REDUCED PERFORMANCE IN FEEDLOT STEERS SUPPLEMENTED WITH 1.25% AMMONIUM SULPHATE IN THE DIET TO CONTROL UROLITHIASIS

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SUMMARY

Two groups of long fed feedlot steers (mean 255 days on feed) were fed diets supplemented with 1.25% (High AS, n=221) or 0.25% ammonium sulphate (Low AS, n=208) for an additional 73 to 90 days until slaughter. Steers on the High AS diet exhibited reduced group feed intake, growth rates ($P<0.001$), carcase weights ($P<0.05$), P8 fat depth ($P<0.01$) and marbling score ($P<0.01$) but increased dressing percentage ($P<0.001$). Eye muscle area was not affected. The High AS diet also reduced urine pH ($P<0.001$) and increased urine Ca concentration ($P<0.01$) without affecting Na or K concentration. Only one of 247 animals examined at the abattoir had uroliths in the bladder. These results suggest that the use of ammonium sulphate supplementation at 1.25% to prevent urolithiasis is associated with significant reductions in performance.

Keywords: ammonium sulphate, urolith, feedlot nutrition, cattle, growth, carcase

INTRODUCTION

Ammonium sulfate (AS) is widely used as a feed additive in feedlot rations. It is generally used either to provide supplemental S to the diet, particularly in diets containing non-protein nitrogen sources, or as a urinary acidifier for the prevention of struvite urolithiasis. AS has been successfully used to prevent urolithiasis in Australian feedlot cattle when incorporated in the diet at a level of 1.25% (Vanselow 1994). However at higher levels of incorporation (2-4%) it is known to depress feed intake and this has been used to limit feed intake of steers being introduced to grain based diets (May and Barker 1989). High intakes of sulphates in ruminants (>2%) can also result in polioencephalomalacia (Raisbeck 1982) and this condition has been observed in Australian feedlot cattle supplemented with AS to control urolithiasis. Since AS can clearly have profound negative effects on animal performance, we designed this study to determine whether it has toxic effects when supplemented at the moderate levels used to control urolithiasis in feedlot cattle.

MATERIALS AND METHODS

Experimental design

The experiment was conducted between March and June 1997 at a commercial feedlot. The experimental animals comprised 429 Angus and Murray Grey steers which had already been in the feedlot for a mean of 255 days. The animals were randomly allocated to two adjacent pens and placed on diets containing 1.25% AS (High AS, n=221) or 0.25% AS (Low AS, n=208) on a DM basis. The feedlot had previously supplemented with 1.25% AS routinely to control urolithiasis but had used 0.25% AS for the 2 months prior to the experiment because of concerns about animal performance. Hormonal growth promotants were not used before or during the experiment. Pens had an area of 3250 m^2 and feed was provided *ad libitum* in cement bunks. Water was also available *ad libitum* in concrete troughs from a common surface water source.

Experimental diets

The experimental diets were based on wheat and barley with added molasses, water, mill mix, barley stubble, cottonseed hulls, whole cottonseed, urea, ammonium sulphate, salt, limestone and a vitamin and mineral premix. Diets were mixed and fed on a daily basis. Ration samples were collected daily and bulked for subsequent analysis by Agritech Laboratory Services, Toowoomba.

Measurements

All experimental animals were weighed on days -2 and 71 relative to the start of experimental feeding (day 0, 28 March 1997), and again on the afternoon prior to slaughter. Urine samples were collected from a subset of animals (n=20/treatment) on days -2, 43, 71 and immediately post-mortem on day 77. Urine was tested immediately for pH and specific gravity then acidified to pH <3.0 with 36% HCl for storage. At the completion of the experiment urine samples were analysed for sodium and potassium using flame photometry, and total calcium using the COBAS BIO analyser (Roche Diagnostics). Trough water samples collected

during the experimental period were analysed at the Tamworth Environmental Laboratory. The experimental animals were slaughtered in two commercial export abattoirs between days 73 and 90. Variables obtained were hot carcass weight, dressing percentage, P8 fat depth, marbling score and eye muscle area (AUS-MEAT 1994).

Statistical analysis

Treatment effects were estimated using analysis of variance (AnOV) and analysis of covariance (AnCOV). Growth and performance data were analysed by AnOV with carcase attributes also analysed by AnCOV using final weight or carcase weight as covariates. Urine electrolyte concentrations were log transformed prior to analysis and subjected to AnCOV using urine specific gravity as the covariate.

RESULTS

Animal health and wellbeing

One animal from each treatment was removed from the experiment for ill health and a further animal in the Low AS group died during the experiment. There was no evidence of clinical urolithiasis in either treatment and post-mortem examination of bladders from 247 animals at the abattoir revealed only one animal with urinary calculi in the bladder. This animal was from the Low AS treatment and the composition of the calculi was mixed, containing a mixture of calcium oxalate and uric acid.

Feed and water analysis

The experimental diets did not differ in N or predicted ME content. The High AS diet contained more S and less NaCl than the Low AS diet (Table 1). The dietary cation anion difference (DCAD, being the sum of [Na] and [K] minus the sum of [Cl]and [S]) for the two diets was -15 and -153 meq/kg for the Low and High AS diets respectively. Trough water collected during the experimental period had a pH of 7.7, total hardness of 76 mg/L and concentrations of Na, K, Ca, Mg, Cl and sulphate of 38.4, 21, 12, 11.2, 26 and 6.0 mg/L respectively.

Urine composition

Consistent effects of treatment across all sampling periods were only observed for urine pH and total Ca concentrations (Table 2). The High AS treatment induced a significant reduction in urine pH and a significant increase in urine Ca concentrations ($P<0.01$).

Feed intake, liveweight and growth during the experimental period

Steers on the Low AS diet had higher feed intakes and grew significantly faster ($P<0.001$) than those on the High AS diet (Table 3).

Table 1. Mineral and electrolyte content of the experimental diets (g/kgDM) and water (g/L)

Source	DM (%)	P	K	Ca	Mg	Na	S	Cl
AS 0.25% diet	74.6	3.7	8.6	9.4	2.0	3.6	2.7	7.8
AS 1.25% diet	74.6	3.6	8.4	8.6	2.0	1.8	4.7	5.5
Water[1]			0.021	0.012	0.011	0.038		0.026

[1]See text for additional measurements

Table 2. Urine data (least square means ± s.e.) prior to (day -2) and following the imposition of treatments (days 43,71,77). Data for the three post treatment samples are pooled

Variable	Day -2		Days 43, 71 and post slaughter (day 77)	
	AS 0.25% (n=20)	AS 1.25% (n=20)	AS 0.25% (n=55)	AS 1.25% (n=60)
pH	7.18±0.16[a]	7.42±0.09[a]	7.57±0.07[a]	6.50±0.09[b]
Specific gravity	1.005±0.0004[a]	1.011±0.002[b]	1.015±.001[a]	1.012±.001[a]
[1]Na (mmol/L)	137±2.26[a]	64.1±1.18[b]	68.5±1.14[a]	45.3±1.19[a]
[1]K (mmol/L)	52.5±1.87[a]	70.1±1.13[a]	56.0±1.10[a]	68.2±1.14[a]
[1]Ca (mmol/L)	3.61±1.72[a]	1.79±1.11[a]	1.73±1.07[a]	4.50±1.10[b]

[ab] Means within sampling periods not sharing a common letter in the superscript are significantly different $P<0.05$

[1]Urine electrolyte values are back transformed from log data

Pre-slaughter weights and carcase data

Full slaughter records were available for 400 of the experimental animals. There were significant effects of treatment on all performance variables except days on feed, whether measured over the entire period in the feedlot, or at slaughter (Table 4). The effects of treatment were removed when analysis of covariance was performed using either final weight or carcase weight as the covariate.

Table 3. Liveweight (LW, kg) average daily LW gain (ADG), feed intake and feed conversion efficiency (FCE) during the experimental feeding period (mean ± s.e.)

Treatment	n	LW day -2	LWT day 71	ADG (g/d)	Intake (kg)[1]	FCE[1] (feed/gain)
AS 0.25%	206	689.0±2.5[a]	756.0±3.0[a]	910±17[a]	9.68	10.64
AS 1.25%	220	687.7±2.4[a]	746.7±2.8[b]	799±15[b]	8.89	11.13

[1] Single estimate from group means. No statistical analysis possible.
[ab] Means within columns not sharing a common letter in the superscript are significantly different P<0.05

Table 4. Key final performance indicators for the experimental animals over the entire period in the feedlot (mean ± s.e.)

Variable	AS 0.25%	AS 1.25%	Significance[1]
n	193	207	
Days on feed	344±0.6	345±0.6	ns
Final weight (kg)	757±3.0	738±2.9	***
Daily gain (g)	1022±9	964±8	***
Carcase weight (kg)	438±1.8	431±1.9	*
Dressing %	57.9±0.11	58.4±0.10	***
P8 fat depth (mm)	29.3±0.52	27.1±0.44	**
Marbling score	3.10±0.036	2.94±0.033	**
Eye muscle area (cm^2)	46.7±0.13	46.0±0.28	ns

[1] Significance ns P>0.05, * P<0.05, **P<0.01. ***P<0.001

DISCUSSION

Both experimental diets contained dietary sulphur levels well in excess of the 1.5 g/kgDM recommended for cattle by SCA (1990). The 1.25% AS diet, previously used to control urolithiasis at this feedlot, successfully reduced urine pH but also caused increased urinary Ca concentrations, reduced feed intake, reduced growth rates, reduced P8 fat and reduced marbling score when compared to the 0.25% AS diet. Reduction of AS content to 0.25% over the last 73-90 days did not result in clinical or post mortem evidence of urolithiasis under the conditions of this experiment.

Most of the reduced performance observed in animals on the 1.25% AS diet can be attributed to reduced feed intake with flow on effects on weight gain and FCE. Treatment effects on carcase attributes were lost when data were adjusted for final weight or carcase weight indicating that effects on carcase attributes were secondary to those on growth. Our results are broadly consistent with other reports although some studies using animals with shorter periods on feed have found effects of dietary AS on eye muscle area but not carcase fatness (eg Zinn *et al.* 1997; Thompson *et al.* 1972). Zinn *et al.* (1997) demonstrated significant reductions in feed intake, weight gains and feed efficiency in feedlot steers when the S content of the ration was increased from 0.2 to 0.25% by incorporating 0.4% rather than 0.2% AS. There were no differences in performance between animals fed 0.2% S diet and the basal diet containing 0.15% S and no AS. Both this study, and that of Qi *et al.* (1993) with wether goats, suggest that feed intake and animal performance is inhibited once dietary S exceeds 0.2%, provided supplemental S is provided in the form of highly available sulphates. Both diets in our experiment would fall into this category. Studies using elemental S as a supplement have shown mixed results with S levels of up to 0.44% having no effect on performance in some (Pendlum *et al.* 1976) while levels of 037-0.42% reduced feed intake but not growth in others (Thompson *et al.* 1972; Rumsey 1978). Undoubtedly some of the differences in these reports are due to the low availability of elemental S for rumen microbes (~35%, Kahlon *et al.* 1975). The mechanism by which dietary S reduces voluntary feed intake is unknown with Zinn *et al.* (1997) finding only very subtle effects on ruminal and post-ruminal digestive function. Sulphur-induced polioencephalomalacia is closely associated with a dramatic increase in rumen

concentrations of hydrogen sulphide gas (Gould *et al.* 1997) and absorption of H_2S across the ruminal and respiratory epithelia may be involved in the pathogenesis of this condition (Radostits *et al.* 1994). It may also be involved in subclinical S toxicity, manifest in reduced feed intake.

The effects of AS level in the diet are potentially confounded by inadvertant differences in NaCl concentrations in the experimental diets arising out of fears by feedlot management of urolithiasis in the LowAS diet. This resulted in 0.5% NaCl being added to the Low AS diet and only 0.25% being added to the High AS diet. However there is no evidence in the literature that the levels of sodium and chloride in the diets used would influence feed intake or growth performance. The levels of Na and Cl in both diets are well above the recommended requirements for growing cattle of 0.8 g/kgDM and 0.7-1 g/kgDM, and responses to sodium supplementation are generally only seen when dietary levels fall below 0.5 g/kgDM (SCA 1990). The concentrations in both diets are also 10-20 fold below the levels at which depressions in feed intake would be expected (SCA, 1990; Forbes *et al.* 1992). Water quality during the experiment was good and the contribution of water to NaCl intake would be negligible in comparison with that of feed (Table 1).

The increased urinary calcium concentrations observed in the High AS treatment are consistent with other reports that feeding diets with a negative DCAD or those that promote a mild metabolic acidosis increase blood ionised Ca concentrations and urinary excretion of Ca (Block 1994; Abu Damir *et al.* 1994; Won *et al.* 1996). This hypercalciuria may predispose to the formation of calcium containing uroliths although this was not observed in this study.

These results demonstrate that the use of AS to control urolithiasis in feedlots by urinary acidification may incur significant penalties in terms of animal performance, and suggest that it may also affect calcium metabolism. Using alternative urinary acidifiers such as ammonium chloride, and restricting treatment times to those of greatest risk of struvite urolithiasis are alternative strategies that should be considered in the light of these findings.

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