

FEED ADDITIVES IN RUMINANT NUTRITION

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Summary

The opportunities for using chemicals or food additives to improve feed intake or enhance digestion of grazing ruminants is discussed. The difficulty of spraying chemicals onto standing pasture or cereal straws during harvesting as well as the need for correct timing of the application of some compounds to optimise response will limit their application. Rumen modifiers which manipulate the digestion and increase the retention of protein and energy without depressing feed intake should enhance productivity of grazing ruminants. Preliminary results with the rumen modifier ICI 139603 are presented.

I. INTRODUCTION

The growth rate and wool production of the grazing ruminant is very much dependant upon the quantity and quality of the available herbage. There is an increasing trend by Australian farmers to minimise the effects seasonal variation has on animal productivity by strategic supplementary feeding and by using feed additives which enhances growth. Other speakers will discuss the use of supplements and anabolic agents to maximise productivity. I will discuss the use of additives in the broadest sense either to manipulate the diet to enhance feed intake, or to manipulate digestion to improve animal productivity.

(a) Manipulation of the diet

Livestock performance is frequently depressed in many grassland regions due to low digestibility. As the plant matures the fibre and structural components increases while the protein and mineral levels decline. The effect of these changes in plant structure is to reduce herbage intake by the animal (Corbett 1969). This decline in digestibility is often substantial. Allden (1968b) recorded changes in the digestibility of herbage eaten by sheep in the Mediterranean areas of Southern Australia declining from a high of 75% to a low of 42% with a corresponding decline in feed intake. These low levels of digestibility persisted for up to six months and the animals were unable to maintain liveweight despite the abundance of feed. Attempts have been made to improve the digestibility of low quality roughages and cereal straws by alkali treatment to remove lignin and silica (Jackson 1977).

(i) Alkali Treatment The idea of converting indigestible straw or roughage into a useful feed is very appealing to farmers. Each year cereal growers plant about 12 million hectares of cereals for grain leaving almost 30 million tonnes of straw which is poorly utilised by sheep and cattle.

Kellaway et al (1977) using a simple on-farm system treated oaten straw with sodium hydroxide and urea and recorded an increase in vitro digestibility from 47% to 58% and an average liveweight gain in Hereford heifers from 143 g/day to 564 g/day following treatment. Similar improvements in digestibility and animal performance were reported when tropical native hays were treated with solutions of potassium hydroxide, urea and sodium sulphate (Winks 1984). In these studies dry matter digestibility was increased from 42% to 53% and dry matter intake increased to 270% of the unsupplemented controls. Cattle fed the treated hay gained weight while those fed the untreated hay lost weight.

Unfortunately the cost and the logistics of handling hazardous chemicals has prevented this technology from being adopted in Australia.

(ii) Plant Growth Regulators Other alternatives that are available to improve the quality of the standing feed is to spray the pastures with plant regulators which act either to maintain the plants at peak digestibilities or prolong plant growth delaying the onset of maturity.

Paraquat a plant dessicant was first used in grazing studies with sheep in Western Australia (Arnold and Barrett 1978) where it was shown to improve the value of mature summer pastures resulting in good liveweight gains during the early summer but the overall reduction in dry matter yield following spraying reversed the gains.

Other studies with paraquat revealed that spraying reduced the set of seeds of annual pastures lowering dry matter yields in the autumn which reduced weight gains of cattle but not sheep.

The difficulties in using paraquat as chemical freezing technique were further increased when it was shown that rainfall which occurred between spraying and the beginning of summer leach the nutrients reducing feed quality.

Mefluidide, a plant regulator which delays the onset of plant maturity, maintaining the plant in a vegetative state is showing promise in USA and New Zealand (3M Technical Data Summary 1982) as a means of increasing animal production. Since 1975 studies have been conducted in the USA on tall fescue grasses where it has been shown that the application of mefluidide at rates of 0.14, 0.26 and 0.56 kg/ha during spring, when the plant is in the early vegetative stage, will enhance liveweight gains and milk production of cattle. Work conducted over three years in New Zealand at Ruakura Research Station has shown consistent improvements in liveweight gain. Lambs grazing ryegrass pasture sprayed with mefluidide (0.2 kg/ha) gained 3 kg liveweight per head over a 56 day trial.

There is a slight depression in pasture yield following mefluidide treatment but the critical factor in its application is the availability of soil moisture to ensure continuous plant growth. In many parts of Southern Australia pasture growth is terminated by a summer drought.

Selected irrigation or high rainfall areas in Australia could provide the appropriate plant growth conditions for effective use of mefluidide.

(b) Manipulation of Digestion - Rumen Modifiers

Manipulation of digestion with rumen modifiers appears to offer much greater scope for improved animal production under extensive animal husbandry conditions of Australia.

The process of digestion and fermentation are well established in the rumen. Complex polysaccharides and proteins are converted to volatile fatty acids and amino acids with the production also of useless high energy products such as methane and heat losses during fermentation.

The main end products of rumen digestion are the volatile fatty acids, acetic, butyric, and propionic acid which provides 70% of the energy available to the rumen. The efficiency of conversion of polysaccharides to VFA's varies. The conversion to acetic acid is 62% efficient, butyric acid 78% and 109% for propionic acid as estimated from respective heats of combustion. Any compounds which can shift the fermentation from acetic acid production to propionic acid will trap more useful energy for the animal. Monensin, lasalocid salinomycin, ICI 139603 are polyether ionophores which alter VFA patterns. Two glycopeptides, actaplanin and avoparcin also switch VFA production while avoparcin has the additional characteristic of improving the efficiency of amino acid absorption post-ruminally (Rowe 1984). The rumen is such a delicately balanced eco-system that rumen modifiers rarely have one single effect on rumen fermentation. There is scope for rumen modifiers to vary in their overall effect on the rumen ecosystem and hence vary in their effect on production responses.

The commercial use of ionophore feed additives in Australia has been restricted. This restriction may be associated with the difficulty of administration of small quantities of compound on a regular basis or it may be that the overall effect of manipulation of rumen fermentation has been to reduce feed intake which would limit their application to grazing animals.

I would like to discuss the biological profile of one of these ionophores, ICI 139603, which is not yet commercially available but which may have beneficial use for grazing sheep and cattle.

II. BIOLOGICAL EFFECT

The effect of 139603 on the degradation of amino acids has been examined in fistulated sheep fed 800 g oats/lucerne chaff (90:10w/w) supplemented with 60 g casein daily. Results for three experiments covering a range of 139603 dose levels administered orally in three successive days show that the compound does act as an effective deaminase inhibitor in the rumen (Table 1).

Table 1. Acute effects of 139603 on degradation of amino acids to ammonia in the rumen of sheep (Graham, Edwards and Cumming unpublished data 1983)

Treatment	Dose mg/kg	Rumen parameters	
		Amino acids % control	Ammonia % control
139603	0.25	169.6 A	77.4 NS
139603	0.125	184.0 A	109 NS
139603	0.033	124 NS	79 NS

Letters significantly different from each other and control (P<0.05).

However Rowe et al (1983) reported that ionophores reduce microbial protein synthesis by about 20% and the overall effect is a small increase in the quantity of protein available to the animal. The grazing conditions most likely to provide a response to ionophores are those where there is potentially an abundance of rumen degradable protein. In a trial to examine the potential for 139603 to increase nitrogen available to the animal (Graham et al 1984) rumen fistulated sheep were fed a lucerne chaff diet (16.0% CP) and dosed with graded levels of 139603 (Table 2).

Table 2. The mean effect (+SE) of ICI 139603 on nitrogen balance, VFA ratios (acetic + butyric ÷ propionic) and protozoal numbers

Dose mg/kg LWT	n	N balance g/hd/day	VFA ratios	Prot. numbers
0	5	7.3 (1.1)	3.40 (0.22)	618 (39)
0.05	5	10.3 (3.5)	2.85*(0.16)	408*(60)
0.10	5	9.6 (4.0)	2.95*(0.15)	394*(40)
0.15	4	11.2*(1.0)	2.75*(0.09)	290*(40)

* Means are significantly different from controls (p<0.05)

n = Number of animals.

NS = not significant.

The results suggested that extra nitrogen was being retained following treatment with the ionophore and a significant reduction in acetic acid production and protozoal numbers were also observed.

III. PRODUCTION RESPONSES

In an extensive review of the results of using ionophores in grazing studies with cattle, Rowe (1984) demonstrated a substantial increase in liveweight gain and attributed the response to increased intake of metabolisable energy. Most of the successful use of ionophores with grazing cattle has been recorded in Europe while in Australia only a limited number of studies have reported a significant improvement in liveweight gain (Watson & Laby, 1978). Any ionophore which depresses feed intake will negate the improvement achieved in improved efficiency of fermentation. Ionophores which are active over a wide dose range without depressing feed intake will be of greater benefit to grazing animals.

In two grazing studies in which 139603 was either fed with a grain supplement daily to Hereford weaner cattle, grazing rye grass-clover pastures in Victoria or incorporated into an intra ruminal device and administered to Zebu cross steers grazing improved tropical pastures in North Queensland, produced significant improvements in liveweight gain (Table 3).

Table 3. Liveweight gain of grazing cattle supplemented with ICI 139603 (Edwards and Graham unpublished data 1984)

	Pasture			
	Temperate		Tropical	
	Untreated Control	Treated Control	Untreated Control	Treated Control
Mean Dose Level mg/kg.d.	-	0.1	-	0.2
Number of Cattle	20	20	30	30
Liveweight Gain kg/d	0.76	1.1+	0.29	0.40+

+ Means significantly different from controls $p < 0.05$.

While improvements in cattle liveweight gain are of economic importance to farmers any significant improvements in wool production or wool quality will be of similar importance. Wool production normally shows large variation in seasonal growth rate ranging from 8 g of clean wool per sheep daily in late summer up to 20 g of clean wool per sheep daily in spring ((Purser, 1981). In autumn/early winter when pasture availability is low but quality is high, feed additives which can improve energy intake should improve wool growth while any improvement in the amount of protein available to the animal could also increase wool growth. In a penned feeding experiment (Graham et al 1984) where varying levels of 139603 were fed to crossbred lambs receiving a lucerne chaff diet (19.8% CP) produced a significant increase in greasy wool weight (Table 4) but no significant increase in liveweight gain.

Table 4. The mean effect (\pm SE) of ICI 139603 on Greasy Fleece Weight and Liveweight Change

Dose mg/kg	No. of Sheep	Greasy Fleece Weight (kg)	Liveweight Gain (g/hd/day)
0	20	1.4 (0.07)	136.1 (7.7)
0.05	19	1.6+(0.08)	126.5 (6.4)
0.10	19	1.7+(0.08)	149.1 (10.5)
0.15	19	1.9+(0.06)	130.8 (6.4)
0.20	19	1.9+(0.06)	156.8 (4.2)
			NS

+ = Means are significantly different from controls (P<0.05)
 NS = Not significant.

However, Ellis and Schlink (1982) found no increase in wool growth in grazing animals when given monensin but they did observe a faster growth rate. Further field tests will be required to define the optimum dose levels and dietary regimes which will provide predictable increases in wool growth.

IV. CONCLUSION

Feed additives which improve the efficiency of rumen fermentation without depressing feed intake of grazing animals will play an increasingly important role in animal productivity. There appears to be limited scope, because of cost effectiveness, of improving feed intake of grazing animals by spraying the standing feed with existing chemicals.

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