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IMMEDIATE AND CARRYOVER EFFECTS OF SHORT-TERM THERAPEUTIC FEEDING OF CHLORTETRACYCLINE ON DIGESTIVE FUNCTION IN FEEDLOT STEERS

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ABSTRACT: Eight crossbred steers (138 kg) with cannulas in the rumen and proximal duodenum were used in a completely random design to evaluate the immediate and carryover effects of oral chlortetracycline (CTC) on characteristics of ruminal and total tract digestion. The basal diet contained (DM basis): 21.0% alfalfa hay, 7.0% sudangrass hay, 52.1% steam-flaked corn, 5.0% cottonseed meal, 2.0% blood meal, 1.5% limestone, .5% urea, .5% trace-mineralized salt, .4% chromic oxide (digesta marker), 10 mg/kg laidlomycin propionate, 2.0% yellow grease, and 8.0% cane molasses. Steers were adapted to the basal diet for 14 d prior to beginning the trial. From d 3 to 7 of the 28-d trial, 4 steers were fed 22 mg/kg BW of CTC. Measures of digestive function were made on d 4 to 7 (wk 1), d 11 to 14 (wk 2), d 18 to 21 (wk 3), and d 25 to 28 (wk 4). Oral medication did not influence ($P > .10$) ruminal digestion of OM and NDF. Total tract digestion of OM was moderately depressed (2.1%, $P < .10$) during wk 2, owing to decreased (11.4%, $P < .10$) total tract NDF digestion. Oral CTC increased slightly (.4%; $P < .05$) total tract starch digestion during the wk 3. Oral CTC did not influence ($P > .10$) ruminal digestion of feed N, but it depressed ruminal microbial efficiency (g MN/kg OM fermented) and increased postruminal N digestion (wk 3 and 4, $P < 0.05$) and total tract N digestion (wk 1 and 4, $P < .10$). Across the 28-d trial, oral CTC increased ($P < .10$) ruminal pH. During the wk 1, oral CTC decreased ruminal protozoal counts (69%, $P < .10$) and ruminal acetate:propionate molar ratio (42%, $P < .01$). Ruminal protozoal counts and VFA molar ratios were similar ($P > .10$) to that of nonmedicated steers by wk 2. We conclude that oral medication with a therapeutic level of CTC will have an immediate but short-lived depressing effect on ruminal protozoal counts and VFA molar ratios. Within 1 wk following removal of CTC from the diet, protozoal counts and VFA molar ratios will have returned to levels similar to those of nonmedicated steers. Oral CTC may have a slight depressing effect on ruminal NDF digestion, an effect that may persist for an additional wk following antibiotic removal from the diet. Oral medication for 5 d with a therapeutic level of CTC will increase ruminal pH, and this effect may persist for more than 3 wk.

Key Words: Chlortetracycline, Rumen, Digestion

Introduction

In February, 1996, chlortetracyline (**CTC**) was approved for oral feeding to calves, beef, and nonlactating dairy cattle as a therapeutic treatment (22 mg/kg BW for a maximum of 5 d) for bacterial enteritis caused by *Escherichia coli*, and bacterial pneumonia caused by *Pasteurella multocida* organisms susceptible to chlortetracycline. In-vitro studies (Simpson, 1976; Baldwin et al., 1982; Rumsey et al., 1982) have demonstrated potential depressing effects of CTC on cellulose digestion. Subtherapeutic (100 to 500 mg steer^{-1} d^{-1}) oral administration of CTC has depressed fiber and protein digestion in some cases (Bell et al., 1950; Lassiter et al.,1954; Horn et al.,1955). In others (Zinn, 1986), CTC supplementation at levels of 400 to 800 mg steer^{-1} d^{-1} did not affect fiber digestion in either receiving or finishing diets, although protein digestion decreased linearly. Oral administration of a therapeutic level (22 mg/kg BW) of CTC to steers fed a 71% concentrate receiving diet decreased ruminal ADF digestion and total tract digestion of OM, starch, and N. In all of the above studies, the effects of CTC on digestion were determined following continuous feeding for a minimum of 10 d. The influence of short-term feeding (5-d) of a therapeutic level of CTC on digestion, as well as the persistence of those effects following CTC withdrawal from the diet has not been determined. The objective of this study was to evaluate immediate and carryover effects of a 5-d supplementation of 22mg/kg BW CTC on the digestive function in steers fed 71% concentrate receiving diet.

Experimental Procedures

Eight Holstein steers (138 kg) with cannulas in the rumen and proximal duodenum (Zinn and Plascencia, 1993) were used to evaluate immediate and carryover effects of a 5-d supplementation of 22mg/kg BW CTC on the digestive function. Composition of the basal diet is shown in Table 1. Chromic oxide was added as a digesta marker. Steers were adapted to the basal diet for 14 d prior to beginning the trial. From d 3 to 7 of the 28-d trial four steers were fed 22 mg/kg BW CTC. Measures of digestive function were obtained on d 4-7 (week 1), d 11-14 (week 2), d 18-21 (week 3), and d 25-28 (week 4). Steers were maintained in individual slotted-floor pens (3.9 m^2) with free access to water. Feed intake was restricted to 2.94 kg/d (2.1% of BW). Diets were fed to all steers in equal proportions at 0800 and 2000 daily. During collection, duodenal and fecal samples were taken twice daily as follows: d 1, 0750 and 1350; d 2, 0900 and 1500; d 3, 1050 and 1650, and d 4, 1200 and 1800. During the final day of each collection period, ruminal samples were obtained from each steer at 4 h after feeding, via the ruminal cannula. Ruminal fluid pH was determined on fresh samples. Ruminal fluid samples were strained through 4 layers of cheesecloth.

Freshly prepared 25% (wt/vol) *m*-phosphoric acid (2 mL) was added to 8 mL of strained ruminal fluid. Samples were then centrifuged (17,000 x g for 10 min) and supernatant fluid stored at -20° C for analysis of VFA concentrations (gas chromatography). A separate sample of strained ruminal fluid (100 mL) was used for measuring total protozoa (1 mL of strained ruminal fluid was mixed with 8 mL of .16 N saline solution plus 1 mL of a 10% formol solution, and protozal counts determined using a Neubauer counter). Upon completion of the trial, approximately 500 ml of ruminal fluid were obtained from each steer, and composited; bacteria were isolated via differential centrifugation (Bergen et al., 1968). The microbial isolates were prepared for analysis by oven drying at 70°C and ground with mortar and pestle. Feed, duodenal and fecal samples were prepared for analysis by oven drying at 70°C and ground in a lab mill (Micro-Mill, Bel-Arts Products, Pequannock, NJ). Samples were oven dried at 105°C until no further weight was lost and stored in tightly sealed glass jars. Samples were subjected to all or part of the following analyses: ash, ammonia N, Kjeldahl N (AOAC, 1984); chromic oxide (Hill and Anderson, 1958); NDF (Goering and Van Soest, 1970, corrected for neutral detergenent insoluble ash); purine (Zinn and Owens, 1986); and starch (Zinn, 1990). Microbial organic matter (MOM) and N (MN) leaving the abomasum were calculated using purine as a microbial marker (Zinn and Owens, 1986). Organic matter fermented in the rumen was considered equal to OM intake minus the difference between the amount of total OM reaching the duodenum and MOM reaching the duodenum. Feed N escape to the small intestine was considered equal to total N leaving the abomasum minus ammonia-N and MN and, thus, includes any endogenous additions. This trial was analyzed as a completely random design (Hicks, 1973).

Results and Discussion

Oral medication did not influence ($P > .10$) ruminal digestion of OM and NDF (Tables 2 and 3). In some of the earlier studies, continuous feeding of from 100 to 3,600 mg/d CTC has depressed fiber digestion (Bell et al., 1950; Lassiter et al.,1954; Horn et al.,1955). In others (Zinn, 1986), CTC supplementation at levels of 400 to 800 mg/d did not affect fiber digestion. Total tract digestion of OM was moderately depressed (2.1%, $P < .10$) during the wk 2, due to decreased (11.4%, $P < .10$) total tract NDF digestion.

Oral medication did not influence ($P > .10$) overall ruminal or total tract starch digestion (Table 4), although CTC increased slightly (.4%; $P < .05$) total tract starch digestion during wk 3. In previous studies the effect of CTC on starch digestion has ranged from nil (Zinn, 1986) to slightly depressed (2%; Zinn, 1992).

Oral medication did not influence ($P > .10$) ruminal digestion of feed N (Table 6), but depressed ruminal microbial efficiency (g MN/kg OM fermented) and increased post ruminal N digestion (wk 3 and 4, $P < .05$), and total tract N digestion (wk 1 and 4, $P < .10$). Similar responses have been observed with low-level feeding of ionophore antibiotics (Poos et al., 1979; Bergen and Bates, 1984; Zinn et al., 1996; Ramirz et al., 1998).

Because postruminal digestibility of microbial N is usually lower then that of feed N (Zinn and Owens, 1980), postruminal N digestion is inversly related to microbial efficiency. Thus, in previous studies where oral CTC did not influence ruminal microbial efficiency postruminal N digestion was likewise unaffected (Zinn, 1986). Where oral CTC increased microbial efficiency, postruminal N digestion was depressed (Zinn, 1992).

Across the 28-d trial, oral CTC increased ($P < .10$) ruminal pH (Table 7). During the wk 1 (when CTC was being administered), CTC medication reduced (69%, $P < .10$) ruminal protozal counts, with counts returning to levels similar to that of nonmedicated steers by wk 3 (Table 5). This effect of oral CTC on ruminal protozoal counts is apparently related to dosage level. Very low (20 to 90 mg/d) levels of CTC supplementation have increased ruminal protozoal counts (Klopfenstein et al., 1964; Purser et al., 1965).

As with protozoa, CTC medication caused an immediate decrease ($P < .01$; Table 7) in ruminal molar proportions of acetate (17.4%) and butyrate (36.4%) and increased (40.6%, $P < .01$) ruminal molar proportions of propionate. A narrowing of ruminal acetate:propionate molar ratios has been a consistent response to oral antibiotics (Beede and Farlin, 1977a, 1977b; Essig et al., 1972; Michell et al., 1969; Zinn et al., 1991; Zinn, 1992). Eadie and Mann(1970) observed that with high grain diets defaunation enhances ruminal molar proportions of propionate, lowering the acetate:propionate molar ratio. The carryover effect of CTC supplementation was brief. Ruminal VFA molar proportions were similar ($P > .10$) to nonmedicated steers by the wk 2.

Implications

Oral medication with a therapeutic level of chlorotetracycline will have an immediate, but short-lived, depressing effect on ruminal protozoal counts and acetate:propionate molar ratios. Within one week following removal of chlortetracycline from the diet, protozoal counts and volatile fatty acid molar proportions will have returned to levels similar to nonmedicated steers. Oral medication may have a slight depressing effect on ruminal fiber digestion, which may persist for an additional week following antibiotic removal from the diet. Oral medication for five days with a therapeutic level of chlortetracycline will increase ruminal pH, and this effect may persist for more then 3 weeks.

Literature Cited

AOAC. 1975. Official methods of analysis(12th ed). Association of Official Analysis Chemist. Washington D.C.

Baldwin, K. A., J. Bitman, and M.J. Thompson. 1982. Comparison of N,N-dimetheldodecanamine with antibiotics on in vitro cellulose digestion and volatile fatty acid production by ruminal microorganisms. J. Anim. Sci. 55:673-679.

Beede, D. K. and Stanley D. Farlin. 1977. Effects of antibiotics

on apparent lactate and volatile fatty acid production in vitro rumen fermentation studies. J. Anim. Sci. 45:385-392.

Bell, M.C., C.K. Whitehair and W.D. Gallup. 1950. The effect of Aureomycin on digestion in steers. J. Anim. Sci. 9:64 (Abstr.).

Bergen, W. G., and D. B. Bates. 1984. Ionophores: Their effect on production efficiency and mode of action. J. Anim. Sci. 58:1465-1483.

Essig, H. W., C. E. Rogillio, F. Hagan, and W. J. Drapala. 1972. Organic acid, hydrogen ion concentration and buffering capacity of rumen content from bloated and nonbloated steers given different medicants. J. Anim. Sci. 34:653-659.

Goering, H. K., and P. J. Van Soest. 1970. Forage fiber analyses (apparatus, reagents, procedures and some applications). Agric. Handbook 379. ARS, USDA, Washington, DC.

Hicks, C. R. 1973. Fundamental concepts in the design of experiments. Holt, Rinehart and Winston, New York, NY.

Horn, L. H., R. R. Sharp, and L. S. Gall. 1955. The effects of antibiotics upon the digestion of feed nutrients by yearling steers, with bacteriological data. J. Anim. Sci. 14:243-248.

Klopfenstein, T.J., D.B. Purser and W.J. Tyznik. 1964. Influence of aureomycin on rumen metabolism. J. Anim. Sci. 23:490-495.

Lassiter, C. A., T. W. Denton, and C.L. Davis and J.A. Taylor. 1954. The effects of various surfactants and aureomycin on the digestibility of feed nutrients by daily steers. J. Anim. Sci. 13:991(Abstr.).

Poos, M. I., T. L. Hanson, and T. J. Klopfenstein. 1979. Monensin effects on diet digestibility, ruminal protein bypass and microbial protein synthesis. J. Anim. Sci. 48:1516-1524.

Purser, D.B., T.J. Klopfenstein and J.H. Cline. 1965. Influence of tylosin and aureomycin on rumen metabolism and the microbial population. J. Anim. Sci. 24:1039-1050.

Ramirez, J. E., E. G. Alvarez, M. Montano, Y. Shen, and R. A. Zinn. 1998. Influence of dietary magnesium level on growth-performance and metabolic responses of Holstein steers to laidlomycin propionate. J. Anim. Sci. 76:1753-1759.

Rumsey, T.S., J. Bitman, T.R. Wrenn, K.A. Baldwin, H.Tao and M.J. Thompson. 1982. Performance, ruminal fermentation and blood constitutes of lambs fed N, N-dimethydodecanamine and chlortetracycline. J. Anm. Sci. 54:1040-1050.

Simpson, M. E., P. B. Marsh, and D. A. Dinius. 1976. Monensin and other antibiotics on in vitro digestion of cellulosic substrates. J. Anim. Sci. 42:1580 (Abstr.).

Zinn, R. A. 1986. Short-term effect of antibiotic feeding on site and extent of digestion of growing and finishing diets in feedlot cattle. J. Anim. Sci. 63:2013-2017.

Zinn, R. A. 1990. Influence of flake density on the comparative feeding value of steam-flaked corn for feedlot cattle. J. Anim. Sci. 68:767-775.

Zinn, R.A. 1992. Influence of oral antibiotic on digestive function in Holstein steer fed a 71% concentrate diet. J. Anim. Sci. 70:213-217.

Zinn, R. A., and F. N. Owens. 1980. Predicting net uptake of nonammonia N from the small intestine. In: Protein Requirements for Cattle. Oklahoma State University MP-109. pp 133-140.

Zinn, R. A. and F. N. Owens. 1986. A rapid procedure for purine measurement and its use for estimating net ruminal synthesis. Can. J. Anim. Sci. 66:157-166.

Zinn, R. A., and A. Plascencia. 1993. Interaction of whole cottonseed and supplemental fat on digestive function in cattle. J. Anim. Sci. 71:11-17.

Zinn, R.A., M.K. Song and T.O. Lindsey. 1991. Influence of Ardacin supplementation on feedlot performance and digestive function of cattle. J Anim. Sci. 69:1389-1396.

Zinn, R. A., Y. Shen, C. F. Adams, M. Tamayo, J. Rosales. 1996. Influence of dietary magnesium level on metabolic and growth-performance responses of feedlot cattle to laidlomycin propionate. J. Anim. Sci. 74:1462-1469.

Table 1. Composition of diet fed to steers.

Item	Basal diet
Ingredient composition, % (DM basis)	
Alfalfa hay	21.00
Sudangrass hay	7.00
Steam-flaked corn	52.50
Cottonseed meal	5.00
Blood meal	2.00
Limestone	1.50
Urea	.50
Magnesium oxide	.20
Trace mineralized salt[a]	.50
Laidlomycin propionate, mg/kg	10
Yellow grease	2.00
Cane molasses	8.00

[a]Trace mineral salt contained: $CoSO_4$, .068%; $CuSO_4$, 1.04%; $FeSO_4$, 3.57%; ZnO, 1.24%; $MnSO_4$, 1.07%; KI, .052%; and NaCl, 92.96%.

Table 2. Effects of CTC on OM digestion.

Item	Control	CTC	SEM
Intake, g/d			
DM	2,938	2,938	
OM	2,715	2,715	
Ruminal OM digestion, % intake			
Week 1	66.3	65.7	1.6
Week 2	68.6	66.5	1.3
Week 3	63.9	66.5	2.1
Week 4	64.4	64.0	2.2
Average	66.1	65.8	1.5
Total tract OM digestion, % intake			
Week 1	80.9	80.0	.6
Week 2[a]	82.4	80.7	.6
Week 3	80.6	82.4	1.5
Week 4	80.7	82.2	1.1
Average	81.3	81.4	.7

[a]Treatments differ, $P < .10$.

Table 3. Effects of CTC on NDF digestion.

Item	Control	CTC	SEM
NDF intake, g/d	498	4984	
Ruminal NDF digestion, % intake			
Week 1	43.1	35.4	4.2
Week 2	49.0	40.0	4.3
Week 3	34.9	43.2	8.0
Week 4	46.7	47.8	6.2
Average	46.3	44.0	4.1
Total tract NDF digestion, % intake			
Week 1	53.1	47.0	3.4
Week 2[a]	54.2	48.0	1.8
Week 3	45.6	49.9	6.0
Week 4	55.6	57.9	4.0
Average	54.7	53.0	2.4

[a]Treatments differ, $P < .10$.

Table 4. Treatment effects on characteristics of starch digestion.

Item	Control	CTC	SEM
Starch intake, g/d	1,129	1,129	
Ruminal Starch digestion, % intake			
Week 1	89.6	91.0	2.2
Week 2	89.0	90.2	2.4
Week 3	86.2	88.6	2.0
Week 4	83.6	85.7	1.9
Average	87.2	88.9	2.0
Postruminal starch digestion, % leaving abomasum			
Week 1	94.0	93.2	.6
Week 2	96.4	94.5	1.3
Week 3[a]	93.8	96.5	.7
Week 4	95.4	96.8	.8
Average	95.0	95.6	.5
Total tract starch digestion, % intake			
Week 1	99.4	99.4	.1
Week 2	99.6	99.5	.2
Week 3[b]	99.2	99.6	.1
Week 4	99.3	99.5	.1
Average	99.4	99.5	.1

[a]Treatments differ, $P < .10$.
[b]Treatments differ, $P < .05$.

Table 5. Effects of CTC on ruminal protozoal counts.

Item	Control	CTC	SEM
Ruminal protozoa, counts x 10^5/mL			
Week 1[a]	3.64	1.14	.79
Week 2	4.25	1.72	1.00
Week 3	1.30	1.00	.58
Week 4	1.30	1.69	.34
Average	2.62	1.39	.53

[a]Treatments differ, $P < .10$.

Table 6. Effects of CTC on N digestion.

Item	Control	CTC	SEM
N Intake, g/d	78.8	78.8	
N efficiency, NAN leaving abomasum/N intake			
Week 1	1.05	1.05	.03
Week 2	.95	.96	.02
Week 3	1.03	.96	.04
Week 4	.97	.94	.02
Average	.99	.97	.02
Microbial N, g/kg OM fermented			
Week 1	24.8	26.3	1.4
Week 2	22.0	22.0	1.1
Week 3[a]	25.8	22.1	1.4
Week 4[a]	26.7	24.0	.9
Average	24.6	23.5	.9
Ruminal digestion of feed N, %			
Week 1	52.9	55.6	1.2
Week 2	59.4	56.2	1.5
Week 3	55.5	56.5	2.9
Week 4	57.0	55.0	1.3
Average	56.5	56.0	1.0
Postruminal digestion, % leaving abomasum			
Week 1[a]	75.9	78.3	.6
Week 2	75.2	74.5	.7
Week 3	75.0	75.9	.9
Week 4[b]	73.7	75.7	.7
Average[b]	75.0	76.1	.4
Total tract N digestion, % intake			
Week 1[a]	74.1	76.4	.6
Week 2	75.8	74.6	.9
Week 3	73.4	76.1	1.5
Week 4[b]	73.6	76.4	1.0
Average	74.4	76.0	.7

[a]Treatments differ, $P < .05$.

[b]Treatments differ, $P < .10$.

Table 7. Effects of CTC on ruminal pH, and VFA molar proportions.

Item	Control	CTC	SEM
Steer replicates	4	4	
Ruminal pH			
Week 1	6.19	6.46	.15
Week 2	6.44	6.40	.06
Week 3	6.33	6.61	.17
Week 4	6.21	6.44	.11
Average[a]	6.29	6.48	.06
Ruminal VFA, mols/100 mols			
Week 1			
Acetate[b]	56.4	46.6	1.2
Propionate[b]	32.9	46.6	1.4
Butyrate[b]	10.7	6.8	.4
Week 2			
Acetate	51.6	52.4	2.1
Propionate	37.3	35.6	2.4
Butyrate	11.0	12.0	.5
Week 3			
Acetate	54.0	55.4	2.1
Propionate	35.5	32.4	2.9
Butyrate	10.5	12.2	1.2
Week 4			
Acetate	57.7	57.9	1.4
Propionate	29.9	28.9	1.9
Butyrate	12.4	13.1	.7
Average			
Acetate	55.0	53.2	1.4
Propionate	33.8	35.6	1.8
butyrate	11.2	11.2	.5

[a]Treatments differ, $P < .10$.

[a]Treatments differ, $P < .01$