ADDING A POTASSIUM, CLINOPTILOLITE ZEOLITE TO FEEDLOT RATIONS TO REDUCE MANURE NITROGEN LOSSES AND ITS IMPACT ON

RUMEN pH, E-COLI AND PERFORMANCE

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Introduction

Environmental concerns associated with the confined feeding operations (CAFOS) have been a topic of major importance in Canada and the United States for several years. In 2000, in Ontario Canada a severe E-coli problem resulted in approximately seven deaths and an additional 2300 people became ill. It is believed the E-coli source was drinking water, contaminated by livestock "run off". Nitrogen (N) losses from manure and ammonia emissions associated with CAFOS are a worldwide concern. As a result of these problems, four studies (1999 –2002) were conducted at a research facility (AAT, Inc.) located near Guelph, Ontario, Canada.

In each of the studies a control high concentrate ration containing Rumensin-Tylan (RT) was compared to a similar ration containing a potassium, calcium, clinoptilolite zeolite (CZ)*. The CZ was selected because of its ability to bind ammonia and certain toxic substances and its buffering capacity. The CZ used in this study is relatively high in potassium and calcium, low in sodium and has a high cation exchange capacity (CEC). It has very low free crystalline silica and minimal clay levels.

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On a worldwide basis, there has been considerable research on a variety of applications for zeolites, but results are sometimes misleading. This is at least partially because the general term zeolite is often used to describe materials with vastly different characteristics and efficacy. There are a variety of uses for zeolites including air and water filtration, environmental clean up involving heavy metals and radio active contamination, a soil amendment for golf courses, greenhouses, etc., cat litter, paper production, etc. It is also used in feed as a pellet binder, flow agent, to improve ammonia utilization, bind toxins and heavy metals, a buffering agent and for reducing bloat and metabolic problems.

Experimental Design

Four experiments were conducted using predominately Black English and English-Continental cross steers. The experimental facilities were covered with a concrete floor, which aided in the collection of manure.

The experimental ration used in each Trial is shown in Table 1. Treatments 1 & 2 in each of the trials compared a RT control diet to a similar diet containing 1.2% (CZ) (DMB) added in place of an equivalent amount of grain. Additional feed additives including microbials, yucca extract and 2 X CZ level were also tested.

There were eight to eleven reps of 7-8 head each per treatment. The steers were medium age but relatively heavy yearlings. Upon arrival, they received standard animal health treatments, were implanted and after they were adjusted to the finish ration, weighed initially with a 4% pencil shrink. Thereafter, they were weighed individually (4% shrink) and gains, feed consumption and conversions were collected at 28-day intervals and at termination of the trials.

Many of the cattle were fed for the high quality Japanese export market thus final weights are relatively heavy. At finish, the cattle were shipped to packing plants in Pennsylvania or Quebec and individual carcass data was collected. Regardless of plant location, the quality grade was based on USDA grades and liver abscess scores based on the Elanco scoring system. Carcass trimming procedures differ in Canada thus the average dressing percentage is lower than would be expected at U.S. packing plants.

In each trial rumen pH, fecal E-coli and N content of fresh and stored manure was measured. For the pH and E-coli studies, one animal from each rep was sampled.

E-coli O157:H7 Observations

It had been suggested that increasing rumen pH could reduce E-coli occurrence and certain zeolites have rumen buffering activity. In addition, studies have shown zeolites may bind certain toxins, which led to speculation they might reduce E-coli problems. Some scientists have suggested that the use of Rumensin may be related to E-coli problems, although there is little scientific data to support this. In the first trial, the effect of CZ with and without Rumensin on the occurrence of E-coli and rumen pH was studied. Fecal grab samples were obtained from one steer from each rep at approximately mid-point in the study.

The results are shown in Table 2 and E-coli levels were very high in all treatments. E-coli levels were lowest in treatment 2, which contained RT plus CZ and eliminating RT in Treatment 3 had no effect on E-coli levels. The addition of CZ to Treatments 2 and 3 increased rumen pH.

The addition of CZ in the first study appeared to reduce E-coli levels, however, subsequent studies failed to confirm this. In additional studies, E-coli was significantly reduced when a microbial additive was used (Lactobacillus Acidophilus). Based on a four-study summary it was concluded that RT and CZ had no impact on E-coli, but a microbial additive did reduce E-coli levels.

Rumen Buffering Activity

In each of the four studies, rumen pH of steers in Treatment 1 (RT) and Treatment 2 (RT+CZ) was measured. The results are shown in Table 3 and indicate that CZ significantly increased rumen pH.

Manure Composition and N Losses

Manure production from confined feeding operations (CAFOS) present potential environmental problems and manure nutrients of major concern are N phosphorus (P). However, if properly managed, both have significant fertilizer value. Unfortunately, much of the N excreted can be rapidly lost as air emissions, or later as run off which may lead to increased ground water nitrate levels. N added by manure may be less than the plant requires, but P levels in soils may be too high and excess added P “run off” can contaminate surface water. Many plants have the ability to “take up” excess soil N and potassium (K), but not P. The N: P ratio is therefore important and P content often limits the amount of manure, which can be applied to land. Thus, manure N losses prior to application reduce N fertilizer value and result in a less desirable N: P ratio. Because of microbial and urease activity, N losses as ammonia emission can occur rapidly. It is estimated that approximately 50 to 60% of the N excretion occurs in the urine and half of this can be lost as ammonia emissions within 48 hours. Atmospheric ammonia emissions contribute to odors, the formation of PM 2.5 and 10 particles and can be a smog component.

The average N content of the stored manure at day zero and day twenty-eight to thirty is shown in Table 4. The phosphorus content and N: P ratios are also shown. Actual N loss varied by experiment depending on factors such as amount of bedding, sampling procedures, etc. However, the relative difference in N losses and N: P ratios was similar in each comparison. In the control treatment, approximately 30% of the manure N was lost in 28 to 30 days as compared to 10% in the CZ treatment. P and K levels did not change with time, thus the N: P ratio was more favorable in the CZ manure.

The reduction in the manure N losses should mean less ammonia emissions and greater fertilizer value for the CZ manure. The CZ manure could have an additional value because of its potential as a soil amendment. Currently, CZ is used, as a soil amendment in specialty areas as golf courses, greenhouses and in a zeoponic media used by the National Aeronautics and Space Administration (NASA). NASA uses this zeoponic media to grow plants for the production of food, the recycling of waste and the conversion of CO_2 to oxygen in Lunar Space Outposts.

Adding CZ directly to manure from control animals also reduced N losses compared to the control, but was not as effective as adding CZ to the diet (Table 5). Increasing the feed CZ level to 2.4% (DMB) was no more effective than the 1.2% level (Table 6). Adding a yucca extract product, believed to have anti urease activity in combination with the CZ, was very effective in reducing early manure N losses (Table 6).

Plant growth chamber studies were conducted comparing control and CZ manure as the only sources of soil N and commercial fertilizer treatments with and without added CZ. Low, medium and high N fertilizer levels were compared when growing a hard red spring wheat variety (Celtic) in pots under greenhouse conditions. The results indicate reduced plant growth for CZ treatments at low N levels, however, at medium and high levels plant growth was equal to or superior for the CZ treatments (Table 7). This may be due to N binding by CZ which when soil N levels are defiecent, may add to the problem, but when adequate or excess N is available, results in a more desirable N release rate. Since there was no attempt to balance overall soil nutrient levels, comparisons between the manure and commercial fertilizer treatments would not be valid.

Performance and carcass characteristics

Performance data is shown in Table 8 and in each of the four studies, gain was higher for the CZ treatment. Feed consumption was slightly higher and conversions slightly lower for the CZ treatment, but these differences were not always statically significant.

Carcass data was obtained in three of the four trials and the results are also shown in Table 8. Overall carcass quality grade was excellent in both treatments and although dressing percentage appears low, this is because of cattle processed in Canada where there is additional carcass trim. Differences in carcass quality grades were not significant. Total liver abscesses and A + abscesses were quite low in both treatments considering the length of feeding period and the high ration concentrate level. A + abscess levels were lower in the CZ treatment which may relate to buffering activity.

Summary

Adding a potassium, calcium, clinoptilolite zeolite (CZ) to the diet increased rumen pH, but had no consistent impact on E-coli levels. A Lactobacillus Acidophilus microbial additive also tested did reduce manure E-coli.
Performance studies show an improvement in gain and small differences in consumption and conversions on the CZ diet. There were no significant differences in carcass quality grade, but A + liver abscesses were reduced in the CZ treatment.

Adding 1.2% CZ did not affect initial manure N, P or K levels. However, after storage from 15 to 30 days, manure N loss was reduced from an average of 32% in the control diet to 11% in the CZ diet. This represents 2/3 reduction in manure N losses. Manure P and K levels did not change in the stored material. It is speculated the dietary CZ excreted in the manure binds ammonia reducing N losses. Plant growth chamber studies indicated manure from the CZ treatment increased plant growth at medium and high N fertilizer levels.

The consistent reduction in manure N loss should reduce ammonia emissions, possibly reduce odors, especially in high density CAFOs and improve manure fertilizer value which is important for sustainable AG production. This CZ feeding strategy could have similar environmental benefits in other classes of livestock and poultry.

TABLE 1

Ration Composition 1.) 2.)

Ingredients	Amount (D.M.B)
Steam flaked corn & wheat	86.0%
Corn Silage	06.50
Premix	07.50
	100.%

Estimated Analysis	
Protein	13%
NPN	2.9
Fat	3.6
Fiber	4.3
Calcium	0.71
Phosphorus	0.33

3) Rumensin and Tylan added to control & experimental. rations

4) CZ added in place of grain at 1.2% (DMB) level in experimental. Ration

5) Vitamins and Trace Minerals added to premix

TABLE 2

TRIAL 1

E. COLI OCCURRENCE AND RUMEN pH

	TREATMENT 1	TREATMENT 2	TREATMENT 3
	Rumensin + Tylan (RT)	RT + 1.2% CZ	NO RT + 1.2% CZ
E. Coli (dy 102)*	85%	65%	80%
Rumen P.H.	6.02	6.33	6.35

*E Coli 0157:H7 grub samples obtained for one steer/Rep

** One steer/Rep sampled with Geishauser Prope

TABLE 3

Effect of CZ on Rumen pH 1.) 2.)

	RT	RT + CZ
Trial 1	6.02	6.33
Trial 2	6.30	6.62
Trial 3	6.51	6.79
Trial 4	6.51	6.71

a. 6.61*

1) One animal/rep/treatment sampled (8-11 reps/treatment)

6) Rumen samples obtained via Geishauser Probe

* Significantly higher (P<. 08)

TABLE 4

AVG. OF INITIAL & 15 – 30 DAYS

N, P & K MANURE ASSAYS (D.M.B)

	Control Diet	Control + CZ Diet
Initial Manure Assay		
N	3.28%	3.28%
P	0.61	0.61
P_2O_5 (P X 2.29)	1.40	1.40
K	1.43	1.43
K_2O (K X 1.2)	1.72	1.72
Initial N/P ratio	5.4	5.4
15 – 30 Day Manure Assay		
N	2.23%	2.90%
N Loss	32.1%	11.7%
P	0.62	0.62
K	1.45	1.45
N/P Ratio	3.6	4.7

TABLE 5

Trial 1

Nitrogen Losses From Manure and Bedding

	Control Diet	CZ Diet	Control +1% CZ added to Manure
Day 1			
N (%)	2.161	2.301	2.121
Day 3			
N (%)	2.016	2.164	2.006
N Loss (%)	6.7	5.9	5.5
Day 30			
N (%)	1.467	2.121	1.755
N Loss (%)	32.1	7.8	17.3

TABLE 6

Trial 4
EFFECT OF KCZ ON
MANURE N LOSS*

Treatment	Control	CZ1.2%	CZ1.2%+YP**	CZ2.4%
N/Loss/day (%)				
3	21.6	4.6	1.4	3.8
7	22.0	6.7	1.9	9.4
14	25.3	6.4	2.4	10.3
21	28.2	9.1	8.5	12.7
28	34.9	12.8	17.1	18.3

*Manure collected fresh from cement floor and stacked
8 reps/Treatment sampled

**Yucca Plus from Prince Agra Products

TABLE 7

Plant response by average plant weight and

N content for each nitrogen source treatment

Parameter	N rate	Control Manure	CZ Manure	CZ + Comm.Fert.	Comm. Fert.only
Plant weight	low N-45lb/acre	0.51	0.27	0.87	1.43
(dry matter, g)	med N-90lb/acre	0.53	0.45	1.24	0.71
	high N-135lb/acre	0.42	0.56	0.85	0.24
Plant N	low N	2.43	2.57	4.59	4.28
Content	med N	2.49	2.75	4.56	5.38
(N%)	high N	2.97	2.38	4.82	4.60

TABLE 8

PERFORMANCE & CARCASS CHARACTERISTIC

Treatment	RT			RT + CZ		
(LBS)	ADG	AD Consp.	Conv.	ADG	AD Consp.	Conv.
2000	4.11	23.28	5.68	4.23	24.2	5.74
2001	3.98_a	21.1_a	5.32	4.11_b	22.2_b	5.4
2002	4.11	23.3	5.67	4.23	23.6	5.57
2002	3.18_a	23.1	7.27_a	4.03_b	23.1	6.52_b
AVG	3.85	22.7	5.99	4.03	23.3	5.81

Three Trials / Average

Treatment		RT	RT + CZ
St. Wt.	(lb)	959	960
Final Wt.	(lb)	1518	1545
Dressing	(%)	61.0	60.6
Choice Prime	(%)	78.1	84.9
Liver Ab. Total	(%)	14.3	11.7
A+ Liver abs.	(%)	4.3	1.3
Rep/ Treatment		8 – 11	8 – 11
St/ rep		7 - 8	7 - 8
Total reps		37	37
Total steers		286	286

Rumensin (R) & Tylan (T)

Potassium Calcium Clinoptilolite-zeolite (CZ)

substituted for 1.2% of grain (D.M.B)

Canadian carcass trim procedures used in same trials

- a b differing subscript indicate sign. Difference ($P < 0.10$)