Effects of a dietary complex of humic and fulvic acids (FeedMAX 15™) on the health and production of feedlot cattle destined for the Australian domestic market

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Objective To examine the effects of a dietary humic and fulvic acid complex, FeedMAX 15™, on the health, growth rate, feed conversion ratio, and carcase characteristics of feedlot cattle.

Design Cattle, in eight pens of 125 animals each, were fed either a diet containing a humic and fulvic acid complex (FeedMAX 15™, FeedMAX Industries, Toowoomba, Queensland) or the same diet without the additive. Control or FeedMAX 15™ diets were allocated to each pen at random. Individual cattle were allocated alternately to control or treatment pens based on order of presentation. Comparisons of disease incidence, mortality, feed intake, growth rate, feed conversion ratio, fat depth, dressing percentage, meat colour, fat colour and marbling were made at the conclusion of the feeding period.

Results No differences were found between cattle fed FeedMAX 15™ and cattle not fed the additive in entry body weight ($P = 0.99$), exit body weight ($P = 0.91$), dressing percentage ($P = 0.66$), P8 fat depth ($P = 0.57$), meat colour ($P = 0.67$), marbling ($P = 0.70$), all diseases ($P = 0.64$), bovine respiratory disease ($P = 0.91$), or mortalities ($P = 1.0$). Cattle fed FeedMAX 15™ reached the market specifications for body weight and fat depth in fewer mean days ($P = 0.0001$), had a greater average daily gain ($P = 0.05$), a lower feed conversion ratio ($P = 0.05$) and whiter fat ($P < 0.0001$).

Conclusions Feeding the humic and fulvic acid complex, FeedMAX 15™, at 0.055 g per kg body weight per day, can increase growth rate and feed conversion efficiency in feedlot cattle.

Key words: feedlots, cattle, diet, feed conversion
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ADG	Average daily gain
BRD	Bovine respiratory disease
BW	Body weight
DMI	Dry matter intake
FCR	Feed conversion ratio

FeedMAX 15™ is a stable multivalent phenyl and aromatic humic and fulvic acid compound complexed with trace minerals. In a pilot study, FeedMAX 15™ was included in the diets of 400 cattle in four pens, with 399 cattle in four pens not fed the additive as controls. This study showed no effects on health or mortalities ($P > 0.69$), but cattle fed the complex had a greater ($P < 0.0001$) average daily gain (ADG) and a lower ($P < 0.0001$) feed conversion ratio (FCR), which prompted the experiment described below.

There is considerable variation in the composition of humic and fulvic acid–containing products[1,2] and these compounds have not yet been completely characterised.[1,3] In addition, humic and fulvic acid containing products can contain varying amounts of trace minerals and other compounds, which have also not been adequately quantified in the few published papers investigating their effects. This observation explains the variable results found thus far with unpublished commercial experiments using humic and fulvic acid–containing products. Further, the results of the experiment below cannot be extrapolated to other humic and fulvic acid–containing products, because of variations in composition and a lack of knowledge of the mechanisms of action.

Materials and methods

Location and timing

The study was done in a commercial feedlot in southern Queensland of 7000 head capacity from September 2005 to January 2006.

Animals and treatments

Two thousand mixed-breed beef cattle, each weighing approximately 328 kg, were purchased through saleyards inside a 500 km radius of the feedlot. Time from arrival at the feedlot to entry processing varied from 1 to 4 days. The experimental diets were randomly allocated to pens. The cattle were alternately allocated to treatment or control groups as they were processed through the crush at feedlot entry, until 16 pens of 125 animals were filled. There were eight treatment and eight control pens.

FeedMAX 15™ is composed of humic and fulvic acids complexed with trace minerals (Table 1). It was mixed into the rations of the cattle in the treatment pens to provide approximately 20 g of the complex per animal per day. The untreated cattle were fed immediately before those that were fed the additive, to clean any remnants of the additive out of the feed wagon while feeding cattle not in the experiment. Cattle were fed once daily between 0600 and 0900 h. The aim of the feeding regimen was to maximise intake.

Table 1. Chemical composition[a] of the humic and fulvic acid complex FeedMAX 15™.

Element or compound	Concentration in FeedMAX 15™ dry matter
Carbon (C)	46.70%
Hydrogen (H)	2.20%
Oxygen (O)	16.61%
Sulphur (S)	0.22–0.24%
Total nitrogen	1.04–1.20%
Phosphate (P_2O_5)	0.08%
Potassium Oxide (K_2O)	0.30%
Sodium (Na)	6.7–8.9%
Calcium (Ca)	0.37–0.74%
Magnesium (Mg)	0.10–0.23%
Iron (Fe)	700–2940 mg/kg
Zinc (Zn)	34–54 mg/kg
Manganese (Mn)	34–52 mg/kg
Copper (Cu)	45–77 mg/kg
Selenium (Se)	20–27 mg/kg
Chromium (Cr)	0.5–1.9 mg/kg
Chlorine (Cl)	0.15%
Silica	0.7%
Organic Acids	65.6%

[a]Ranges from manufacturer and Symbio Alliance, Eight Mile Plains, Queensland.

At feedlot entry, all animals were vaccinated against clostridial diseases (Websters 5-in-1 Vaccine with Vitamin B12®, Fort Dodge Australia Pty Ltd, Baulkham Hills, NSW) and bovine herpesvirus 1 (Rhinogard®, Q-Vax Pty Ltd, Brookfield, Queensland). A macrocyclic lactone anthelmintic drench (Cydectin®, Fort Dodge Australia Pty Ltd, Baulkham Hills, NSW) and a hormonal growth promotant (Synovex Plus®, Fort Dodge Australia Pty Ltd, Baulkham Hills, NSW) were administered, and numbered ear tags were applied. There was an adaptation period of 16 days to the introduction of the final diet and cattle were fed commercial feedlot diets for the duration of the experiment (Tables 2, 3 and 4). The cattle were removed from the experiment for slaughter when they were assessed as meeting the market specifications of the required body weight (BW) and P8 fat depth.

Measurements

The occurrence of all diseases and mortalities, dry matter intake (DMI), days on feed and BW gained were recorded at the feedlot, and from these, ADG and FCR were calculated. P8 fat depth and dressing percentage were recorded by the abattoir on the carcase processing chain, and meat colour, fat colour and marbling were recorded in the abattoir's refrigerated storage facilities by AUS-MEAT accredited assessors (AUS-MEAT Ltd, South Brisbane, Queensland). Disease occurrence was a measure of all cattle identified as requiring treatment by the feedlot

Table 2. Final ingredient composition of a commercial feedlot diet fed to cattle throughout the study.

Ingredient	% diet dry matter
Wheat	9.0
Sorghum	54.1
Barley	5.0
Barley silage	20.0
Dried distillers grains with solubles	4.2
Vitamin–mineral supplement with molasses carrier	7.7

Table 3. Ingredient composition of the vitamin–mineral supplement with molasses carrier in the final commercial feedlot diet.

Ingredient	% of diet dry matter
Molasses (85 brix)	54.3
Limestone	17.3
Mixing solution (Bundaberg Molasses, Oakey)	15.6
Urea prills (Incitec, Brisbane)	9.16
Flossy salt	2.50
Suspending agent (Xantham and guar gums, Bundaberg Molasses, Oakey)	0.55
Micronutrient mixture[a]	0.50
Vitamin E 400 DSM (Hoffmann La-Roche, Basel, Switzerland)	0.0379
Rovimix A 400DLC (Hoffmann La-Roche, Basel, Switzerland)	0.009

[a]Micronutrient mixture composition: selenium 2 mg/kg; zinc 600 mg/kg; manganese 500 mg/kg; iron 100 mg/kg; copper 55 mg/kg; cobalt 2 mg/kg; iodine 5 mg/kg; vitamin D 5000 IU/kg; vitamin B1 40 mg/kg; monensin 250 mg/kg; virginiamycin 200 mg/kg.

Table 4. Calculated specifications of the experiment final diet (dry matter basis).

Diet measurement	Nutrient calculation
Metabolisable energy, MJ/kg	12.4
Crude protein (%)	14.8
Fat (%)	3.0
Crude fibre (%)	8.4
Neutral detergent fibre (%)	15.9
Calcium (%)	0.81
Phosphorus (%)	0.36
Sulfur (%)	0.16
Potassium (%)	0.69
Monensin (mg/kg)	25.6
Virginiamycin (mg/kg)	20.5

Table 5. Health and production effects in cattle fed 21.3 g/animal/d FeedMAX 15™ compared with cattle not fed the complex.

Variable	Treatment group		
	FeedMAX 15™	No additive	P
Heath effects			
Cases of disease[a]	62 (6.2 ± 0.8)	57 (5.7 ± 0.7)	0.64
Initial cases of BRD[a]	40 (4.0 ± 0.6)	41 (4.1 ± 0.6)	0.91
Mortalities[a]	6 (0.6 ± 0.07)	6 (0.6 ± 0.07)	1.0
Production effects			
Pen DM intake (kg)	80799 ± 1788	94758 ± 1788	0.0001
Average daily gain (kg/animal/d)	1.67 ± 0.07	1.48 ± 0.07	0.05
Feed conversion ratio (kg diet DM/ kg BW gain)	5.67 ± 0.24	6.38 ± 0.24	0.05
Days on feed	69.0 ± 1.6	81.4 ± 1.6	0.0001
Feedlot exit BW (kg)	444.5 ± 1.13	444.3 ± 1.13	0.91
Dressing percentage (carcase weight/ live BW)	53.7 ± 0.09	53.7 ± 0.09	0.66
P8 fat depth (mm)	9.1 ± 0.12	9.0 ± 0.12	0.57
Meat colour[b] (490 animals)[c]	1.2 ± 0.02	1.2 ± 0.03	0.67
Fat colour[d] (483 animals)	0.52 ± 0.03	0.72 ± 0.03	< 0.0001
Marbling[e] (473 animals)	0.07 ± 0.01	0.07 ± 0.01	0.70

Brd = Bovine respiratory disease; BW = body weight; DM = dry matter; Values in parentheses are mean ± SE.
[a]Cases per 100 animals
[b]Higher numbers represent darker meat.
[c]Not all chiller assessment data were retrieved.
[d]Higher numbers represent more coloured fat.
[e]Higher numbers represent more intramuscular fat per unit area.

animal health staff in consultation with the feedlot veterinarian. A diagnosis of BRD was based on the absence of clinical signs referable to systems other than the respiratory system, and two or more of the clinical signs of dyspnoea, nasal and/or oral discharge, lethargy and inappetance. ADG was calculated from feedlot entry weight, after at least 24 h access to feed and water, and exit weight at the conclusion of the feeding period within 1 week of slaughter.

Statistical analysis

The occurrence of disease and mortality were categorical binomial data and were analysed with a chi-square goodness of fit test. Entry weight, ADG, FCR, P8 fat depth and dressing percentage were distributed normally and were analysed with one way ANOVA. Meat colour, fat colour and marbling data were symmetrical but not distributed normally and were analysed with the Kruskal-Wallis non-parametric test. Each pen of 125 cattle was treated as one observation, and the ADG data include cattle that died during the experiment. The analysis was done with Statistix software (version 8, Analytical Software, Tallahassee, Florida 32317).

Results

Gender distribution did not differ (P = 0.85) between treatment and control groups. The pens fed FeedMAX 15™ had 637 heifers and 363 steers, and the pens not fed the additive had 633 heifers and 367 steers. The mean daily DMI of the cattle with FeedMAX 15™ added to their diet was 9.39 kg. For a concentration of FeedMAX 15™ of 2.27 g/kg of complete ration dry matter, the intake of FeedMAX 15™ was 21.3 g per animal per day. Therefore, for a mean BW during the experiment of 386 kg the cattle ate 0.055 g FeedMAX 15™ per kg BW per day. The health and performance comparisons between the cattle fed diets including FeedMAX 15™ and those fed diets not including the complex are presented in Table 5.

Whilst the mean fat colour in the cattle fed FeedMAX 15™ was whiter than that of the cattle not fed the additive, the mean fat colour measurements of both groups were within the specifications of the target market, so the difference was not of practical consequence.

Discussion

Results of this study show that to achieve the same exit specifications, with similar exit BW and fat depth, the cattle fed FeedMAX 15™ ate 15% less in total and grew 14% faster than the other cattle. This resulted in an 11% FCR advantage, and a shorter feeding period than those not fed the additive. An electronic literature search found no refereed journal articles on the use of humic and fulvic acid complexes in feedlot cattle. There were references to the effectiveness of humic acid preparations in the prevention of mastitis[4,5] and increased milk production[6] in dairy cows, and a humic acid preparation enhanced the effects of a trace mineral supplement on the growth rate of bulls.[7] The efficacy of humic acid preparations in the prevention and treatment of diarrhoea in calves has been variable.[8,9] However, marked variability in the chemical composition of humic and fulvic acid complexes makes comparisons of generic humates meaningless. Detailed characterisation of these products is essential for research into their activities because variation in composition may be related to variation in physiological responses to their administration. While the contribution of trace elements from FeedMAX 15™ to the diet in the above experiment was substantially smaller than that provided by the liquid supplement (for example 1.6 versus 51.0 mg copper per animal per day), the formulation of trace elements complexed with weak organic acids might have contributed to the observed response. An enhanced response to trace element supplementation with the feeding of humate has been observed previously.[7] Research in this area might provide information on the mechanism of action of humic and fulvic acid complexes that could improve the effectiveness of their use.

No effects on health outcomes from the feeding of FeedMAX 15™ were observed in this experiment. The improvements in DMI, ADG and FCR seen with the additive might therefore be due to local effects on rumen fermentation leading to increased fermentative efficiency, rather than generalised systemic effects.

Humic and fulvic acids are weak acids and organic colloids and can therefore adsorb metal ions with desorption occurring at a higher pH,[3] or in the presence of a greater sodium concentration.[10] Thus, humic and fulvic acid complexes might transfer trace elements out of the rumen into the small intestine, where the minerals are released due to a higher pH. In addition, humic and fulvic acids might modify the oxidation/reduction potential of the rumen liquor[3] and could exert a minor buffering effect.

Further research into the mechanisms of action of FeedMAX 15™ should focus on rumen fermentation. Applied feedlot research would be best directed at investigating the effects of the additive with a variety of diets, and establishing a dose response curve to realise the greatest economic benefits from the use of the product.

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BOOK REVIEW

***Diseases of sheep**. 4th edition. Aitken, ID, ed. Blackwell Publishing, 2007, 624 pages. ISBN: 978-1-4051-3414-9.*

This is the fourth edition of the popular and well recognised book, *Diseases of sheep*. As the editor comments in the Preface, the book does not claim to be a comprehensive coverage, but there is no doubt it provides an excellent source for veterinarians involved in sheep work.

The book is largely written from the UK (and European) perspective, and this is strongly reinforced by the sheep shown on the front cover. However, given the range of diseases in sheep in the UK and Europe, this ensures a more complete coverage of many interesting diseases, particularly the more important exotic diseases of interest to Australian veterinarians. There are also contributions from Australian authors (John Egerton, Peter Kirkland, Stephen Page and John Plant).

The book begins with an interesting overview of the sheep industry from the UK perspective and includes reasonably recent (eg 2002 to 2003) world statistics. It then has an excellent section on welfare, as well as covering reproductive physiology.

Diseases are dealt with primarily on a systems approach under the six headings of: reproductive, alimentary, respiratory, nervous, feet (and legs) and a combined skin, wool and eyes section. Additional sections cover metabolic and minerals, poisons, tumours, and others (primarily vector borne diseases). Country specific issues are briefly covered for each of the major non-European areas, including a contribution by John Plant on the Australian (or NSW!) issues. This includes commentary on internal and external parasites, footrot and OJD. A final section covers pharmacology, anaesthesia and sampling. Two useful Appendices on *normal* blood and biochemistry parameters are also included.

This book is an excellent reference for any veterinarian involved in either occasional or full time sheep practice. It is well presented, and provides sufficient information on all the likely (and unlikely) sheep diseases encountered in practice. The index is comprehensive and the book is easy to use as a reference source to look up either specific diseases, presenting clinical signs or procedures. In addition to the comprehensive coverage of diseases, the sections on welfare, reproduction, pharmacology and surgery provide further useful information.

As the book is written from the UK perspective, occasionally some information is less relevant, and the Australian practitioner will need to use his/her knowledge of local conditions/practices to ensure appropriate measures are implemented. On the other hand, though, the comprehensive nature of the information and the range of authors ensures the reader has a good overview of the relevant disease and treatment options. The information on the major exotic diseases is particular relevant and useful, especially under the current scrutiny of quarantine measures.

I would therefore recommend this book as an excellent reference for all veterinarians likely to be involved in any type of sheep practice. Don't be put off by the picture on the front cover!

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