal grains. *Journal of the science of food and agriculture* **58:** 321-329.

Terrill, T.H., Douglas, G.B., Foote, A.G., Purchas, R.W., Wilson, G.F., Barry, T.N. 1992b. Effect of condensed tannins upon body growth, wool growth and rumen metabolism in sheep grazing sulla (Hedysarum coronarium) and perennial pasture. *Journal of agricultural science, Cambridge.* **119:** 265-273.

Waghorn, G.C., Caradus, J.R. 1994. Screening white clover cultivars for improved nutritive value - development of a method. *Proceedings of the New Zealand Grassland Association.* **56:** 49-53.

Waghorn, G.C., Jones, W.T. 1989. Bloat in cattle. 46. Potential of dock (*Rumex obtusifolius*) as an antibloat agent for cattle. *New Zealand journal of agricultural research.* **32:** 227-235.

Waghorn, G.C., John, A., Jones, W.T., Shelton, I.D. 1987. Nutritive value of *Lotus corniculatus* L containing low and medium concentrations of condensed tannins for sheep. *Proceedings of the New Zealand Society of Animal Production.* **47:** 25-30.

Wang, Y., Douglas, G.B., Waghorn, G.C., Barry, T.N., Foote, A.G., Purchas, R.W. 1996a. Effect of condensed tannins upon the performance of lambs grazing *Lotus corniculatus* and lucerne (*Medicago sativa*). *Journal of agricultural science, Cambridge.* **126:** 87-98.

Wang, Y., Douglas, G.B., Waghorn, G.C., Barry, T.N., Foote, A.G. 1996b. Effect of condensed tannins in *Lotus corniculatus* upon lactation performance in ewes. *Journal of agricultural science, Cambridge.* **126:** 353-362.

West, J.W., Hill, G.M., Utley, P.R. 1993. Peanut skins as a feed ingredient for lactating dairy cows. *Journal of dairy science.* **76:** 590-599.