INFLUENCE OF LOW-LEVEL CONDENSED TANNINS CONCENTRATIONS IN TEMPERATE FORAGES ON SHEEP PERFORMANCE

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ABSTRACT

Results from a series of six comparative lamb grazing trials with temperate forages are summarised, and compared with results from the literature. Condensed tannin (CT) concentrations in the diet ranged from 0.12% to 0.47% on a dry matter (DM) basis. Values were generally similar for Yorkshire fog (*Holcus lanatus*), perennial ryegrass (*Lolium perenne*) and annual ryegrass (*L. multiflorum*), each grown with white clover (*Trifolium repens*), in similar circumstances. Concentrations for tall fescue (*Festuca arundinacea*)/white clover pastures were relatively low, but may have been artefacts. Drenching with polyethylene glycol (PEG) to bind dietary CT generally reduced live weight gain, wool growth and carcase weight, though effects were only significant at CT concentrations. Use of PEG enhanced wool production in lambs grazing perennial ryegrass. It is suggested that a CT concentration of 0.5% in the DM represents the marginal value above which consistent advantages to animal performance might be expected, and that this concentration may be achieved in temperate grasses by appropriate plant selection techniques.

KEYWORDS

Plant tannins, Yorkshire fog (*Holcus lanatus*), perennial ryegrass (*Lolium perenne*), annual ryegrass (*Lolium multiflorum*), tall fescue (*Festuca arundinacea*)

INTRODUCTION

Work with a range of legume species has led to the suggestion that concentrations of condensed tannins (CT) should be in the range 2%-4% in the dry matter for optimal effects on forage digestion and production in ruminant animals. Higher concentrations of CT may inhibit forage consumption and depress animal performance (Barry, 1989; Waghorn et al., 1990). However, there is little evidence on the effects of the lower concentrations of condensed tannin present in forage grasses, or on the minimum CT concentration required to improve ruminant production (Terrill et al., 1992a). This paper summarises the results of a series of studies designed to measure the ingestive behaviour, forage intake and performance of grazing lambs in comparative studies involving a range of temperate forage grasses.

METHODS

Six studies were carried out with weaned lambs between 1992 and 1995, involving paired comparisons between swards of Yorkshire fog (*Holcus lanatus* : YF) and either perennial ryegrass (*Lolium perenne* : PRG), annual ryegrass (*Lolium multiflorum* : ARG) or tall fescue (*Festuca arundinacea*: TF), each grown with white clover (*Trifolium repens*). Details are given in Montossi (1995) and Liu (1996), and are summarised in Table 1.

Experiments 1-5 were carried out at Massey University, Palmerston North, New Zealand (40° 23'S, 175° 37'E), and Experiment 6 at the INIA Tacuarembó Research Station, Uruguay (32° O1'S, 57° 00'W). The soil for Experiments 1-5 was a gleyed yellow-grey earth with relatively high nutrient status (Olsen P in the range 25-27 µg/ml) and regular application of 50 kg P ha^{-1}. yr^{-1}. That for Experiment 6 was a shallow brown-reddish and black basaltic litosole with very low P status (Resinas P 1.75 µm/g), which received 70 kg P.ha^{-1} at sowing.

Experiments 1 and 2 involved continuous stocking management on replicate paddocks; all other experiments involved rotational grazing. Lambs were managed under non-restrictive sward conditions except for Experiment 5, where half of the animals grazed as "leaders" and half as "followers" in a rotation. Measurements of animal performance were made over periods of 8-12 weeks. Estimates of growth rate were based on weekly weighing of unfasted animals; those of wool growth were based on mid-side patch samples (Bigham, 1974) taken at the beginning and end of each study. All animals were slaughtered at the end of each experiment.

In all studies, half the lambs on each treatment were given polyethylene glycol (PEG, molecular weight 4000) in solution, by drench, twice daily, in quantities estimated to bind and inactivate any CT in the grazed forage (Barry and Forss, 1983). Control animals received equivalent volumes of water by drench twice daily. In experiments 1 and 3-5 observations on diurnal fluctuations in rumen ammonia concentration in rumen fistulated animals grazing with the lambs provided indications of the effect of PEG in preventing the binding of dietary N by CT (Waghorn et al., 1987).

Estimates of total CT and extractable and bound components in the diets of grazing animals were made by the method of Terrill et al. (1992b) on samples of extrusa collected from animals fistulated at the oesophagus which were rotated between experimental treatments in a balanced design. All animals were drenched with anthelminthic at monthly intervals to minimize infection with gastro-intestinal nematode parasites.

RESULTS AND DISCUSSION

Table 1 summarises the results of the grazing studies, and also incorporates the results presented by Terrill et al. (1992a) for lambs grazing perennial ryegrass/white clover pastures. CT concentrations ranged from 0.12% to 0.47% on a dry matter (DM) basis, the highest concentrations being observed in forage species grazing on relatively low nutrient status soils. Values were generally similar for Yorkshire fog and either perennial ryegrass or annual ryegrass pastures growing in similar conditions. Concentrations for tall fescue paddocks were relatively low, and the absence of any measurable effects of PEG on rumen ammonia concentrations in animals grazing this species (Liu, 1996) suggests that in this case the estimates of CT may have been an artefact of the analytical procedure. PEG drenching tended to increase rumen ammonia concentration by a small but consistent amount on other treatments (Montossi, 1995; Liu, 1996).

The use of PEG usually depressed liveweight gain, carcase weight and wool growth in lambs. Though few of these effects were significant at the lower CT concentrations, they are consistent with the expectation that PEG would block the effect of CT in binding plant protein in the rumen and increasing the supply of amino acids to the small intestine (Barry, 1989). The main exceptions to this generalisation were increases ($P<0.05$) in wool growth of lambs grazing perennial ryegrass pastures in Experiments 1 and 2, and the increases (NS) in weight gain, carcase weight and wool growth of the lambs grazing Yorkshire fog at both unrestricted and restricted levels in Experiment 5. These effects are difficult to explain in the context of the low CT concentrations in the diets, but the former is consistent with other observations by Terrill et al. (1992a) and Niezen et al. (1993) on lambs grazing perennial ryegrass pastures. Taken together with the fact that PEG effects on performance were generally smaller for perennial ryegrass than for Yorkshire fog at equivalent levels of dietary CT concentration, this indicates the likelihood that PEG may have effects on the digestive process in addition to those associated with the binding of dietary protein.

The main effects of PEG on animal performance were observed at levels of dietary or herbage CT concentration close to 0.5%. This might be taken as the effective minimal CT concentration for consistent effects on protein digestion and animal performance. There is little experimental information in the range 0.5% - 2.0% CT, but the results in Table 1 suggest that the effects of CT concentrations of the order of 0.5% in grasses may be close to those observed for dietary concentrations of 2% - 4% in legume forages (Waghorn et al., 1990).

The relatively high CT concentration observed in Experiment 6 reflected limiting soil conditions for plant growth, rather than plant genotype effects. Nevertheless, the confirmation of substantial animal performance benefits from CT concentrations only twice those of established plant cultivars indicates the opportunity for increasing CT concentrations by conventional plant selection techniques.

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Table 1
The effects of forage species and PEG drenching on liveweight gain (g/day), carcase weight (kg) and wool growth (mg/100 cm^{-2} day) in grazing lambs.

Experiment	Species[1]	Dietary CT concentration (% DM)	Liveweight gain (g/d)			Carcase weight (kg)			Wool growth (mg/100 cm^2/d)		
			Ctrl[2]	PEG[3]	Dif %[4]	Ctrl	PEG	Dif %	Ctrl	PEG	Dif %
1 summer	YF	0.18	129	113	-12.4	16.2	16.4	+1.2	109	109	0.0
	PRG	0.19	130	131	+0.8	17.3	17.6	+1.7	108	121	+12.0 *
2 winter	YF	0.18	145	142	-2.1	16.3	16.2	-0.6	87	74	-14.9
	PRG	0.21	173	174	+0.6	17.0	17.1	+0.6	78	91	+16.7 *
3 summer	YF	0.18	103	95	-7.8	15.0	14.5	-3.3	116	119	+2.6
	TF	0.12	77	75	-2.6	14.0	13.9	-0.7	113	110	-2.7
4 autumn	YF	0.21	80	73	-8.8	14.4	14.1	-2.1	114	111	-2.6
	TF	0.13	77	75	-2.6	14.1	14.1	0.0	111	98	-11.7
5 summer	YF	0.26	103	111	+7.8	14.7	15.3	+4.1	107	115	+7.5
	YF	0.23	33	40	+21.2	12.4	12.5	+0.8	92	93	+1.0
6 spring	YF	0.42	174	135	-22.4 **	19.3	18.7	-3.1	154	140	-9.0 *
	ARG	0.37	111	105	-5.4	17.1	17.0	-0.6	134	122	-9.0 *
Terrill et al (1992b)	PRG	0.47	175	136	-22.3 *	19.2	18.3	-4.7	115	97	-15.7 *

[1] For abbreviations, see text.
[2] Drenched with water, and 3 drenched with PEG (see text)
[4] Dif % = $\frac{\text{Ctrl-PEG}}{\text{Ctrl}} \times 100$
* and ** indicate PEG effects significant at P<0.05 and P<0.01 respectively