NUTRITION AND MANAGEMENT STRATEGIES FOR CONFINEMENT FED CATTLE: STEP-UP PROGRAMS, ALTERNATIVE FEED INGREDIENTS, AND HEALTH PROGRAMS

by

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Abstract

Three experiments were conducted to examine nutritional and management strategies for different segments of the beef industry.

The first experiment examined the effects of feeding traditional step-up diets (STEP) vs. limit-feeding (LIMIT) the finishing diet to adapt cattle to high-concentrate diets. When all cattle reached *ad libitum* intake of the finishing diet there was a trend ($P = 0.09$) for DMI to be different between treatments. During week 1, STEP cattle had higher total VFA concentrations ($P = 0.02$), while LIMIT cattle had higher valerate absorption ($P = 0.02$) and disappearance ($P = 0.08$). During week 4, LIMIT cattle had higher total VFA concentrations ($P = 0.03$) and lower valerate disappearance and absorption ($P = 0.05$) than STEP cattle. These results indicate that limit-feeding the finishing diet may inhibit nutrient absorption from the rumen or this method may cause increased production of valerate by lactate utilizing bacteria due to a more acidotic rumen environment.

The second experiment examined the effects of feeding 5% (DM basis) dried, full-fat corn germ (GERM) on feedlot performance and carcass characteristics of naturally raised yearling steers and heifers. Carcass-adjusted ADG was higher for GERM cattle ($P = 0.04$). There were no other differences in performance or carcass characteristics. Total incidence of liver abscesses and the incidence of severe liver abscesses were decreased by 12 and 8.2% ($P = 0.01$ and 0.02, respectively) when GERM was added to the diet. Corn germ can be added to finishing diets at 5% without affecting performance and carcass characteristics. Producers raising natural cattle may also be able to benefit from the reduced incidence of liver abscesses.

The third experiment examined concurrent metaphylactic treatment of high-risk calves with tulathromycin and chlortetracycline. Calves were placed on 1 of 3 treatments: 1) no top-dress pellets; 2) diet top-dressed with pellets containing chlortetracycline; or 3) diet top-dressed with pellets containing no chlortetracycline. There were no differences in the performance or health of these calves ($P > 0.25$). There

are no additive benefits of concurrent metaphylaxis using both chlortetracycline and tulathromycin. This information could assist producers when designing receiving health protocols for high-risk calves.

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CHAPTER 1 - A Review of Literature

Introduction: Limit-feeding

Feeding newly arrived cattle is commonly characterized by a series of step-up diets, wherein concentrate levels are increased to promote ruminal adaptation to a high-concentrate finishing diet. This adaptation period allows the ruminal microbial population to adjust to the large amounts of starch and readily fermentable carbohydrates provided in finishing diets. Increasing diet concentrate levels too rapidly can result in acidosis and other ruminal disorders, which result from the rapid production and accumulation of lactic acid. These disorders have the ability to impose long-term consequences that can hinder performance (Owens et al., 1998). Therefore, using more cost efficient methods of adapting cattle to high concentrate diets without impairing rumen function can increase profitability.

High-concentrate diets primarily comprised of cereal grains are preferred in today's cattle feeding industry due to lower cost per megacalorie of NE_m or NE_g (Brown et al., 2006). However, cattle arriving at the feedlot have typically consumed a more forage-based diet, hence the need for dietary adaptation. Limit-feeding the finishing diet as a means of ruminal adaptation to higher concentrate diets may offer a more economical approach to adapting cattle to finishing diets. Several studies have demonstrated that restricting dry matter intake can improve feed efficiency (Hicks et al., 1990; Loerch and Fluharty, 1998; Choat et al., 2002). Not only does adapting cattle in this manner decrease cost per unit of dietary energy, but it can also reduce costs associated with the storage and handling of forages (Lake, 1986). Another benefit that limit-feeding may provide is a decrease in manure excretion and subsequently, the costs associated with its removal from pens (Murphy et al., 1994).

Limit-feeding and Effects on Cattle Performance

The beneficial effects of limit-feeding on feed efficiency have been seen in several studies. Glimp et al. (1989) evaluated the effects of limit-feeding on feed efficiency of Rambouillet ewe and wether lambs by offering them a 90% concentrate diet *ad libitum* or restricting them to 85 or 92.5% of *ad libitum* intake of the same diet. Feed efficiency tended to be improved and was improved substantially by the two restriction treatments respectively. Carcass weight, dressing percent (DP), and yield grade were unaffected by intake level. Lambs that were offered the diet *ad libitum* had improved quality grades when compared to those restricted to 85% of *ad libitum*, but there were no other differences in quality grade. Similarly,

Hicks et al. (1990) assessed the effects of restricting intake to some degree of *ad libitum* using crossbred steers and heifers in 3 different studies. In the first study, steers were offered the finishing diet in amounts to allow for *ad libitum* intake or were limited to 85% of *ad libitum* consumption. Feed efficiency of the limit-fed steers was improved 14% during the second half of this study and was improved 8.4% over the entire 140 day feeding period. Limit-fed steers also had lower final weights. Carcass weight, DP, and fat thickness were unaffected by treatment; however, those steers fed the *ad libitum* treatment had higher marbling scores and a higher percent grading Choice. During the second study, heifers were given *ad libitum* access to feed or restricted to 89% of *ad libitum* intake. While limiting intake did not affect feed efficiency during the first 56 days of the experiment, efficiency was improved by 19.8 and 10.9% respectively for the second half of the study and the entire 140 day feeding period without affecting final weights. No differences were seen in this portion of the study with regards to carcass traits. In the third study, steers were allowed *ad libitum* consumption or fed at 80% of controls for 56 days followed by *ad libitum* access to feed. During the second half of this study, efficiency was improved by 7.2%. Feed efficiency was improved 3.3% based on carcass weight for the 138 day trial. There was a tendency for carcass weight and DP to be reduced for limit-fed steers. Fat thickness was reduced in steers that were full-fed; however, marbling scores were increased. Percent Choice was increased and yield grades were reduced for the *ad libitum* treatment. Reinhardt et al. (1998) examined the effects of limit-fed and full-fed whole and steam-flaked corn based diets versus silage based diets for growing Holstein steers. They found that the limit-fed corn based diets improved the gain-to-feed ratio (G:F) when compared to the silage based diet fed to achieve *ad libitum* intake. The also saw improved efficiencies when limit-feeding a steam-flaked corn based diet when compared to limit-feeding a whole corn diet. However, no differences were noted between cattle receiving the limit-fed corn based diet when compared to those receiving the *ad libitum* corn based diets. A period of compensatory gain occurred in these cattle once they were switched to full-fed rations. Those that were fed silage or limit-fed ate less feed, gained faster, and had improved feed efficiency compared to those receiving *ad libitum* intake for the duration of the study. When overall performance was evaluated, those fed a steam-flaked corn diet *ad libitum* gained the fastest and those limit-fed whole corn and then switched to the whole corn diet *ad libitum* gained the slowest. All other treatments were similar. Overall efficiency was better for steers limit-fed the high grain diets

even though they gained more slowly. External fat tended to be reduced and marbling was increased by limit-feeding, but steers that were full-fed attained slaughter weight 17 days sooner on average. Other carcass characteristics were unaffected by treatment.

Programmed feeding

Although feed efficiency has been improved by limit-feeding, it is commonly associated with a decrease in live weight gain and longer days on feed (Loerch and Fluharty, 1998). Programmed feeding is an alternate form of limit-feeding that has been investigated as a means to overcome some of these disadvantages. Knoblich et al. (1997) examined how step-wise increases in rate of gain and differing lengths of intake restrictions may affect feed efficiency and the subsequent effects it may have on final weight and days on feed. In the first of two studies, calves that were programmed to gain 1.13 kg/d for an intermediate period of time followed by a programmed gain of 1.36 kg/d for a longer period of time had improved feed efficiencies when compared to those given *ad libitum* access to feed for the duration of the experiment. Cattle in all four programmed feeding systems were fed for a similar number of days and finished at a similar final weight to those in the *ad libitum* treatment. Hot carcass weights, DP, quality grade, and percent choice were unaffected by treatment. Cattle in system 2 (*ad libitum* access to feed for the final 31.7 kg of weight gain) had reduced 12th rib back fat, kidney, pelvic, and heart fat, and yield grade when compared to those offered the diet *ad libitum* for the duration and those given *ad libitum* access to feed for the final 122.4 kg of gain. In the second study, cattle were offered *ad libitum* access to feed or were placed in one of four programmed feeding systems in which the severity and duration of restriction and the duration and intervals of *ad libitum* intake were varied. This study resulted in no differences in feed efficiency during any portion of the trial and no differences in final weight or days on feed between the four restriction treatments and those given *ad libitum* access to feed for the entire feeding period. There were also no differences in any carcass traits that were measured. In a similar study by Loerch and Fluharty (1998), cattle were programmed to achieve 0.91, 1.13, or 1.36 kg/d or offered *ad libitum* access to feed. Overall there were no differences in final weight or days on feed. Feed efficiency was improved for all programmed feeding strategies during period two; however, in periods one and three and in the overall trial G:F was unaffected by treatment. Final weight was unaffected by treatment. Days on feed were not statistically different, but those in the *ad libitum* treatment and those fed to achieve 1.36 kg/d of gain had numerically lower days on feed than the two more

severely restricted intake treatments. Carcass characteristics were unaffected by treatment as well. In a second study, steers were fed one of the following treatments: increasing, decreasing, or constant rates of gains or given *ad libitum* access to feed. There were no differences in final BW or days on feed among the treatments. Feed efficiency was unaffected by treatment in any of the three periods; however, overall G:F tended to be increased for steers fed to achieve increasing rates of gain. These steers also tended to consume less feed. Back fat tended to be lower for steers fed to achieve decreasing rates of gain. No other carcass traits were affected by treatment. Rossi et al. (2001) also examined the effects of programmed feeding on feedlot performance. They allowed two groups of steers ad libitum access to feed for 168 or 203 days. The third and fourth groups of steers were restricted for 168 or 203 days. In periods one and two they were restricted to rates of gain of 1.13 and 1.36 kg/d respectively. Then in period three both groups were given *ad libitum* access to feed until they reached the aforementioned 168 (third group) or 203 (fourth group) days on feed. Final BW of the restricted intake steers was decreased. Feed efficiency was improved for those given *ad libitum* access to feed in period one; however, during period two and overall those fed at restricted intakes had higher G:F. The steers that were program fed also ate less feed throughout the study. Dressing percentage, HCW, and backfat thicknesses were greater for steers receiving *ad libitum* access to feed. Percent choice was also decreased for steers with programmed intakes. In a second study, the authors fed steers to achieve *ad libitum* intake or one of two programmed feeding diets. Steers programmed to achieve lower rates of gain were fed to gain 1.13 kg/d for the first 85 kg and then to gain 1.36 kg/d for the next 122 kg of gain. Those fed to higher rates of gain were programmed to gain 1.25 kg/d and 1.47 kg/d for the same total amounts of gain described above. All of the steers that were restricted for the first two periods received *ad libitum* access to feed for the final 58 kg of gain. Steers in the *ad libitum* treatments and those programmed for the lowest rate of gain tended to have improved feed efficiency for the first period. During period two, both groups receiving restricted amounts of feed had improved feed efficiency and in the third period those programmed for a lower rate of gain were more efficient. Overall, there were no differences in feed efficiency, final BW, or days on feed among treatments. There were no treatment differences in any of the carcass characteristics measured.

Limiting protein and energy

Altering energy and protein concentrations to some level relative to animal requirements has also been shown to beneficially alter certain aspects of performance (Choat et al., 2002). Diets were offered to allow *ad libitum* access to feed or at some multiple of maintenance energy requirements for steers by Xiong et al. (1991). In addition, the authors were examining different flake densities of sorghum grain and two different roughage levels. During weeks 1-3 steers were fed at 2.3, 2.5, and 2.7 times maintenance respectively, and from week four to the conclusion of the study they were fed at 2.9 times maintenance. Average daily gain was unaffected by the feeding regimen used. Steers that were fed a roughage level of 18% with *ad libitum* access to feed tended to gain faster than those fed a multiple of maintenance at the same roughage level. At 9% roughage there were no differences between the two treatments. Intake was unaffected by treatment at 9% roughage; however, those given *ad libitum* access to feed and 18% roughage tended to have higher DMI than those fed a multiple of maintenance and 18% roughage. Steers consuming 18% roughage diets tended to gain faster than steers receiving 9% roughage rations over the 112 d study. This was attributed to higher DMI and subsequently higher energy consumptions. No advantages were seen for restricting intake at higher roughage levels; however, some benefits of intake restriction were seen when steers were fed a low roughage diet. The authors suggested that feeding steers a diet at a multiple of maintenance when lower roughage levels are used could lead to beneficial effects, potentially due to reduced ruminal upset (Xiong et al., 1991). The effects of severity and duration of both metabolizable protein and net energy for gain restrictions were examined by Drouillard et al. (1991). Three restriction treatments were used in combination with either the protein or energy restrictions outlined above for a total six restriction treatments. Restrictions were imposed by using one of the following: severe restriction, long duration; severe restriction, short duration; or mild restriction, short duration. Two other groups of steers were used as controls and treatments were as follows: started with *ad libitum* access to a finishing diet or fed a growing diet for 154 days prior to finishing (Drouillard et al., 1991). They found that all steers except for those in the short duration mild energy restriction experienced faster growth during finishing than the finishing controls. Energy restricted steers consumed more DM than controls, while protein restricted steers only tended to consume more. Restricted steers tended to have lower yield grades than the

finishing controls. Steers that were restricted in protein had heavier carcass weights than controls. No differences were seen in quality grade.

Compensatory Gain

Compensatory gain is commonly defined as a period following feed or nutrient restrictions in which cattle experience more rapid and efficient growth (Sainz et al., 1995). This phenomenon has been studied several times since Osborne et al. (1915) observed growth at an accelerated rate following a long period of restriction. Abdalla et al. (1988) used Holstein steers fed diets that were protein deficient in 2 studies to evaluate compensatory growth. In their first study, calves were fed a high protein (H), energy restricted (ER), or low protein (L) during period one. This was followed by a second period where half of the calves in each of the above treatments were fed either the H or L diets and a third period in which all calves received a high-energy diet. In their second study, dietary treatments were the same minus the exclusion of the energy restricted diet in period one. The authors reported increased gains and improved feed efficiency in animals that were realimented despite timing of restriction and realimentation and regardless of whether they were limited in protein or energy. Diet effects on compensatory gain have also been studied by Lofgreen and Kiesling (1985). They fed stocker calves one of three receiving diets; 1) native grass hay; 2) native grass hay and .91 kg daily of a 40% protein supplement; or 3) 75% concentrate feed for the entire receiving period and native grass hay for the first week only. These animals then received either an 85% concentrate diet for the remainder of the study or a 50% concentrate diet until they weighed 272 kg, then the 85% concentrate diet for the rest of the 196 d growing-finishing study.   During the receiving period calves on the concentrate diet consumed more feed and had increased weight gains and feed efficiencies when compared to those receiving hay only or hay and a protein supplement. The same was true for those receiving hay and protein supplement when compared to those fed hay only. During the finishing period the animals that gained the slowest in the receiving period had the highest rates of gain. Feed intake was increased for calves from all receiving treatments when fed 50% concentrate followed by 85% concentrates; however, only those received on hay alone experienced increased weight gain as a result. Calves fed only the 85% concentrate diet had improved feed efficiency regardless of receiving treatment. Calves that were received on hay only and then fed only the 85% concentrate only regained 15.6 kg of the 30.2 kg deficit in

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gain from the receiving period; however, the group receiving the 50% concentrate diet followed by the 85% concentrate diet was able to fully compensate. This was also true for cattle received on hay and protein supplement. The rate of compensatory gain for cattle received on hay only when compared to those received on hay and a protein supplement was not different. Calves received on the concentrate ration had heavier carcass weights and increased dressing percentages when compared to the other two receiving treatments. No other differences were observed in carcass characteristics. The compensatory gains seen in the two groups received on hay and hay plus protein supplement was attributed to the increased feed consumption by these steers during the finishing period. Sainz et al. (1995) also studied compensatory growth in steers that had been growth-restricted. Calves were fed one of three diets during the growing phase. They received either a low concentrate diet continuously (FA) or a high concentrate diet continuously (CA) or fed to gain at a similar rate to the animals receiving the FA diet (CL). During finishing steers received ad libitum access to a high-grain diet (CA) or the same diet restricted to 70% of those fed CA (CL). One group of calves was slaughtered initially, three groups of calves were slaughtered after the growing phase and the five remaining groups were slaughtered after the finishing phase. Intake during the growing phase was similar between CA and FA, which resulted in reduced gains of those fed FA due to lower metabolizable energy (ME) intakes. Daily gain was not different between those fed FA and CL, which was by design. Efficiency of gain was best for those fed CA, followed by CL and FA respectively, but these were confounded by different rates of intakes and energy densities of the diet. Compensatory gains were evident during the finishing phase as those fed CL-CA and FA-CA had increased empty BW gains when compared to CA-CA. Feed efficiency was also improved in the finishing phase for CL-CA, CL-CL, and FA-CA when compared to those receiving CA-CA. Increased DMI accounted for most of the compensatory gain seen in both steers fed low concentrate and limit-fed high concentrate. Animals that were growth restricted and re-fed experienced different fat distributions in the form of lower subcutaneous fat and increased internal fat. Carstens et al. (1991) also examined the effects of compensatory growth on performance and carcass characteristics. They fed steers either a control diet (CON) or the control diet at levels that would restrict growth to 0.45 kg/d (CG). Within treatment these steers were assigned to one of four serial slaughter groups. Steers receiving the CG treatment gained 0.4 kg/d while consuming 3.96 kg of DM/d and CON steers gained 1.51 kg/d on 8.64 kg of DM/d of feed during the period

of growth restriction. Upon realimentation CG steers gained 2.17 kg/d while CON steers gained only 1.26 kg/d. Steers in the CG treatment that were fed to 500 kg experienced 37% greater daily gain than controls, even though DMI was similar between the two groups. Hot carcass weights did not differ when compared as a proportion of empty BW. Restricting growth resulted in a change in the partitioning of nutrients. Deposition of protein was increased while fat deposition was decreased as cattle were realimented. This result was greater for non-carcass tissues than carcass tissues. These studies show that restricting intake can lead to animals utilizing nutrients differently and possibly more efficiently. Limiting available nutrients can also lead to compensatory gain and increased efficiencies.

Diet Effects on the Rumen

Changes in the cattle industry that favored feeding cattle high concentrate diets have also resulted in digestive disorders linked to ruminal acidosis (Krehbiel et al., 1995a). These disorders can lead to keratinization of ruminal epithelium and subsequently have a negative effect on the absorption of volatile fatty acids (VFA) from the rumen (Huntington and Britton, 1979). Reductions in VFA absorption can lead to reduced gain and efficiency since 65 to 75% of total metabolizable energy comes from VFA absorbed from the rumen (Bergman, 1990). The diet an animal is fed has a profound influence on the development of the rumen and the microbial population which inhabits it. This impact may best be seen during the transition period when cattle are adapted to high concentrate diets (Schwartzkopf-Genswein et al., 2003). This adaptation period results in a decrease of fibrolytic bacteria and an increase in amylolytic bacteria (Goad et al., 1998; Tajima et al., 2001).

Ruminal microbial development has been studied numerous times in calves. Eadie et al. (1959) reported that diet and other factors could greatly influence rumen flora. They also observed that inoculating the rumen with ciliated protozoa and associated bacteria was only successful when the ruminal environment was appropriate for the development of the supplementary organisms. Lengemann and Allen (1959) observed differences in the development of rumen microorganisms when comparing four feeding strategies using dairy calves. The four dietary treatments were as follows: 1) milk fed at 10 % of BW with a maximum of 10 lb/day and ad libitum grain and hay (Normal); 2) milk fed at 10% of BW for 3 weeks, and then gradually withdrawn until none was offered at the end of the seventh week and

grain with aureomycin and hay was made available ad libitum (Aureo); 3) same as 2 without aureomycin (Non-Aureo); and 4) milk fed at 12% of BW for 8 weeks, then at the start of the ninth week grain and hay were fed ad libitum and the amount of milk was reduced rapidly until none was fed at the end of the eleventh week (LM). The authors found that feeding grain to calves in treatments 1-3 resulted in a ruminal flora that was equally diverse compared to that of an adult animal by the eighth week of the study. However, for those in treatment LM it was not until the tenth week that the rumen was similar to that of an adult animal. Anderson et al. (1987) studied ruminal metabolic development in calves based on whether they were early weaned or conventionally weaned. One group of calves was fed a pelleted diet and milk until they were weaned at 4 weeks of age, after which they received only pelleted feed. The second group of calves also received a pelleted diet and milk until weaning at 6 weeks of age, after which they only received a pelleted diet. Rumen samples were collected at 1, 4, 8, and 12 weeks of age over a 12 h period post feeding. Daily intakes increased with age for both treatments. Calves that were weaned early had higher feed intakes during weeks 1 to 4. Calves in both groups experienced similar trends for ruminal pH, but those weaned early had a lower pH at 4, 8, and 12 h. These calves also had a higher VFA concentration at the same measuring times. They found molar proportions of acetate to be highest and molar proportions of propionate to be lowest during week 1. This ratio declined as the calves consumed more fiber and starch in the form of pellets than milk. Proportions of butyrate were higher for early weaned calves as well. These authors concluded that weaning calves earlier causes a decrease in ruminal pH and an increase in ruminal VFA concentrations which is indicative of increased ruminal activity. Rumen development in calves fed different forage levels and forms of diet was examined by Coverdale et al. (2004). In the first of two studies, calves were fed a commercial starter (C), a starter with ground grain (G), or a coarse starter with either 7.5% grass hay (H1) or 15% grass hay (H2). All calves were also offered milk at 10% of initial body weight daily until they were weaned. In the second study, calves received the same diets as in study one and milk replacer at the same 10% of initial body weight daily until they were weaned. In the first study, DMI increased with age and calves consuming the hay diets tended to have higher intakes than the other two treatments. Average daily gain was increased by feeding the coarse diet and the addition of hay. Postweaning BW, ADG, and feed efficiency were improved for those fed the hay diets followed by those fed coarse grain. VFA concentrations also increased with age. Total VFA was higher

for calves fed G than those fed C. Molar proportions of acetate were higher for G than for C, proportions of propionate were higher for G than for C, H1, and H2, and the molar concentrations of butyrate, valerate and isobutyrate were higher for G than for C. As a percent of total VFA calves receiving diet G tended to have increased proportions of isobutyrate, had greater proportions of valerate, and tended to have decreased proportions of acetate when compared to calves receiving the C diet. Calves receiving diet H1 had increased proportions of propionate and lower proportions of propionate than those receiving diet H2. In experiment two DMI increased with age and calves receiving diets H1 and H2 tended to have increased DMI when compared to those fed diet C, which is similar to the results they observed in experiment 1. Post-weaning intake was also affected by treatment. Those fed the two hay diets tended to eat more than those fed diet C, while those fed diet C consumed more feed than those receiving diet G which indicates that diet form can impact intake of solid feed. Average daily gain and feed efficiency were unaffected by diet composition. Ruminal VFA concentrations were not studied in the second study. This study suggests that forage inclusion can lead to heavier calves and altered VFA production that may be the result of a healthier ruminal environment.

Diet effects on rumen bacterial populations and VFA production have also been examined in finishing cattle. The fermentation process can be altered in many ways. Not only can diet affect ruminal fermentation patterns, but other methods such as propionate enhancers and other chemical processes have been employed to increase the metabolic efficiency of cattle (Chalupa, 1977). Chalupa went on to explain that glucose and pyruvate fermentation by rumen microbes causes the production of metabolic hydrogen and that to attain maximum energy yields this hydrogen must be eliminated. He further explained that the efficiencies of fermenting hexose to acetate, propionate, and butyrate were 62, 109, and 78% respectively, and that this was due to differences in the manufacturing and utilization of metabolic hydrogen. Because propionate is most efficient in this respect, feeding diets containing large quantities of concentrates should lead to a more efficient production, due to the metabolic shifts that lead to increased propionate production. Weigand et al. (1975) examined the effect of all grain versus all hay diets on rumen mucosal activity. They fed Holstein steers either alfalfa hay ad libitum or a diet composed of 80% ground corn and 15.5% soybean meal for three to fourth months at which point they slaughtered 1 steer from each treatment at weekly intervals. Rumen fluid was collected one day before slaughter. The pH averaged 6.8 for those receiving hay and 5.4 for

those fed all concentrate. Papillae were collected at slaughter and incubated with various VFA.

They found the papillation to be very different between treatments. When steers were fed hay

only papillation was limited primarily to central areas of the rumen sacs and the papillae were

found to be very similar in coloring, size, and shape. When steers received the grain diet the

papillae were diversely colored and also differed in size and shape. Feeding of the grain diet also

resulted in papillae that were commonly clumped together, and the interpapillary spaces often

contained feed particles and hair. Upon incubation, papillae from hay-fed steers utilized larger

amounts of the VFA substrates. Propionate and isovalerate were the only two VFA substrates

for which there was no difference. These results were explained as either these steers having

more available endogenous substrates causing a reduced need to metabolize those provided

exogenously or possibly a decreased metabolic activity of papillae from grain-fed steers resulting

from papillary structural differences. Volatile fatty acid production in the rumen and cecum-

colon of steers fed different forage-to-concentrate ratios and the physical form of the forage has

also been examined (Siciliano-Jones and Murphy, 1989). Holstein steers were fed one of two

forage to concentrate ratios (20:80 or 80:20) and two forage types (long alfalfa hay or ground

and pelleted alfalfa). Dry matter intake, cecal pH and fluid osmolality were unaffected by diet.

Total cecal VFA concentrations increased with grain feeding and this was mirrored by increases

in cecal acetate, propionate, and butyrate. Increases in propionate were greater than those of

acetate resulting in a decreased acetate to propionate ratio (A:P). However, cecal VFA

concentration did not follow the diurnal pattern of ruminal VFA concentrations in response to

feeding times. Cecal lactate concentrations tended to be higher and ammonia concentrations

were lower for steers receiving primarily concentrate diets. Acetate production in the rumen was

increased for steers receiving long alfalfa hay diets when compared to those receiving pelleted

alfalfa diets. Ruminal production rates of propionate and butyrate were unaffected by diet. Diet

effects on ruminal activity can be seen both in changes in ruminal and cecal VFA production;

however, cecal concentrations do not change with the fermentation patterns in the rumen.

Franzolin and Dehority (1996) examined the effects of prolonged grain feeding and forage

addition on ruminal protozoa concentrations and also the effects of pH on protozoal numbers.

Steers in this study were adapted for three weeks after which they received an all concentrate diet

or a 90% concentrate diet and 10% forage. Diet did not affect total concentrations of protozoa or

the concentration of the *Entodinium* species. Concentrations of both *Isotricha* and *Epidinium*

were higher when forage was included in the diet. Feeding of the all concentrate diet resulted in elimination of *Diplodiniinae* in all steers. These results indicate that while changes in ruminal pH as a result of feeding higher concentrate diets may have some effect on protozoal populations in the rumen, there may be other factors such as passage rate and salivary production that influence the microbial population of the rumen. Effects of diet on shifts in bacterial populations of the rumen have also been examined using PCR (Tajima et al., 2001). Dry Holstein cows were fed either a basal diet containing 3.5 kg of hay, 1 kg of hay cube, and 1.5 kg concentrate twice daily or a high grain diet consisting of 0.5 kg hay, 2.4 kg of concentrate, and 3.6 kg of barley in the morning and only the grain portions of the diet in the evening. Bacterial DNA was then extracted from rumen fluid samples taken on days 0, 3, and 28 and quantified using real-time PCR. *Fibrobacter succinogenes*, a major fibrolytic bacterium in cattle being fed hay, fell 20 and 57 fold on days 3 and 28 respectively after cattle were switched to concentrate diets. *Ruminococcus flavefaciens*, another fibrolytic bacterium, also experienced reductions of 10% of original values on days 3 and 28. *Prevotella ruminicola* and *P. bryantii*, two rumen bacteria that aid in the breakdown of protein and carbohydrates, experienced increases of 7 and 263-fold on day 3; however, by day 28 *P. ruminicola* had decreased 3-fold and *P. bryantii* was maintained at the elevated level. *Eubacterium ruminantium*, another xylanolytic bacterium, decreased 14-fold by day three and remained at this decreased level on day 28. *Treponema bryantii* levels decreased 7-fold over the 28 day feeding period. Amounts of *A. lipolytica* DNA were unaffected by diet. *Succinivibrio dextrinosolvens* experienced a slight increase by day 3; however, DNA of the bacterium was undetected on day 28. *Streptococcus bovis* increased 67-fold after three days of feeding grain, but on day 28, this bacterium was decreased 2-fold compared to values from hay-fed animals. *Selenomonas ruminantium-M. multiacida* DNA was increased 8-fold on day 3, but only twofold on day 28. The changes in bacterial counts in this study followed a pattern that would be expected when changing diets from forage to concentrate. Those bacteria possessing both fibrolytic and xylanolytic properties experienced decreases in counts when grain was fed. In contrast, bacterium possessing amylolytic properties experienced increases in counts when grain was fed.

Introduction: Naturally Raised Cattle

Recent events, including the cases of bovine spongiform encephalopathy, massive beef recalls, and worries about antibiotic and hormone residues, have lead a portion of the American public as well as consumers abroad to the consumption of "naturally raised" beef. Natural beef can be defined by one of several different definitions. For the remainder of this discussion "natural beef" or "naturally raised" beef will refer to cattle that have never been implanted with growth promoting hormones, fed animal by-products, or received antibiotics by injection or in their feed. Beneficial effects of implants on cattle performance have been reported by Kreikemeier and Mader (2004). They found that four out of five implant regimes increased final weights and ADG and improved feed efficiency in yearling heifers. These heifers also had heavier hot carcass weights with minimal effects on other carcass characteristics. Response of ADG has ranged from a decrease of 5% (Foutz et al., 1997) to an increase of 38.6% (Gerken et al., 1995). The average increase in ADG seen when using implants is approximately 14% (Lawrence and Ibarburu, 2007). The effects on feed-to-gain ratio have ranged from an increase of 7.7% (Henricks et al., 1997) when using implants to a decrease of 22.8% (Gerken et al., 1995). On average feed-to-gain ration is decreased 8.8% when utilizing implants (Gerken et al., 1995). Subtherapeutic levels of antibiotics have also been evaluated. Their effect on ADG has ranged from a decrease of 9% (chlortetracycline) (Rumsey et al., 2000) to an increase of 11% (ardacin) (Zinn et al., 1991) and the effect on F:G has ranged from an increase of 19% (virginiamycin) (Rogers et al., 1995) to a decrease of 8% (oxytetracycline) (Lee, B. and Lauder, S., 1984). The elimination of implants, ionophores, and beta-agonists in the feedlot has been estimated to increase production costs $80-$81 (Lawrence and Ibarburu, 2007). As a result producers of naturally raised beef must achieve price premiums for their products to maintain competitive profitability.

Acidosis

Acute and subacute acidosis have been associated with reduced performance of ruminants for a number of years (Fulton et al., 1979; Stock et al., 1990; Nagaraja and Titgemeyer, 2007). Acidosis is commonly associated with the feeding of high-concentrate feeds which is customary in feedlots. These diets, which are rich in readily fermentable carbohydrates, often lead to a buildup of VFAs and lactic acid in the rumen and a subsequent reduction in

ruminal pH (Brent, 1976; Slyter, 1976). Several changes occur in the rumen during clinical and subclinical acidosis. While many researchers have attempted to characterize these changes by experimentally inducing acidosis (Goad et al., 1998; Bevans et al., 2005), others still feel the need for additional research in the area of feed intake patterns and the need for understanding why certain animals are better able to cope with higher VFA and lactate loads (Galyean and Eng, 1998; Schwartzkopf-Genswein et al., 2003). Acidosis is also a precursor to other ailments in cattle such as laminitis and liver abscess (Brent, 1976; Nagaraja and Chengappa, 1998).

Ruminal pH and organic acid accumulation

Accumulation of VFA and lactic acid in the rumen has been associated with decreased pH of the rumen contents. Depression of pH below 5.6 is the standard measurement used to determine whether an animal is acidotic or not (Nagaraja and Titgemeyer, 2007). A pH range of 5.0 to 5.6 is considered as subacute acidosis, while a pH less than 5.0 is generally associated with acute acidosis (Owens et al., 1998; Krause and Oetzel, 2006). This reduction in pH is believed to be the result of the accumulation of VFA initially and also an increase in lactic acid production and a decrease in lactic acid fermentation (Huber, 1976; Nagaraja and Lechtenberg, 2007a). When cattle are switched from forage-based to grain-based diets the energy density of the diet is increased. Initially this results in a more rapid production of VFA and a subsequent decrease in pH. This decreased pH (below 5.6) causes a more rapid absorption of these VFAs; however, the lower pH also causes a shift in the microbial population of the rumen leading to an increased production of lactic acid. Accumulations of lactic acid lead to even lower pH and reductions in the normal flora of the rumen bacteria (Nagaraja and Lechtenberg, 2007a). Consequently when the normal microbial population of the rumen is altered, concentrations of VFA are reduced due to lower production and also because of the entry of more fluids to compensate for increased osmolality which dilutes the concentration of VFA present (Huber, 1976). At these lower pHs acid-tolerant lactobacilli become established in the rumen, but lactate fermenting bacteria are inactive because the pH range is too low (Therion et al., 1982). During subacute acidosis lactate-fermenting bacteria remain active; therefore lactic acid does not accumulate (Goad et al., 1998). Other microbial products such as ethanol, methanol, histamine, tyramine, and endotoxins have also been associated with ruminal acidosis (Koers et al., 1976; Slyter, 1976).

Ruminal osmolality

Changes in osmotic pressure of the rumen have also been measured in cattle experiencing acidosis. Normal ranges for osmotic pressure in forage fed animals range from 240 to 265 mOsm/L, while for those fed concentrate the normal range is from 280 to 300 mOsm/L (Garza et al., 1989). In animals experiencing experimentally-induced acidosis the osmolality has been measured as a high as 515 mOsm/L (Owens et al., 1998). Increased osmolality in the rumen leads to water from the blood moving rapidly through the rumen wall into the rumen. The rapid movement of water in this manner can lead to swelling of rumen papillae and even the removal of interior layers of rumen epithelium from outer layers (Eadie et al., 1959). When these tissues are repaired they become thicker due to hyperkeratosis and parakeratosis which can lead to decreased VFA absorption from the rumen (Krehbiel et al., 1995a). The reticulorumen senses an increase in osmotic pressure which subsequently inhibits intake (Carter and Grovum, 1990). Fiber and starch digestion by rumen bacteria can also be decreased at osmolalities greater than 350 mOsm (Owens et al., 1998). High osmotic pressure within the rumen may reduce the frequency of ruminal contractions and if this gut stasis affects the abomasum, reducing passage rate, even more VFA and lactic acid can build up in the rumen (Carter and Grovum, 1990; Owens et al., 1998).

Acidosis and liver abscesses

Acidosis is commonly linked to liver abscesses in feedlot cattle (Brent, 1976; Nagaraja and Lechtenberg, 2007b). Reported prevalences of liver abscesses in feedlots have ranged from as low as 1 to 2% and as high as 90 to 95% (Nagaraja and Lechtenberg, 2007b). Brink et al. (1990) found the prevalence in most feedlots to range between 12 and 32%. This is of economic relevance to the feedlot industry because liver abscesses lead to condemnation of the liver, and severe abscesses can reduce daily gain and lower efficiency (Brink et al., 1990). In addition, severely abscessed livers can also lead to carcass trim that will further reduce hot carcass weight, which can lower dressing percentages (Nagaraja and Lechtenberg, 2007b). Researchers have attempted to characterize the bacterial flora of liver abscesses and have found *Fusobacterium necrophrum* to be the primary and *Actinomyces pyogenes* to be the secondary bacteria associated with liver abscesses. These bacteria are also found as normal inhabitants of the rumen (Tan et al., 1996). Acidosis resulting in rumenitis, which allows bacteria to enter the portal circulation and travel to the liver, is believed to be the primary pathway in which these bacteria cause liver

abscesses (Brent, 1976; Nagaraja and Chengappa, 1998; Nagaraja and Lechtenberg, 2007b).

Ulcerative lesions of the rumen were first correlated to liver abscesses by Smith (1944). Jensen et al. (1954) also found a high correlation between abscesses in the liver and ruminal pathology. Once the wall of the rumen is damaged by acidity or foreign objects it can be invaded and colonized by *F. necrophorum* (Nagaraja and Chengappa, 1998). Once the bacterium reaches the portal circulation it is filtered by the liver, where it can subsequently cause infection and liver abscesses (Nagaraja and Lechtenberg, 2007b). Narayanan et al. (1997) isolated *F. necrophorum* from the rumen contents (6 of 11), rumen wall (9 of 11), and liver abscesses (11 of 11) of cattle at slaughter. Nagaraja et al. (1999) used tylosin to control concentrations of *F. necrophorum* in cattle rapidly adapted to a high concentrate diet. They found that increasing the amount of concentrates in the diet caused an increase in concentrations of *F. necrophorum*; however, this increase was prevented when tylosin was added to the diet. They concluded that a decrease in the prevalence of liver abscess could be attributed to the control of increases in certain bacterial concentrations with tylosin, and that because tylosin is partially absorbed it may also have antimicrobial effects in the liver.

Fat Addition in Finishing Diets

Intake

Energy density of finishing diets can be enhanced by feeding supplemental fat. Cattle commonly respond to the added fat in the diet with improved gain and feed efficiency; however, fats of different origin and differences in degree of saturation of these fats can elicit an assortment of differing responses (Haaland et al., 1981; Felton and Kerley, 2004).

Supplemental fats in finishing diets have had variable effects on dry matter intake. Clary et al. (1993) fed 4% tallow in finishing diets containing no ionophores, monensin plus tylan, or lasalocid and monensin plus tylan. DMI was negatively affected only for the diet containing monensin plus tylan and 4% tallow. In contrast, Zinn (1988) fed monensin and 4% yellow grease in a 2×2 factorial arrangement and found no effects on DMI. Krehbiel et al. (1995b) conducted two studies examining level of tallow supplementation. In the first study, they saw no differences in intake between those receiving 0% tallow and the three tallow containing treatments (4% tallow fed throughout; 0% tallow for 33 d followed by 4% tallow until slaughter; 4% tallow for 33 d followed by 0% tallow until slaughter). However, when they fed tallow at 0,

2, or 4% in the second study, cattle experienced a linear decrease in DMI. Similarly Montgomery et al. (2005) saw a decrease in DMI for calves fed either tallow or 10% or 15% dried full-fat corn germ when compared to controls (3.1 % crude fat vs 6.9, 7.2, and 9.3% crude fat, respectively). Reduced intake has also been reported by Engle et al. (2000) when feeding 4% soybean oil in dry rolled corn diets. Ngidi et al. (1990) also observed reduced feed intake when feeding 0, 2, 4, or 6% calcium soap, a ruminally inert calcium salt of long-chain fatty acids, to finishing steers. In contrast to the above authors, Brandt and Anderson (1990) fed soybean oil, tallow, and yellow grease (all at 3.5% diet DM) and found no differences in level of feed intake. Zinn (1989) also saw no differences in intake based on level of inclusion or fat source (4 or 8% yellow grease or 4, 6, or 8% blended vegetable fat).

ADG and feed efficiency

Although dietary fat may decrease dry matter intake, it has also resulted in increased average daily gain and feed efficiency. Cattle fed 4% supplemental fat had heavier final weights and higher ADG and G:F in the first study by Zinn (1988). In a second study, only feed efficiency was improved for cattle receiving added fat. Feeding 3.5% on a DM basis of soybean oil, tallow, or yellow grease improved daily gains and feed efficiencies for crossbred yearling steers (Brandt and Anderson, 1990). In the second portion of this study, only diets containing a blend of 70% acidulated soybean soapstock and 30% tallow improved both daily gains and efficiency. Brandt et al. (1992) also observed improved efficiency when feeding 4% yellow grease. Dried full-fat corn germ has also been shown to improve daily gains and increase feed efficiencies when included in the diet (Montgomery et al., 2005).

Carcass characteristics

In addition to the increased performance observed when fat is supplemented in the diet, some carcass characteristics may also be improved when feeding supplemental fat. Dressing percentage and hot carcass weights have been increased with the addition of yellow grease to finishing diets (Plascencia et al., 1999; Nelson et al., 2004). Hot carcass weights were increased linearly by the inclusion of 4 or 8% yellow grease and marbling scores tended to be increased in the same manner (Zinn, 1989). Hot carcass weights were increased by inclusion of yellow grease in finishing diets and dressing percentage was improved by adding soybean oil, tallow, or yellow grease to diets (Brandt and Anderson, 1990). Felton and Kerley (2004) observed

increased dressing percentages when feeding full-fat soybeans or choice white grease, and choice white grease improved marbling scores when added to finishing diets (Nelson et al., 2004).

Introduction: Receiving Cattle Health

There are many factors that can affect the health of cattle arriving at the feedyard. Stressors that commonly have a negative effect on health include commingling, transportation, feed and water deprivation and feed and water changes, dust, adverse weather conditions and disease challenge upon arrival at the feedlot (White, 2007). Two major effects of stress are decreased appetite and shrink or loss of body mass (Hutcheson and Cole, 1986). Preconditioning should provide increased farm gains, reduce transit shrink, and improve feedlot health and performance while improving profits (Cole, 1985). Macartney et al. (2003) found that calves that were vaccinated or preconditioned were less likely to be treated for BRD during the first 28 days after arrival the feedlot. No differences were observed in mortality rate. Beef producers have the opportunity to enhance immunity through pre-weaning management and vaccination programs (Galyean et al., 1999). Altering dietary roughage and energy levels, or supplementing the diet with crude protein, vitamins, and minerals may all offer benefits for the health of stressed cattle (Galyean et al., 1999).

Bovine respiratory disease

Bovine respiratory disease (BRD) continues to be a major problem for the feedlot industry. Not only is it the most frequently observed disease in feedlots but is also the most costly (Smith, 1998; NAHMS, 2000). Respiratory disease has been shown to affect the highest percentage of placements and has one of the highest treatment costs of the most common disease problems faced in the feedlot (NAHMS, 2000). Snowder et al. (2006) showed the economic effects of BRD on 1,000 head of calves and concluded that estimated losses due to respiratory disease would total $13,895. These costs did not account for feed consumed before death or labor and other handling costs of sick animals. Respiratory disease is caused by numerous factors and is often the result of interactions between environmental and host factors and pathogen load. Several stress factors can make calves more susceptible to BRD upon entering the feedlot. White (2007) listed weaning, transporting, commingling, feed and water changes, dust, and dehydration as some of these factors.

There are several infectious agents involved in BRD as well. These include viruses such as infectious bovine rhinotracheitis (IBR), bovine viral diarrhea (BVD), bovine respiratory syncytial virus (BRSV), and parainfluenza type 3 virus (PI-3) and bacteria such as *Mannheimia haemolytica*, *Pasteurella multocida*, *Histophilus somnii*, and *Mycoplasma bovis* (White, 2007). Signs of BRD include nasal and ocular discharge, depression, lethargy, and labored breathing, and when this is coupled with a rectal temperature of ≥39.7ºC, animals are usually treated therapeutically (Duff and Galyean, 2007). Possibly more important than costs associated with death loss and treatment of cattle experiencing BRD are the associated effects that it can have on performance. Wittum et al. (1996) examined the effects of BRD on performance of crossbred steers. They found that treatment status had no effect on mean daily gain of calves (1.30 and 1.32 kg/d for treated and untreated respectively). However, they found that pulmonary lesions present at slaughter, which were indicative of a past or present pneumonia, reduced mean daily gains (1.35 and 1.27 kg/d for no lesions and lesions, respectively). Upon examining the lungs of these calves, 78% of those treated had pulmonary lesions evident at slaughter. More intriguing than that is the 68% of calves that had never been treated for respiratory disease that also had pulmonary lesions at slaughter. Similarly, Bryant et al. (1999) looked at performance of calves based on treatment records and pulmonary lesions at slaughter. They found that only 40% of the 73% treated for respiratory disease had lung lesions at slaughter, while 42% of those never treated also had lung lesions at slaughter. Lung lesions at slaughter caused a 2.5% reduction in ADG, and those lesions indicative of cranial ventral bronchopneumonia (CVBP) caused a 3% decrease in ADG. In a commercial population of calves they found that CVBP-type lesions resulted in a 12.6% reduction in ADG. Performance of calves affected by BRD was also examined by Gardner et al. (1999). They found that calves which were never treated had higher final weights, ADG, hot carcass weights (HCW), fat thickness, and percentage kidney, pelvic, and heart fat (KPH %) when compared to those that were treated for BRD. In addition those that were only treated once had higher ADG, fat thickness, and KPH% and tended to have increased DP and HCW when compared to those that were treated more than once for BRD. They also examined performance and carcass traits based on the presence of respiratory tract lesions. Initial weights were different among lesion categories. Steers with no lesions were lighter initially than those with lesions and steers with inactive lesions had lower initial BW than steers with active lesions. Cattle with no lesions had higher final weights and ADG than those with

lesions present. Dressing percentage, HCW, longissimus muscle area (LMA), and KPH% were also higher for those with no lesions present. Cattle with inactive respiratory tract lesions had increased ADG, DP, LMA, and marbling scores when compared to those with active lesions. Contrary to the previous authors, Stovall et al., (2000) found no differences in performance of heifer calves based on times treated for respiratory disease. However, they found that marbling score was increased for those never treated when compared to those treated one or more times for BRD. Carcass value was also decreased for those treated more than once when compared to those never treated or treated once. In addition, the net value per head was decreased $37.34 and $25.86 for those treated more than once when compared to those never treated or treated once respectively. In addition to treatment records and pulmonary lesions at slaughter, Thompson et al. (2006) examined the effects of BRD on the performance of South African feedlot cattle using bronchopneumonia and pleural adhesion scoring. Cattle that were treated for BRD tended to experience decreased ADG. Healthy cattle tended to have increased ADG when compared to those classified as subclinical and had significantly higher ADG than those experiencing clinical BRD. An interaction occurred between sex and presence of lung lesions. Males experienced a significant decrease in ADG; however, females were unaffected. Cattle with bronchopneumonia involving >50% of the cranioventral lobes tended to have lower ADG. Any lesions of pleuritis were associated with a decrease in ADG. Respiratory disease (treated for BRD and/or lung lesions present at slaughter) reduced ADG.

Receiving cattle nutrition

Several factors must be taken into account when formulating rations for newly received feedlot cattle. This becomes increasingly difficult when the previous nutritional and health status of the cattle is unknown. Roughage levels and energy densities of receiving diets are two areas that have received a lot of attention. A common belief is that increased energy density is negative in terms of BRD but beneficial for performance (Rivera et al., 2004). Lofgreen et al. (1985) evaluated health and performance of calves fed concentrate diets (25, 50, or 75% concentrate) with or without free choice alfalfa hay. Death loss, number treated, number of return treatments and days to regain shipping shrink were reduced when hay was available free choice. In addition, daily gains were higher and feed per kg of gain was lower for these animals. In contrast, Lofgreen et al. (1981) found no differences in health of calves fed hay alone or in combination with a 75% concentrate diet. Feed intake in this study was higher for calves fed the

75% concentrate diet alone or with free choice hay than those fed only hay. The consumption of a greater quantity of feed in combination with the consumption of a higher energy diet resulted in higher daily gains, increased feed efficiency, and faster recovery of transit shrink. Energy density of the diet has also been examined by many authors. Lofgreen et al. (1975) measured health and performance of calves fed varying levels of concentrates in four studies. In the first study, no differences in health were noted. However, feed consumption was higher for calves fed 55 and 72% concentrate than those fed 20%. Daily gains were highest for those on the 72% concentrate diet, followed by the 55 and 20% diets respectively. There were no differences in feed efficiency among the dietary treatments. In agreement with the first study, no health differences were noted for 55, 72, and 90% concentrate diets in the second study. Feed consumption was higher for the 72% concentrate diet than the other two dietary treatments. Daily weight gains were higher for both the 72 and 90% concentrate diets when compared the diet containing 55% concentrates. Again there were no differences in feed efficiency. In the third study, cattle were either allowed to choose the 20, 55, or 90% concentrate diets (each in a different bunk in each pen) or fed the 72 or 90% concentrate diets. No effects of diet on health or performance were seen in this study. During the final study, cattle were fed the 72% concentrate diet with or without free choice hay. Diet did not affect the health status or performance of calves. Energy density of the diet has also been shown to improve performance of newly arrived calves in other studies. Fluharty et al. (1994) saw reduced daily intakes and improved efficiency when cattle were fed a high energy diet versus a low energy diet. In another study, Fluharty and Loerch (1996) saw no effects of concentrate level on health of calves. Dry matter intake linearly increased as concentrate level was increased from 70 to 85%, but there were no other effects on performance. A different portion of this study yielded no health or performance effects based on concentrate levels of either 70 or 85%. Energy and starch concentrations in the diet were examined by Berry et al. (2004). They fed low or high energy diets with low or high levels of starch. Average daily gain and feed efficiency were unaffected by treatment. However, calves fed high energy diets had lower DMI than those receiving low energy diets. Calves fed lower energy diets tended to require treatment sooner and tended to have a higher percentage of animals requiring three treatments. No other health effects were noted based on energy level. Lower levels of roughage inclusion may lead to increased respiratory morbidity in high stress calves; however, if the change in morbidity is too small to

account for the decreased performance of lower concentrate diets then it will not be economical for the producer (Lofgreen, 1988; Rivera et al., 2004).

Stress and illness during the receiving period can lead to decreased intake by newly received calves. When consuming less of a diet they need a higher concentration of certain ingredients to meet the animals' requirement. Galyean et al. (1999) proposed that dietary requirements of protein for newly received calves may largely depend on intake and that using historical data based on different types and sources of cattle could prove useful for estimating true protein requirements. Cole and Hutcheson (1988) examined the effects of pre-fast and post-fast dietary protein concentration on performance of steer calves. They concluded that high-protein diets pre-fast lead to increased weight loss during fasting and slower rate of growth following fasting than lower protein diets. Protein status prior to the fasting period affected how calves reacted to the realimentation diet. They suggested that knowledge of protein status of newly received cattle prior to marketing may be beneficial in determining the optimum protein level of the receiving ration. In two other studies, the above authors examined two different crude protein levels and in the second study they also examined two levels of potassium (K) within each level of crude protein (12 or 16% CP and 0.8 or 1.3% K)(Cole and Hutcheson, 1990). Calves fed 16% CP had less relapses and a lower of number of days treated than those receiving 12% CP. Feeding 16% CP also increased cumulative daily gains, DMI, and G:F from day 0 to 14. In the second study, calves fed 16% CP and 1.3 % K had lower death loss than the other three treatments. Those fed 12% CP and 0.8% K had a lower number of relapses than the other treatments. There were no dietary effects on performance in this portion of the study. Cole and Hutcheson (1990) fed steers 100, 120, 140, or 160% of their required crude protein maintenance requirements (NRC, 1976). This caused a linear increase in feed intake throughout the experiment. Fluharty et al. (1994) compared soybean meal and blood meal as sources of crude protein for newly received calves. Calves fed blood meal as the protein source tended to have higher daily gains and experienced improved feed efficiency when compared to those fed soybean meal. The effects of level and source of crude protein on receiving cattle performance were examined by Fluharty and Loerch (1995) in three studies. The first study evaluated CP levels of 12, 14, 16, and 18% using either soybean meal (SBM) or spray-dried blood meal (SDBM). None of the treatments affected DMI or ADG, but as protein concentration increased feed efficiency was improved linearly. Feed efficiency was also improved for the SDBM

containing diets compared to those with SBM. The second study evaluated crude protein levels of 11, 14, 17, 20, 23, and 26%. Average daily gain and G:F both increased up to 20% CP; however, higher levels resulted in intermediate performance.. In the third study, the authors evaluated different sources of crude protein; however, no effects on performance were found. Fluharty and Loerch (1997) also examined feeding supplemental fat and protein on performance of newly received cattle. They found that feeding calcium soaps to increase energy density was not beneficial. In addition, they stated that when feeding diets with high levels of crude protein the decreased DMI resulting from the addition of calcium soaps could be detrimental. However, they speculated that animal-vegetable fats may be useful for improving feed efficiency when supplementing high crude protein diets.

The combined effect of stressors and disease challenges upon arrival at the feedlot can lead to deficiencies in vitamins and minerals essential to health and performance. Mineral concentrations in receiving rations should be increased to make up for decreased intake of calves (Galyean et al., 1999). Orr et al. (1990) suggested that serum concentrations of minerals can be altered by stress from marketing and transportation of cattle and by BRD and IBR virus infections. They further stated that an animal's ability to handle disease could be influenced by the ability of the diet to provide adequate nutrition during times of high stress or illness. Hutcheson et al. (1984) examined different levels of potassium (K) supplementation in receiving diets in two separate studies and concluded that calves that are transported need 20% more K than those that are not transported due to urinary excretion of K in calves experiencing stress. They recommended that K be included at a level of 1.3 to 1.4% (DM basis) of the receiving diet. In contrast to other species, diets deficient in copper have altered immune function in cattle minimally or not at all (Ward et al., 1997; Ward and Spears, 1999). Supplementing copper at low levels (as low as 20 mg/ kg dry matter) has reduced the performance of steers (Engle and Spears, 2000). Supplemental zinc has increased ADG in the growing phase, but in the same study had no other beneficial effects on performance (Spears and Kegley, 2002). Supplemental zinc may provide some benefit in recovery time for cattle challenged with IBR virus, which may help improve rate of gain and feed efficiency sooner in morbid cattle (Chirase et al., 1991; Chirase et al., 1994). Providing supplemental chromium to receiving cattle has produced some beneficial effects on performance (Chang and Mowat, 1992; Bunting et al., 1994; Kegley et al., 1997). ADG was improved from days 0 to 80 with supplemental chromium by Kegley et al.

(1997). Chang and Mowat] (1992) saw increases in serum levels of immunoglobulin M and total immunoglobulin concentrations when diets were supplemented with chromium.

Metaphylaxis

The concept of metaphylaxis or mass medication of animals is not new to the livestock industry. Antibiotics can be given to animals for a number of reasons which commonly include individuals that are sick, mass medication to treat cattle suffering from shipping fever and to prevent sickness in healthy cattle, and to control liver abscesses. Mass medication is the treatment of all cattle at arrival processing in spite of observed health status (Neumann and Lusby, 1986). It can also be done by feeding antibiotics to all cattle in a pen by inclusion in the ration. Lofgreen et al. (1980) observed the beneficial effects of mass medication when injecting stocker calves with oxytetracycline for three consecutive days immediately post-arrival. Death loss, number treated, number of return treatments, and days to regain shipping shrink were lower for calves that received oxytetracycline. Feed intake was unaffected; however, daily gains and feed efficiency were improved for those that were mass medicated. In four studies by Lofgreen (1983), injectable oxytetracycline, sustained release sulfadimethoxine, and a feed additive containing chlortetracycline and sulfadimethoxine were examined alone or in combinations in four different studies. In the first study, calves receiving no antibiotics had increased treatment days per calf purchased. Administering injectable oxytetracycline for three days increased intake and daily weight gains when compared to those receiving no antibiotics or those that were given a sustained release sulfadimethoxine bolus. In the second study, the number of calves treated and treatment days per calf purchased were lowest for those that received oxytetracycline for three days followed by a sulfadimethoxine bolus. Those that only received the bolus had a lower number treated and treatment days per calf purchased than controls; however, these results were not different from those receiving only oxytetracycline. In third study, both injectable oxytetracycline followed by sulfadimethoxine or injectable oxytetracycline followed by sulfadimethoxine followed by chlortetracycline and sulfamethazine in the feed resulted in a lower number of animals treated and treatment days per calf purchased and a higher feed intake than those receiving no antibiotics. In the fourth study, calves receiving one injection of long-acting oxytetracycline with or followed by sulfadimethoxine had lower numbers of calves treated and treatment days per calf purchased and higher daily gains than controls or those fed chlortetracycline and sulfamethazine. Only long-acting oxytetracycline followed by

sulfadimethoxine reduced treatment days per morbid calf. The number of days chlortetracycline (CTC) is fed and amounts fed were examined by Perry et al. (1986). They fed CTC at 350 mg•hd^{-1}•d^{-1} for 56 days or 1, 2, or 4 g•hd^{-1}•d^{-1} for 14 days. From d 1 to 28, all CTC treatments improved daily gains and feed efficiency when compared to controls. However, for the entire 56 day feeding period only those fed 350 mg•hd^{-1}•d^{-1} and 4 g•hd^{-1}•d^{-1} had increased daily gains and only those receiving 4 g•hd^{-1}•d^{-1} had improved feed efficiency. The use of CTC and sulfamethazine as feed additive antibiotics were examined by Gallo and Berg (1995). When these antibiotics were added to the diets of newly received crossbred calves they experienced higher ADG and better feed conversion than controls from day 0 to closeout. Total morbidity rate and morbidity due to respiratory illness were decreased for animals receiving antibiotics. Similarly, total mortality rate and BRD mortality rate were decreased for calves receiving antibiotics in the feed. In addition, adding antibiotics to the feed decreased total medicine costs, medicine costs per head day, feed costs, and total costs when compared to controls. Galyean et al. (1995) evaluated the use of tilmicosin phosphate as a mass medication tool. In the first of three studies, mass medication had no effects on performance; however, the percentage of calves treated for BRD was lower than controls (0 vs 46.4). The second study yielded the same results for both performance and percent of calves treated for BRD (12.1 vs 32.8). In the third study, there was a third treatment group that only received antibiotics if their rectal temperature was ≥ 39.7ºC. The two antibiotic treatment groups tended to have higher ADG, and did have increased DMI and feed efficiencies when compared to controls. They also had a lower percentage of calves treated for BRD (11.9 and 12.9 vs 43.6 for the two antibiotic treatments, respectively vs controls). In another study examining the metaphylactic use of tilmicosin, Guthrie et al. (2004) found respiratory morbidity to be decreased from days 0 to 28 for animals receiving antibiotics. They also observed that mass medication increased final weights and improved ADG from days 0 to 102 and tended to increase ADG from days 0 to 191. Interestingly, when they compared ADG of healthy and sick calves at reimplant time (102 DOF) they found ADG was improved for healthy mass medicated calves when compared to controls that had never been treated for respiratory illness. This was also true for sick calves from the mass medication treatment when compared to sick calves from the control treatment. These data suggest that although some calves are not observed to be morbid, they may in fact be experiencing subclinical disease for which the antibiotics are beneficial.

Literature Cited

Abdalla, H. O., D. G. Fox, & M. L. Thonney. 1988. Compensatory gain by holstein calves after underfeeding protein. J. Anim Sci. 66(10): 2687-2695.

Anderson, K. L., T. G. Nagaraja, & J. L. Morrill. 1987. Ruminal metabolic development in calves weaned conventionally or early. J. Dairy Sci. 70(5): 1000-1005.

Bergman, E. N. 1990. Energy contributions of volatile fatty acids from the gastrointestinal tract in various species. Physiol. Rev. 70(2): 567-590.

Berry, B. A., C. R. Krehbiel, A. W. Confer, D. R. Gill, R. A. Smith, & M. Montelongo. 2004. Effects of dietary energy and starch concentrations for newly received feedlot calves: I. growth performance and health. J. Anim Sci. 82(3): 837-844.

Bevans, D. W., K. A. Beauchemin, K. S. Schwartzkopf-Genswein, J. J. McKinnon, & T. A. McAllister. 2005. Effect of rapid or gradual grain adaptation on subacute acidosis and feed intake by feedlot cattle. J. Anim. Sci. 83(5): 1116-1132.

Brandt, R. T.,Jr, & S. J. Anderson. 1990. Supplemental fat source affects feedlot performance and carcass traits of finishing yearling steers and estimated diet net energy value. J. Anim Sci. 68(8): 2208-2216.

Brandt, R. T.,Jr, G. L. Kuhl, R. E. Campbell, C. L. Kastner, & S. L. Stroda. 1992. Effects of steam-flaked sorghum grain or corn and supplemental fat on feedlot performance, carcass traits, longissimus composition, and sensory properties of steers. J. Anim Sci. 70(2): 343-348.

Brent, B. E. 1976. Relationship of acidosis to other feedlot ailments. J. Anim Sci. 43(4): 930-935.

Brink, D. R., S. R. Lowry, R. A. Stock, & J. C. Parrott. 1990. Severity of liver abscesses and efficiency of feed utilization of feedlot cattle. J. Anim. Sci. 68(5): 1201-1207.

Brown, M. S., C. H. Ponce, & R. Pulikanti. 2006. Adaptation of beef cattle to high-concentrate diets: Performance and ruminal metabolism. J. Anim. Sci. 84 Suppl: E25-33.

Bryant, L. K., L. J. Perino, D. Griffin, A. R. Doster, & T. E. Wittum. 1999. Bovine Pract. 33(2): 163-173.

Bunting, L. D., J. M. Fernandez, D. L. Thompson Jr, & L. L. Southern. 1994. Influence of chromium picolinate on glucose usage and metabolic criteria in growing holstein calves. J. Anim Sci. 72(6): 1591-1599.

Carstens, G. E., D. E. Johnson, M. A. Ellenberger, & J. D. Tatum. 1991. Physical and chemical components of the empty body during compensatory growth in beef steers. J. Anim. Sci. 69(8): 3251-3264.

Carter, R. R., & W. L. Grovum. 1990. A review of the physiological significance of hypertonic body fluids on feed intake and ruminal function: Salivation, motility and microbes. J. Anim. Sci. 68(9): 2811-2832.

Chalupa, W. 1977. Manipulating rumen fermentation. J. Anim Sci. 45(3): 585-599.

Chang, X., & D. N. Mowat. 1992. Supplemental chromium for stressed and growing feeder calves. J. Anim Sci. 70(2): 559-565.

Chirase, N. K., D. P. Hutcheson, & G. B. Thompson. 1991. Feed intake, rectal temperature, and serum mineral concentrations of feedlot cattle fed zinc oxide or zinc methionine and challenged with infectious bovine rhinotracheitis virus. J. Anim Sci. 69(10): 4137-4145.

Chirase, N. K., D. P. Hutcheson, G. B. Thompson, & J. W. Spears. 1994. Recovery rate and plasma zinc and copper concentrations of steer calves fed organic and inorganic zinc and manganese sources with or without injectable copper and challenged with infectious bovine rhinotracheitis virus. J. Anim Sci. 72(1): 212-219.

Choat, W. T., C. R. Krehbiel, M. S. Brown, G. C. Duff, D. A. Walker, & D. R. Gill. 2002. Effects of restricted versus conventional dietary adaptation on feedlot performance, carcass characteristics, site and extent of digestion, digesta kinetics, and ruminal metabolism. J. Anim. Sci. 80(10): 2726-2739.

Clary, E. M., R. T. Brandt Jr, D. L. Harmon, & T. G. Nagaraja. 1993. Supplemental fat and ionophores in finishing diets: Feedlot performance and ruminal digesta kinetics in steers. J. Anim Sci. 71(11): 3115-3123.

Cole, N. A. 1985. Preconditioning calves for the feedlot. Vet. Clin. North Am. Food Anim. Pract. 1: 401.

Cole, N. A., & D. P. Hutcheson. 1990. Influence of dietary protein concentrations on performance and nitrogen repletion in stressed calves. J. Anim Sci. 68(11): 3488-3497.

Cole, N. A., & D. P. Hutcheson. 1988. Influence of protein concentration in prefast and postfast diets on feed intake of steers and nitrogen and phosphorus metabolism of lambs. J. Anim Sci. 66(7): 1764-1777.

Coverdale, J. A., H. D. Tyler, J. D. Quigley III, & J. A. Brumm. 2004. Effect of various levels of forage and form of diet on rumen development and growth in calves. J. Dairy Sci. 87(8): 2554-2562.

Drouillard, J. S., C. L. Ferrell, T. J. Klopfenstein, & R. A. Britton. 1991. Compensatory growth following metabolizable protein or energy restrictions in beef steers. J. Anim. Sci. 69(2): 811-818.

Duff, G. C., & M. L. Galyean. 2007. Board-invited review: Recent advances in management of highly stressed, newly received feedlot cattle. J. Anim. Sci. 85(3): 823-840.

Eadie, J. M., P. N. Hobson, & S. O. Mann. 1959. A relationship between some bacteria, protozoa and diet in early weaned calves. Nature. 183(4661): 624-625.

Engle, T. E., & J. W. Spears. 2000. Effects of dietary copper concentration and source on performance and copper status of growing and finishing steers. J. Anim Sci. 78(9): 2446-2451.

Engle, T. E., J. W. Spears, V. Fellner, & J. Odle. 2000. Effects of soybean oil and dietary copper on ruminal and tissue lipid metabolism in finishing steers. J. Anim Sci. 78(10): 2713-2721.

Felton, E. E. D., & M. S. Kerley. 2004. Performance and carcass quality of steers fed different sources of dietary fat. J. Anim Sci. 82(6): 1794-1805.

Fluharty, F. L., & S. C. Loerch. 1997. Effects of concentration and source of supplemental fat and protein on performance of newly arrived feedlot steers. J. Anim. Sci. 75(9): 2308-2316.

Fluharty, F. L., & S. C. Loerch. 1996. Effects of dietary energy source and level on performance of newly arrived feedlot calves. J. Anim Sci. 74(3): 504-513.

Fluharty, F. L., & S. C. Loerch. 1995. Effects of protein concentration and protein source on performance of newly arrived feedlot steers. J. Anim Sci. 73(6): 1585-1594.

Fluharty, F. L., S. C. Loerch, & F. E. Smith. 1994. Effects of energy density and protein source on diet digestibility and performance of calves after arrival at the feedlot. J. Anim Sci. 72(6): 1616-1622.

Foutz, C. P., H. G. Dolezal, T. L. Gardner, D. R. Gill, J. L. Hensley, & J. B. Morgan. 1997. Anabolic implant effects on steer performance, carcass traits, subprimal yields, and longissimus muscle properties. J. Anim Sci. 75(5): 1256-1265.

Franzolin, R., & B. A. Dehority. 1996. Effect of prolonged high-concentrate feeding on ruminal protozoa concentrations. J. Anim Sci. 74(11): 2803-2809.

Fulton, W. R., T. J. Klopfenstein, & R. A. Britton. 1979. Adaptation to high concentrate diets by beef cattle. I. adaptation to corn and wheat diets. J. Anim Sci. 49(3): 775-784.

Gallo, G. F., & J. L. Berg. 1995. Efficacy of a feed-additive antibacterial combination for improving feedlot cattle performance and health. Can. Vet. J. 36: 223-229.

Galyean, M. L., & K. S. Eng. 1998. Application of research findings and summary of research needs: Bud britton memorial symposium on metabolic disorders of feedlot cattle. J. Anim. Sci. 76(1): 323-327.

Galyean, M. L., S. A. Gunter, & K. J. Malcolm-Callis. 1995. Effects of arrival medication with tilmicosin phosphate on health and performance of newly received beef cattle. J. Anim Sci. 73(5): 1219-1226.

Galyean, M. L., L. J. Perino, & G. C. Duff. 1999. Interaction of cattle health/immunity and nutrition. J. Anim. Sci. 77(5): 1120-1134.

Gardner, B. A., H. G. Dolezal, L. K. Bryant, F. N. Owens, & R. A. Smith. 1999. Health of finishing steers: Effects on performance, carcass traits, and meat tenderness. J. Anim Sci. 77(12): 3168-3175.

Garza, J. D., Owens, F. N., and Breazile, J. E. 1989. Effects of diet on ruminal liquid and on blood serum osmolality and hematocrit in feedlot heifers.: 68-76.

Gerken, C. L., J. D. Tatum, J. B. Morgan, & G. C. Smith. 1995. Use of genetically identical (clone) steers to determine the effects of estrogenic and androgenic implants on beef quality and palatability characteristics. J. Anim Sci. 73(11): 3317-3324.

Glimp, H. A., S. P. Hart, & D. VonTungeln. 1989. Effect of altering nutrient density (concentrate to roughage ratio) and restricting energy intake on rate, efficiency and composition of growing lambs. J. Anim Sci. 67(4): 865-871.

Goad, D. W., C. L. Goad, & T. G. Nagaraja. 1998. Ruminal microbial and fermentative changes associated with experimentally induced subacute acidosis in steers. J. Anim. Sci. 76(1): 234-241.

Guthrie, C. A., K. C. Rogers, R. A. Christmas, G. J. Vogel, S. B. Laudert, & G. D. Mechor. 2004. Efficacy of methaphylactic tilmicosin for controlling bovine respiratory disease in high-risk northern feeder calves. Bovine Pract. 38(1): 46-53.

Haaland, G. L., J. K. Matsushima, D. E. Johnson, & G. M. Ward. 1981. Effect of replacement of corn by protected tallow in a cattle finishing diet on animal performance and composition. J. Anim Sci. 52(4): 696-702.

Henricks, D. M., R. T. Brandt Jr, E. C. Titgemeyer, & C. T. Milton. 1997. Serum concentrations of trenbolone-17 beta and estradiol-17 beta and performance of heifers treated with trenbolone acetate, melengestrol acetate, or estradiol-17 beta. J. Anim Sci. 75(10): 2627-2633.

Hicks, R. B., F. N. Owens, D. R. Gill, J. J. Martin, & C. A. Strasia. 1990. Effects of controlled feed intake on performance and carcass characteristics of feedlot steers and heifers. J. Anim. Sci. 68: 233-244.

Huber, T. L. 1976. Physiological effects of acidosis on feedlot cattle. J. Anim Sci. 43(4): 902-909.

Huntington, G. B., & R. A. Britton. 1979. Effect of dietary lactic acid on rumen lactate metabolism and blood acid-base status of lambs switched from low to high concentrate diets. J. Anim Sci. 49(6): 1569-1576.

Hutcheson, D. P., N. A. Cole, & J. B. McLaren. 1984. Effects of pretransit diets and post-transit potassium levels for feeder calves. J. Anim Sci. 58(3): 700-708.

Hutcheson, D. P., & N. A. Cole. 1986. Management of transit-stress syndrome in cattle: Nutritional and environmental effects. J. Anim Sci. 62(2): 555-560.

Jensen, R., H. M. Deane, L. J. Cooper, V. A. Miller, & W. R. Graham. 1954. The rumenitis-liver abscess complex in beef cattle. Am J. Vet. Res. 15: 202-216.

Kegley, E. B., J. W. Spears, & T. T. Brown Jr. 1997. Effect of shipping and chromium supplementation on performance, immune response, and disease resistance of steers. J. Anim Sci. 75(7): 1956-1964.

Knoblich, H. V., F. L. Fluharty, & S. C. Loerch. 1997. Effects of programmed gain strategies on performance and carcass characteristics of steers. J. Anim. Sci. 75(12): 3094-3102.

Koers, W. C., R. Britton, T. J. Klopfenstein, & W. R. Woods. 1976. Ruminal histamine, lactate and animal performance. J. Anim. Sci. 43(3): 684-691.

Krause, K. M., & G. R. Oetzel. 2006. Understanding and preventing subacute ruminal acidosis in dairy herds: A review. Animal Feed Science and Technology,. 126(3-4): 215-236.

Krehbiel, C. R., R. A. Britton, D. L. Harmon, T. J. Wester, & R. A. Stock. 1995a. The effects of ruminal acidosis on volatile fatty acid absorption and plasma activities of pancreatic enzymes in lambs. J. Anim. Sci. 73(10): 3111-3121.

Krehbiel, C. R., R. A. McCoy, R. A. Stock, T. J. Klopfenstein, D. H. Shain, & R. P. Huffman. 1995b. Influence of grain type, tallow level, and tallow feeding system on feedlot cattle performance. J. Anim Sci. 73(10): 2916-2921.

Kreikemeier, W. M., & T. L. Mader. 2004. Effects of growth-promoting agents and season on yearling feedlot heifer performance. J. Anim Sci. 82(8): 2481-2488.

Lake, R. P. 1986. Limit feeding high energy rations to growing cattle. Pages 305-313 in Symp. Proc. Feed Intake by Beef Cattle. Okla. Agric. Exp. Sta., Stillwater, OK.

Lawrence, J. D., & M. A. Ibarburu. 2007. Economic analysis of pharmaceutical technologies in modern beef production. Proceedings of the NCCC-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management. : 1-18.

Lee, B. and Lauder, S. 1984. Effects of bovatec, oxytetracycline (OTC), bovatec plus OTC and rumensin-tylan combination on feedlot performance and liver abscess control in finishing steers. Cattleman's Day Report of Progress. 651: 103-105.

Lengemann, F. W., & N. N. Allen. 1959. Development of rumen function in the dairy calf. II. effect of diet upon characteristics of the rumen flora and fauna of young calves. J. Dairy Sci. 42(7): 1171-1181.

Loerch, S. C., & F. L. Fluharty. 1998. Effects of programming intake on performance and carcass characteristics of feedlot cattle. J. Anim. Sci. 76(2): 371-377.

Lofgreen, G. P. 1988. Nutrition and management of stressed beef calves. an update. The Veterinary Clinics of North America. Food Animal Practice. 4(3): 509

Lofgreen, G. P., J. R. Dunbar, D. G. Addis, & J. G. Clark. 1975. Energy level in starting rations for calves subjected to marketing and shipping stress. J. Anim Sci. 41(5): 1256-1265.

Lofgreen, G. P. 1983. Mass medication in reducing shipping fever-bovine respiratory disease complex in highly stressed calves. J. Anim Sci. 56(3): 529-536.

Lofgreen, G. P., A. E. El Tayeb, & H. E. Kiesling. 1981. Millet and alfalfa hays alone and in combination with high-energy diet for receiving stressed calves. J. Anim Sci. 52(5): 959-968.

Lofgreen, G. P., & H. E. Kiesling. 1985. Effects of receiving and growing diets on compensatory gains of stressed calves. J. Anim Sci. 61(2): 320-328.

Lofgreen, G. P., L. H. Stinocher, & H. E. Kiesling. 1980. Effects of dietary energy, free choice alfalfa hay and mass medication on calves subjected to marketing and shipping stresses. J. Anim Sci. 50(4): 590-596.

Macartney, J. E., K. G. Bateman, & C. S. Ribble. 2003. Health performance of feeder calves sold at convential auctions versus special auctions of vaccinated or conditioned calves in Ontario. J. Am. Vet. Med. Assoc. 223: 677-683.

Montgomery, S. P., J. S. Drouillard, J. J. Sindt, M. A. Greenquist, B. E. Depenbusch, E. J. Good et al. 2005. Effects of dried full-fat corn germ and vitamin E on growth performance and carcass characteristics of finishing cattle. J. Anim Sci. 83(10): 2440-2447.

Murphy, T. A., S. C. Loerch, K. E. McClure, & M. B. Solomon. 1994. Effects of restricted feeding on growth performance and carcass composition of lambs. J. Anim. Sci. 72(12): 3131-3137.

Nagaraja, T. G., & M. M. Chengappa. 1998. Liver abscesses in feedlot cattle: A review. J. Anim. Sci. 76(1): 287-298.

Nagaraja, T. G., & K. F. Lechtenberg. 2007a. Acidosis in feedlot cattle. Vet. Clin. North Am. Food Anim. Pract. 23(2): 333-50, viii-ix.

Nagaraja, T. G., & K. F. Lechtenberg. 2007b. Liver abscesses in feedlot cattle. Vet. Clin. North Am. Food Anim. Pract. 23(2): 351-69, ix.

Nagaraja, T. G., Y. Sun, N. Wallace, K. E. Kemp, & C. J. Parrott. 1999. Effects of tylosin on concentrations of fusobacterium necrophorum and fermentation products in the rumen of cattle fed a high-concentrate diet. Am. J. Vet. Res. 60(9): 1061-1065.

Nagaraja, T. G., & E. C. Titgemeyer. 2007. Ruminal acidosis in beef cattle: The current microbiological and nutritional outlook. J. Dairy Sci. 90 Suppl 1: E17-38.

NAHMS. 2000. Feedlot '99 part II: Baseline reference of feedlot health and health management. Available: http://nahms.aphis.usda.gov/feedlot/feedlot99/FD99pt2.pdf Accesed on October, 22, 2007.

Narayanan, S., T. G. Nagaraja, O. Okwumabua, J. Staats, M. M. Chengappa, & R. D. Oberst. 1997. Ribotyping to compare fusobacterium necrophorum isolates from bovine liver abscesses, ruminal walls, and ruminal contents. Appl. Environ. Microbiol. 63(12): 4671-4678.

Nelson, M. L., D. J. Marks, J. R. Busboom, J. D. Cronrath, & L. Falen. 2004. Effects of supplemental fat on growth performance and quality of beef from steers fed barley-potato product finishing diets: I. feedlot performance, carcass traits, appearance, water binding, retail storage, and palatability attributes. J. Anim Sci. 82(12): 3600-3610.

Neumann, A. L., & K. S. Lusby. 1986. Receiving Programs for Stressed Stocker and Feeder Cattle. Pages 153-168 in Beef Cattle. Eighth ed. Jon Wiley & Sons, United States.

Ngidi, M. E., S. C. Loerch, F. L. Fluharty, & D. L. Palmquist. 1990. Effects of calcium soaps of long-chain fatty acids on feedlot performance, carcass characteristics and ruminal metabolism of steers. J. Anim Sci. 68(8): 2555-2565.

NRC. 1976. Nurtrient requirements of beef cattle. NRC. 5th Edition

Orr, C. L., D. P. Hutcheson, R. B. Grainger, J. M. Cummins, & R. E. Mock. 1990. Serum copper, zinc, calcium and phosphorus concentrations of calves stressed by bovine respiratory disease and infectious bovine rhinotracheitis. J. Anim Sci. 68(9): 2893-2900.

Osborne, T. B., L. B. Mendel, & With the cooperation of Edna L. Ferry and Alfred J. Wakeman,. 1915. The resumption of growth after long continued failure to grow. J. Biol. Chem. 23(2): 439-454.

Owens, F. N., D. S. Secrist, W. J. Hill, & D. R. Gill. 1998. Acidosis in cattle: A review. J. Anim. Sci. 76(1): 275-286.

Perry, T. W., J. G. Riley, M. T. Mohler, & R. V. Pope. 1986. Use of chlortetracycline for treatment of new feedlot cattle. J. Anim Sci. 62(5): 1215-1219.

Plascencia, A., M. Estrada, & R. A. Zinn. 1999. Influence of free fatty acid content on the feeding value of yellow grease in finishing diets for feedlot cattle. J. Anim Sci. 77(10): 2603-2609.

Reinhardt, C. D., R. T. Brandt Jr, T. P. Eck, & E. C. Titgemeyer. 1998. Performance, digestion, and mastication efficiency of holstein steers fed whole or processed corn in limit- or full-fed growing-finishing systems. J. Anim. Sci. 76(7): 1778-1788.

Rivera, J. D., M. L. Galyean, & W. T. Nichols. 2004. Review: Dietary roughage concentration and health of newly received cattle. Prof Anim Sci. 21: 345-351.

Rogers, J. A., M. E. Branine, C. R. Miller, M. I. Wray, S. J. Bartle, R. L. Preston et al. 1995. Effects of dietary virginiamycin on performance and liver abscess incidence in feedlot cattle. J. Anim Sci. 73(1): 9-20.

Rossi, J. E., S. C. Loerch, S. J. Moeller, & J. P. Schoonmaker. 2001. Effects of programmed growth rate and days fed on performance and carcass characteristics of feedlot steers. J. Anim Sci. 79(6): 1394-1401.

Rumsey, T. S., K. McLeod, T. H. Elsasser, S. Kahl, & R. L. Baldwin. 2000. Performance and carcass merit of growing beef steers with chlortetracycline-modified sensitivity to pituitary releasing hormones and fed two dietary protein levels. J. Anim Sci. 78(11): 2765-2770.

Sainz, R. D., F. De la Torre, & J. W. Oltjen. 1995. Compensatory growth and carcass quality in growth-restricted and refed beef steers. J. Anim. Sci. 73(10): 2971-2979.

Schwartzkopf-Genswein, K. S., K. A. Beauchemin, D. J. Gibb, D. H. Crews Jr., D. D. Hickman, M. Streeter et al. 2003. Effect of bunk management on feeding behavior, ruminal acidosis and performance of feedlot cattle: A review. J. Anim Sci. 81(14_suppl_2): E149-158.

Siciliano-Jones, J., & M. R. Murphy. 1989. Production of volatile fatty acids in the rumen and cecum-colon of steers as affected by forage: Concentrate and forage physical form. J. Dairy Sci. 72(2): 485-492.

Slyter, L. L. 1976. Influence of acidosis on rumen function. J. Anim Sci. 43(4): 910-929.

Smith, H. A. 1944. Ulcerative lesions of the bovine rumen and their possible relation to hepatic abscesses. Am. J. Vet. Res. 5: 234-242.

Smith, R. A. 1998. Impact of disease on feedlot performance: A review. J. Anim. Sci. 76(1): 272-274.

Snowder, G. D., L. D. Van Vleck, L. V. Cundiff, & G. L. Bennett. 2006. Bovine respiratory disease in feedlot cattle: Environmental, genetic, and economic factors. J. Anim Sci. 84(8): 1999-2008.

Spears, J. W., & E. B. Kegley. 2002. Effect of zinc source (zinc oxide vs zinc proteinate) and level on performance, carcass characteristics, and immune response of growing and finishing steers. J. Anim Sci. 80(10): 2747-2752.

Stock, R. A., M. H. Sindt, J. C. Parrott, & F. K. Goedeken. 1990. Effects of grain type, roughage level and monensin level on finishing cattle performance. J. Anim Sci. 68(10): 3441-3455.

Stovall, T. C., D. R. Gill, R. A. Smith, & R. L. Ball. 2000. Impact of bovine respiratory disease during the receiving period on feedlot performance and carcass traits. 2000 Oklahoma State Animal Science Research Report. : 82-86.

Tajima, K., R. I. Aminov, T. Nagamine, H. Matsui, M. Nakamura, & Y. Benno. 2001. Diet-dependent shifts in the bacterial population of the rumen revealed with real-time PCR. Appl. Environ. Microbiol. 67(6): 2766-2774.

Tan, Z. L., T. G. Nagaraja, & M. M. Chengappa. 1996. Fsuobacterium necrophorum infections: Virulence factors, pathogenic mechanism and control measures. Vet. Res. Commun. 20: 113-140.

Therion, J. J., A. Kistner, & J. H. Kornelius. 1982. Effect of pH on growth rates of rumen amylolytic and lactilytic bacteria. Appl. Environ. Microbiol. 44(2): 428-434.

Thompson, P. N., A. Stone, & W. A. Schultheiss. 2006. Use of treatment records and lung lesion scoring to estimate the effect of respiratory disease on growth during early and late finishing periods in south african feedlot cattle. J. Anim Sci. 84(2): 488-498.

Ward, J. D., G. P. Gengelbach, & J. W. Spears. 1997. The effects of copper deficiency with or without high dietary iron or molybdenum on immune function of cattle. J. Anim Sci. 75(5): 1400-1408.

Ward, J. D., & J. W. Spears. 1999. The effects of low-copper diets with or without supplemental molybdenum on specific immune responses of stressed cattle. J. Anim Sci. 77(1): 230-237.

Weigand, E., J. W. Young, & A. D. McGilliard. 1975. Volatile fatty acid metabolism by rumen mucosa from cattle fed hay or grain. J. Dairy Sci. 58(9): 1294-1300.

White, B. 2007. Evaluating the sick calf. Beef stocker conference, Manhattan, Kansas.

Wittum, T. E., N. E. Woollen, L. J. Perino, & E. T. Littledike. 1996. Relationships among treatment for respiratory tract disease, pulmonary lesions evident at slaughter, and rate of weight gain in feedlot cattle. J. Am. Vet. Med. Assoc. 209(4): 814-818.

Xiong, Y., S. J. Bartle, & R. L. Preston. 1991. Density of steam-flaked sorghum grain, roughage level, and feeding regimen for feedlot steers. J. Anim. Sci. 69(4): 1707-1718.

Zinn, R. A. 1989. Influence of level and source of dietary fat on its comparative feeding value in finishing diets for steers: Feedlot cattle growth and performance. J. Anim Sci. 67(4): 1029-1037.

Zinn, R. A. 1988. Comparative feeding value of supplemental fat in finishing diets for feedlot steers supplemented with and without monensin. J. Anim Sci. 66(1): 213-227.

Zinn, R. A., M. K. Song, & T. O. Lindsey. 1991. Influence of ardacin supplementation on feedlot performance and digestive function of cattle. J. Anim Sci. 69(4): 1389-1396.

CHAPTER 2 - The Effects of Limit-feeding a High-concentrate Diet as a Means of Ruminal Adaptation on Dry Matter Intake and VFA Absorption

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Abstract

Four ruminally-cannulated steers (initial BW = 430 kg) were used in a 2 × 2 switchback design to compare the effects of a conventional 4-diet step-up program to limit-feeding a finishing diet as a means of ruminal adaptation to high concentrate diets. Steers were individually fed either: (1) three conventional step-up diets followed by a finishing diet (beginning with 60% and ending with 92% concentrate), starting at 1.5% of BW (STEP); or (2) limit-fed the finishing diet (92% concentrate), starting at 1.25% BW (LIMIT). Daily programmed increases of either 0.45 kg (STEP) or 0.23 kg (LIMIT) were provided when less than 0.23 kg of feed remained in the bunk 24 h after feeding. At the end of each week steers were given a 1L pulse dose of 1 M solution of valerate through the ruminal cannula and then ruminal fluid samples were collected over an 8 h period. This was done as a marker for VFA absorption from the rumen. Following the 4 week period (7 d/step) steers were placed in an outdoor pen and allowed free choice access to prairie hay and fed 2.27 kg soybean meal per steer for 21d. After all cattle reached *ad libitum* intake of the finishing diet, DMI as a % of BW was unaffected by treatment. During week 1, valerate absorption was higher in the LIMIT steers ($P = 0.02$). However, following week 4 valerate absorption favored the STEP cattle ($P = 0.05$). Differences in total VFA and DMI during week 1 are a result of experimental design but the difference in valerate absorption after adaptation may suggest the conventional step-up diets are beneficial for rumen development and nutrient absorption. Limit-feeding a finishing diet to adapt cattle to a high concentrate diet is effective when comparing DMI to that of conventionally adapted cattle, but the resulting decrease in nutrient absorption may not compensate for the decrease in ration costs. In addition, application of a limit-fed diet may be difficult in large pen settings.

Introduction

Allowing ruminal microorganisms to progressively adjust to a lower pH that commonly accompanies feeding of high-concentrate diets is the basis for the traditional practice of feeding a series of step-up diets with increasing concentrations of grain. Ruminal disturbances such as subacute acidosis and erratic intake, which commonly occur due to overconsumption of grain, can be reduced by allowing cattle time to adapt to these more energy dense diets. Limit-feeding cattle as a means of ruminal adaptation may pose several benefits for producers. The cost per unit of dietary energy can be decreased by removing forage from the diet and replacing it with grain (Brown et al., 2006). Other benefits may include decreased costs of handling and storing of roughages, increased mill efficiency, and decreased costs resulting from manure handling (Lake, 1986). Feed efficiency has been improved when high-concentrate diets were fed at restricted levels. This improvement was seen by Zinn (1986) and Loerch (1990) when steers were programmed to gain at predetermined rates. Restricting feed to some percentage of *ad libitum* consumption has also been beneficial to feed efficiency (Plegge, 1986; Hicks et al., 1990). Restricting intake on the basis of maintenance energy requirements has also improved efficiency (Xiong et al., 1991; Bartle and Preston, 1992). Limit-feeding high-concentrate diets may also have beneficial effects on variation of feed intake, potentially reducing the risk of subacute acidosis (Soto-Navarro et al., 2000). Additionally, limit-feeding of the finishing diet has been used as a replacement feeding strategy for the traditional step-up diets commonly found in production scenarios (Bierman and Pritchard, 1996; Weichenthal et al., 1999; Choat et al., 2002). The objectives of this study were to examine the effects of feeding traditional step-up diets versus limit-feeding the finishing diet on DMI and ruminal fermentation and to examine the effects of method of dietary adaptation on ruminal VFA production and disappearance.

Materials and Methods

Ruminally-cannulated, crossbred steers (n = 4; initial BW = 430 kg) were used in a 2 × 2 switchback design to compare a traditional feedlot diet step-up program versus limit-feeding the finishing diet as a means of ruminal adaptation. Cattle were housed in a tie-stall barn at the Kansas State University Dairy Teaching and Research Unit in Manhattan, KS. Prior to initiation of the experiment steers were housed in an outdoor pen and allowed *ad libitum* access to long-stem prairie hay and were fed 2.27 kg of soybean meal daily. Upon initiation of the study steers

were randomly assigned to one of two treatments: 1) *ad libitum* access to three sequential step-up diets increasing in concentrate from 60 – 81% concentrate followed by a 92% concentrate finishing diet (STEP); or 2) restricted intake of the 92% concentrate finishing diet (LIMIT). Cattle were fed over a 28-d period with 7 d/step. STEP steers were started at 1.5% of their BW DMI and feed offered was increased 0.45 kg/d when 0.23 kg or less remained in the bunk 24 h post-feeding. LIMIT steers were started at 1.25% of their BW DMI and feed offered was increased 0.23 kg/d when refusals were less than 0.23 kg 24 h post-feeding. Steers were fed once daily at 1600 h. Dry matter intake was documented each day and weight and DM content of refusals was determined. Refused DM was removed from the total intake of that steer for the subsequent day.

Sampling

Diets were mixed twice a week and subsamples were taken on the same day that the diets were mixed. At the end of the experiment samples were composited by concentrate level. These samples were ground, using a Wiley mill, to pass a 2-mm screen and stored until later analysis for NDF and CP. On d 0, 7, 14, 21, and 28, at approximately 0700, steers were pulse-dosed with a 1 L solution of 1 M valerate. The solution also contained 4 g/L of Co-EDTA and the pH of the solution was adjusted to 6.0. Ruminal fluid was collected at 0, 0.5, 1, 1.5, 2, 3, 4, 6, and 8 h after dosing. Two mL of 25% (wt/vol) metaphosphoric acid was used to acidify an 8 mL aliquot of fluid. This was frozen (-20°C) for later analysis for VFA and Co.

Liquid passage rates were calculated as the slope of the line where the natural logarithm of Co concentration was regressed over time. From these fractional passage rates were determined and turnover of ruminal liquid was calculated. Rumen volume was estimated by dividing the dose of Co given by the Co concentration at time zero. The slope of the line where the natural logarithm of valerate concentration was regressed over time was considered to be the rate of valerate disappearance. The rate of valerate absorption was then calculated as the rate of valerate disappearance minus liquid passage rate (Val abs = Val disappearance – liquid passage rate).

Laboratory analysis

Percent DM was determined for ground feed samples based on procedures outlined by Undersander et al. (1993). The combustion method was used to determine Nitrogen content of feed samples (Leco FP2000, St. Joseph, MI; AOAC 1996). Neutral detergent fiber of feed

samples was analyzed using the Ankom method (Ankom 200, Fairport, NY; AOAC 1996). After thawing, ruminal fluid samples were centrifuged at $30,000 \times g$ for 20 min. An atomic absorption spectrometer was used to determine Co concentrations in ruminal fluid (AA spectrometer 3110, Waltham, MA). Volatile fatty acid concentrations were determined by gas chromatography (Hewlett-Packard 5890, Santa Clara, CA).

Statistical analysis

All data were analyzed using the random effects MIXED model procedure of the Statistical Analysis System (SAS Institute, Cary, NC). Dry matter intake was analyzed with a model statement that included diet and day. For this analysis steer and period were included as random variables. All remaining data were analyzed with a model statement that included diet, week, and time. For these analyses steer and period were again included as random variables. Means were considered to be statistically significant when $P \leq 0.05$.

Results and Discussion

Experimental diets are presented in Table 1. Dry matter intake was higher during week 1 through 3 for STEP steers ($P < 0.01$); however, this was due to experimental design. During week 4 STEP cattle tended to have increased DMI ($P = 0.09$). Overall DMI intake was higher for STEP steers, which was expected due to design ($P < 0.01$). This was similar to Choat et al. (2002) who observed that restricting intake of steers to 1.25% of BW when feeding the finishing diet as a means of adaptation reduced overall DMI intake during a 70 d feeding period. Acetate-to-propionate ratio was unaffected by diet during any of the weeks. Total VFA was higher in weeks 1 and 3 and tended to be higher during week 2 for STEP cattle; however, during week 4 LIMIT cattle had higher total VFA (Table 2). These findings are similar to Rumsey et al. (1970) who observed that as intake increases so does total VFA concentration. On the contrary, Merchen et al. (1986) and Choat et al. (2002) saw no differences in total VFA concentration when feeding wethers at high and low levels of intake, and restricting steers to 1.65% of BW, respectively. Total valerate disappearance tended to be higher during week 1 for cattle being fed the finishing diet at restricted levels ($P = 0.08$). During week 4 this effect was reversed and STEP adapted steers had increased total valerate disappearance. Valerate absorbance followed a similar trend as it was higher for LIMIT steers during week 1 and tended to be higher for the same group during week 2, but during week 4 STEP cattle had higher valerate disappearance

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(Table 2). Allen et al. (2000) observed that valerate, a short-chain fatty acid with low ruminal concentrations, was not metabolized by mixed ruminal microbes during 20 h *in vitro* incubations. In a follow-up study performed by Resende Jr. et al. (2006), the valerate-cobalt technique used in this experiment was shown to produce results similar to those observed when using a ^{13}C-labeled VFA technique. They concluded that it was a reliable method for determining ruminal clearance of VFA and that it could be used to predict fractional clearance rates of acetate, propionate, and butyrate. No other ruminal parameters measured were affected by type of adaptation to the finishing diet. The changes observed in total VFA concentrations may be explained by the higher level of intake by STEP steers in week 1 and conversely, the higher level of intake by LIMIT steers in week 4. When cattle are fed high grain diets the molar proportion of acetate is reduced and molar proportions of propionate, butyrate, and valerate are increased (Coe et al., 1999). In addition, the acid-tolerant bacteria *Megasphera elsdenii* metabolizes lactate to several VFAs, one of which is valerate. Large increases in butyrate and valerate concentrations have also been observed when monensin was fed and this was attributed to *M. elsdenii* activity (Nagaraja et al., 1985; Coe et al., 1999). As a result, it could be speculated that the decreased valerate disappearance and absorption observed in this study is merely a result of a more acidic rumen environment in which *M. elsdenii* activity is increased. This would cause increased production of valerate and could affect its disappearance and absorption rates. The valerate-cobalt technique has previously been shown to be effective in forage-fed animals; however, its application may be limited in concentrate-fed animals due to increased production of valerate.

Implications

Based on the findings of this experiment, limit-feeding the finishing diet can be used for dietary adaptation and similar results can be seen for DMI once all cattle achieve *ad libitum* intake of the finishing diet. However, based on the higher total VFA concentration and lower total valerate disappearance and valerate absorption observed during week 4 for LIMIT steers, this method of adaptation may lead to changes in the animal's ability to absorb nutrients. Nutrient absorption may also be unaffected and limit-feeding may simply result in higher intakes when cattle are offered feed *ad libitum*, which may increase total VFA concentrations and result in a more active lactate utilizing bacteria population.

Literature Cited

Allen, M. S., L. E. Armentano, M. N. Pereira, Y. Ying, and J. Xu. 2000. Method to measure fractional rate of volatile fatty acid absorption from the rumen. Page 26 in Proc. 25th Conf. Rumen Function, Chicago, IL.

AOAC. 1996. Official Methods of Analysis. 16th ed. Assoc. Offic. Anal. Chem., Arlington, VA.

Bartle, S. J., and R. L. Preston. 1992. Roughage level and limited maximum intake regimens for feedlot steers. J. Anim. Sci. 70(11): 3293-3303.

Bierman, S. J., and R. H. Pritchard. 1996. Effect of feed delivery management on yearling steer performance. South Dakota Beef Report. Available: http://ars.sdstate.edu/BeefEXT/BeefReports/1996/96-5.htm. Accessed Jan. 20, 2008.

Brown, M. S., C. H. Ponce, and R. Pulikanti. 2006. Adaptation of beef cattle to high-concentrate diets: Performance and ruminal metabolism. J. Anim. Sci. 84 Suppl: E25-33.

Choat, W. T., C. R. Krehbiel, M. S. Brown, G. C. Duff, D. A. Walker, and D. R. Gill. 2002. Effects of restricted versus conventional dietary adaptation on feedlot performance, carcass characteristics, site and extent of digestion, digesta kinetics, and ruminal metabolism. J. Anim. Sci. 80(10): 2726-2739.

Coe, M. L., T. G. Nagaraja, Y. D. Sun, N. Wallace, E. G. Towne, K. E. Kemp, and J. P. Hutcheson. 1999. Effect of virginiamycin on ruminal fermentation in cattle during adaptation to a high concentrate diet and during an induced acidosis. J. Anim. Sci. 77:2259-2268.

Hicks, R. B., F. N. Owens, D. R. Gill, J. J. Martin, and C. A. Strasia. 1990. Effects of controlled feed intake on performance and carcass characteristics of feedlot steers and heifers. J. Anim. Sci. 68: 233-244.

Lake, R. P. 1986. Limit feeding high energy rations to growing cattle. Pages 305-313 in Symp. Proc. Feed Intake by Beef Cattle. Okla. Agric. Exp. Sta., Stillwater.

Loerch, S. C. 1990. Effects of feeding growing cattle high-concentrate diets at a restricted intake on feedlot performance. J. Anim. Sci. 68(10): 3086-3095.

Merchen, N. R., J. L. Firkins, and L. L. Berger. 1986. Effect of intake and forage level on ruminal turnover rates, bacterial protein synthesis and duodenal amino acid flows in sheep. J. Anim Sci. 62(1): 216-225.

Nagaraja, T. G., T. B. Averay, S. J. Galitzer, and D. L. Harmon. 1985. Effect of ionophores antibiotics on experimentally induced lactic acidosis in cattle. Am. J. Vet. Res. 46:2444-2452.

Plegge, S. D. 1986. Restricting intake of feedlot cattle. Pages 297-301 in Symp. Proc. Feed Intake by Beef Cattle. Okla. Agric. Exp. Sta., Stillwater, OK.

Resende Junior, J. C., M. N. Pereira, H. Boer, and S. Tamminga. 2006. Comparison of techniques to determine the clearance of ruminal volatile fatty acids. J. Dairy Sci. 89(8): 3096-3106.

Rumsey, T. S., P. A. Putnam, J. Bond, and R. R. Oltjen. 1970. Influence of level and type of diet on ruminal pH and VFA, respiratory rate and EKG patterns of steers. J. Anim Sci. 31(3): 608-616.

Soto-Navarro, S. A., C. R. Krehbiel, G. C. Duff, M. L. Galyean, M. S. Brown, and R. L. Steiner. 2000. Influence of feed intake fluctuation and frequency of feeding on nutrient digestion, digesta kinetics, and ruminal fermentation profiles in limit-fed steers. J. Anim. Sci. 78(8): 2215-2222.

Undersander, D., D. R. Mertens, and N. Thiex. 1993. Forage Analysis Procedures. National Forage Testing Assoc. Omaha, NE.

Weichentahl, B., I. Rush, and B. Van Pelt. 1999. Dietary management for starting finishing yearling steers on feed. Pages 44-46 in Nebraska Beef Cattle Report. Inst. Agric. Nat. Res., Lincoln, NE.

Xiong, Y., S. J. Bartle, and R. L. Preston. 1991. Density of steam-flaked sorghum grain, roughage level, and feeding regimen for feedlot steers. J. Anim. Sci. 69(4): 1707-1718.

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(6): 2013-2017.

Table 2.1 Experimental diets and formulated dietary nutrients of steers fed 3 conventional step-up diets (STEP) or limit-fed the finishing diet (LIMIT) as a means of adaptation.

	% Concentrate			
Ingredient, % DM basis	**60**	**71**	**81**	**92**
Steam-flaked corn	49.51	60.04	70.56	81.09
Ground alfalfa hay	40.00	29.33	18.67	8.00
Steep liquor, corn	5.00	5.00	5.00	5.00
Vitamin-mineral premix	3.26	3.40	3.55	3.68
Feed additive premix[a]	2.23	2.23	2.23	2.23
Nutrient Composition (formulated), %				
CP	14.71	14.48	14.24	14.00
Ca	0.70	0.73	0.75	0.78
P	0.35	0.35	0.35	0.36
NDF	27.17	22.73	21.56	15.94
NE_m, Mcal/kg	1.84	1.94	2.08	2.18
NE_g, Mcal/kg	1.21	1.31	1.40	1.50

[a]Feed additive premix was formulated to provide 300 mg monensin and 90 mg tylosin.

Figure 2.1 Daily DMI of steers fed 3 conventional step-up diets (STEP) or limit-fed the finishing diet (LIMIT) as a means of adaptation.

Diet effect P = 0.04; SEM = 0.07
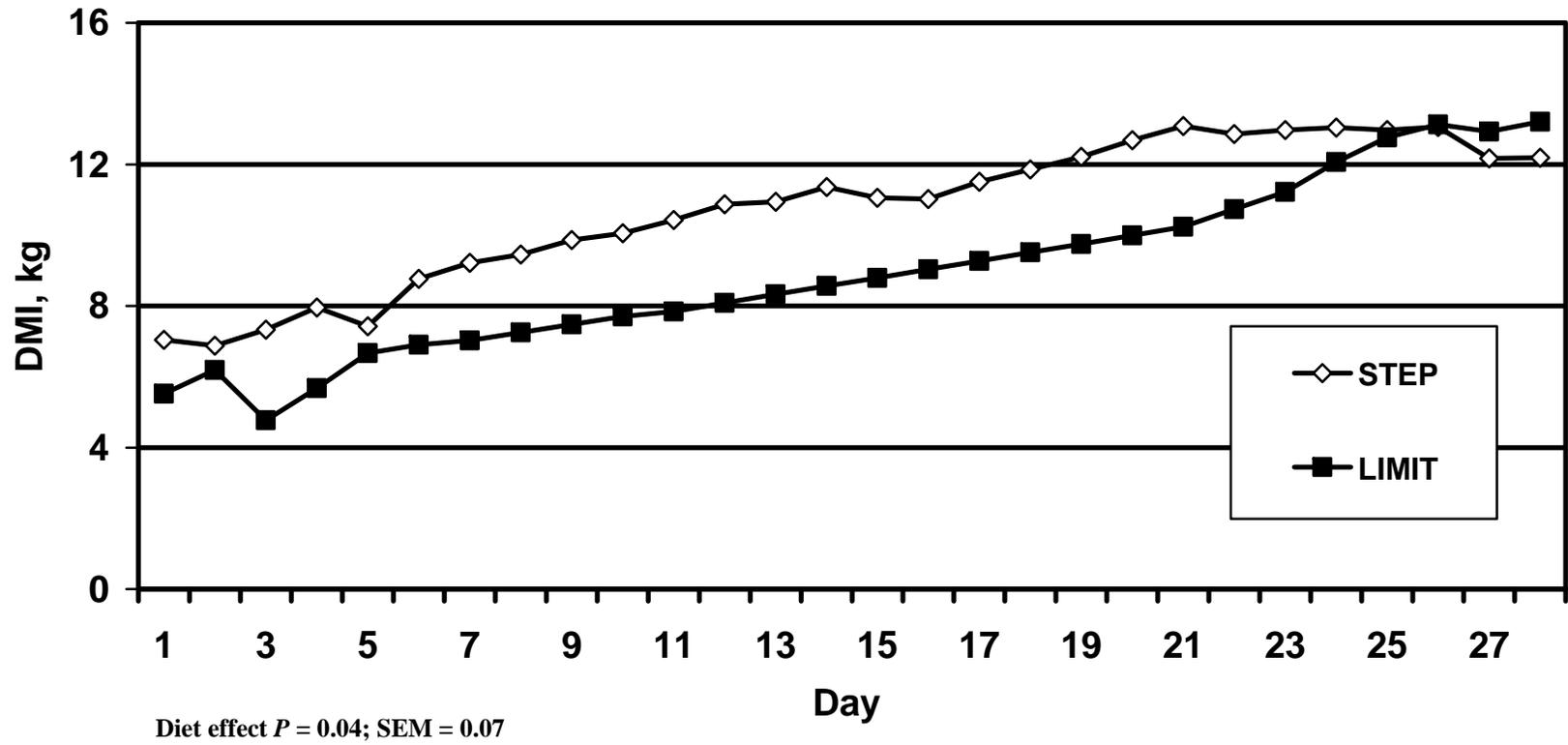
Table 2.2 Ruminal effects of conventional dietary adaptation (STEP) vs. limited intake of the finishing diet (LIMIT).

Item	Treatment[a]		SEM[b]	*P*-value
	STEP	LIMIT		
Week 1				
A:P	1.49	1.42	0.14	0.61
Total VFA, mM/L	116.34	99.67	9.42	0.02
Total valerate disappearance, %/h	0.39	0.56	0.06	0.08
Liquid dilution rate	0.13	0.09	0.03	0.41
Valerate absorption, %/h	0.27	0.46	0.06	0.02
Rumen volume, L	27.16	29.30	6.88	0.79
Liquid turnover, h	8.50	13.90	2.36	0.19
Week 2				
A:P	1.38	1.23	0.07	0.18
Total VFA, mM/L	132.84	108.89	8.85	0.06
Total valerate disappearance, %/h	0.39	0.48	0.04	0.17
Liquid dilution rate	0.13	0.07	0.03	0.20
Valerate absorption, %/h	0.26	0.41	0.05	0.09
Rumen volume, L	28.67	34.55	8.70	0.58
Liquid turnover, h	10.85	39.97	19.91	0.34
Week 3				
A:P	1.00	1.04	0.07	0.73
Total VFA, mM/L	120.82	97.52	10.42	0.04
Total valerate disappearance, %/h	0.65	0.69	0.17	0.76
Liquid. dilution rate	0.10	0.10	0.03	0.94
Valerate absorption, %/h	0.55	0.59	0.17	0.81
Rumen volume, L	39.81	35.85	8.50	0.69
Liquid turnover, h	15.94	11.37	4.13	0.45
Week 4				
A:P	1.64	1.77	0.44	0.48
Total VFA, mM/L	99.85	107.81	2.80	0.03
Total valerate disappearance, %/h	0.67	0.39	0.09	0.05
Liquid dilution rate	0.13	0.16	0.05	0.81
Valerate absorption, %/h	0.55	0.23	0.08	0.05
Rumen volume, L	28.19	22.44	5.56	0.36
Liquid turnover, h	9.48	13.09	5.17	0.58

[a]STEP = steers fed three step up diets and a finishing diet increasing from 60 to 92% concentrate; LIMIT = steers fed restricted amounts of the 92% concentrate diet as a means of adaptation.
[b]SEM = Standard error of the least squares means; n = 4 steers/trt.

CHAPTER 3 - Evaluation of Dried Corn Germ in Finishing Cattle Produced Under a Natural Feeding Regimen

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Abstract

An experiment was conducted to evaluate the effects of dried, full-fat corn germ (GERM) used as a supplemental fat source on feedlot performance, carcass characteristics, and the incidence of liver abscesses in cattle raised without antibiotics or exogenous growth promotants. In this experiment, 4,199 head of yearling steers and heifers were sorted on an every-other-head basis into 26 pens. They were allowed *ad libitum* access to steam-flaked corn based diets containing 0 or 5% GERM on a DM basis. The number of days on feed were not different between the two treatments ($P = 0.41$). Feeding 5% GERM had no effect on final BW or daily DMI ($P > 0.58$). Average daily gain was improved ($P = 0.04$) for cattle receiving GERM when final BW was determined on a carcass adjusted basis (HCW/0.635). Feeding GERM had no effect on F:G ($P > 0.21$). The percent of cattle that were removed from the natural program as a result of being treated for illness was unaffected by treatment ($P = 0.44$) and there was a tendency ($P = 0.06$) for percent death loss to be increased in cattle receiving GERM (0.07 vs 0.73% for Control and 5% Germ, respectively). Hot carcass weight, dressing percentage, and USDA Quality and Yield grades were not affected by treatment ($P \geq 0.15$). The addition of GERM decreased overall incidence of liver abscesses ($P = 0.01$). The percentage of livers affected by mild and moderate abscesses were not different ($P \geq 0.11$) between treatments; however, severely abscessed livers were reduced by 8.2% ($P = 0.02$). These data suggest that GERM can be used as a supplemental fat source in finishing diets fed to naturally raised cattle without negatively affecting performance or carcass characteristics. In addition, supplementing diets fed to naturally raised cattle with GERM may help reduce the incidence and severity of liver abscesses, which could be beneficial to producers who are not able to use feed grade antibiotics as a result of raising cattle for natural programs.

Introduction

Changes in consumer preference for beef produced without growth promotants, ionophores, or antibiotics, and consumers' willingness to pay price premiums for such products, has led some producers to begin raising beef under a "natural" regimen. These "naturally" raised animals are those that never receive injectable or feed additive antibiotics or ionophores, or growth-promotant implants at any point during their lives. The challenge that this creates for producers is raising animals efficiently while combating disease and digestive and metabolic disorders.

Without the use of feed additive antibiotics and ionophores, one of the key problems facing producers feeding cattle under a natural regimen is ruminal acidosis and subsequent liver abscesses. Acidosis is commonly linked with liver abscesses (Brent, 1976; Nagaraja and Lechtenberg, 2007). Brink et al. (1990) found the prevalence of liver abscesses in most feedlots to range from 12 to 32%. Economically, this can lead to condemnation of the liver, and severe abscesses have been shown to decrease daily gains and reduce efficiency (Brink et al., 1990). In addition, severely abscessed livers can also lead to carcass trim that will further reduce hot carcass weight, which can reduce dressing percentages (Nagaraja and Lechtenberg, 2007). *Fusobacterium necrophrum* and *Arcanobacterium (Actinomyces) pyogenes* are believed to be the primary and secondary bacteria which cause liver abscesses and are normal inhabitants of the bovine rumen (Tan et al., 1996). Acidosis resulting in rumenitis, which allows bacteria to penetrate the rumen wall, enter the portal circulation and travel to the liver, is believed to be the primary pathway in which these bacteria cause liver abscesses (Brent, 1976; Nagaraja and Chengappa, 1998; Nagaraja and Lechtenberg, 2007).

Montgomery et al. (2005) observed a decrease in the number of abscessed livers of approximately 5 to 7% when including dried, full-fat corn germ (GERM) in the diets of finishing steers and heifers at rates ranging from 5 to 15% when compared to controls. These diets also included tylosin which is commonly used to control liver abscesses (Brown et al., 1975; Brink et al., 1990). Montgomery et al. (2005) speculated that adding GERM to the diet may decrease starch or alter intake patterns resulting in decreased bouts of acidosis and subsequent rumenitis or it may suppress the growth of *Fusobacterium necrophorum*, both of which could lead to decreased liver abscesses. The latter of these hypotheses was refuted by Montgomery et al.

(2008), when observing a tendency for increased concentrations of *Fusobacterium necrophorum* when feeding supplemental fat at a rate of 4%.

The objectives of this experiment were to assess the impact of supplemental fat in the form of GERM on growth performance, carcass yield and quality grades, and incidence of liver abscesses when fed to finishing cattle as part of a natural feeding regimen applied under commercial feeding conditions.

Materials and Methods

Yearling Angus and Angus-cross steers and heifers (n = 4,199; initial BW = 348±5.78 kg) were used to characterize feedlot performance, health, incidence of liver abscess and carcass traits of feedlot cattle produced under a "natural" feeding regimen with and without the addition of GERM to the finishing diet. Cattle were housed at a commercial feedlot in central Kansas. Prior to initiation of the experiment, cattle were grazing ryegrass or grass pasture. At processing cattle were vaccinated for viral (Titanium IBR™, AgriLabs; St. Joseph, MO) and clostridial (Vision 7™, Intervet, Inc.; Millsboro, DE) diseases, and given an external parasiticide (Ivermax™, RX Veterinary Products; Memphis, TN), tagged with color-coded pen tags, and sorted into treatments on an every-other-head basis. After processing, cattle were weighed on a group scale and placed in their respective pens. There were no mixed sex pens and steers and heifers were equally represented in both treatments.

Following a step-up period of two to three weeks, cattle were placed on one of two finishing diets primarily composed of steam-flaked corn. Diets were either: 1) a traditional finishing diet containing no corn germ (Control) or 2) the traditional finishing diet with 5% of the corn replaced with 5% dried corn germ on a dry matter basis (5% Germ).

Prior to shipment to a commercial abattoir in Lexington, NE, cattle were sorted based on visual appraisal of fatness by feedlot personnel and those being shipped were weighed. Days on feed, dry matter intake, ADG, G:F, morbidity and death loss were calculated for each pen of cattle. Slaughter data collected included HCW, incidence and severity of liver abscess, and dressing percentage. Additionally, USDA yield grade and USDA quality grades were determined by USDA graders.

Laboratory analysis

Samples were taken from each load of GERM delivered to the feedlot and analyzed for dry matter. Neutral detergent fiber of feed samples was analyzed using the Ankom method (Ankom 200, Fairport, NY; AOAC, 2002). Samples were also analyzed for crude protein using the combustion method (Leco FP2000; Leco Corp., St. Joseph, MI) and crude fat (Goldfisch Extractor; Labconco, Kansas City, MO).

Statistical analysis

Growth performance and carcass data were analyzed using the GLM procedure of SAS (SAS Inst., Inc., Cary, NC). Pen was used as the experimental unit and model effects included sex and treatment. Initial head count was included as a covariate to account for differences in pen size. Values were determined to be statistically different when $P \leq 0.05$.

Results and Discussion

Finishing performance, carcass characteristics, and liver abscesses of cattle fed 0 or 5% GERM are presented in tables 3 through 5. No sex × treatment interactions ($P \geq 0.11$) were observed; therefore, only main effects of finishing treatment are presented. Days on feed was not different between the two treatments ($P = 0.39$). There is little research concerning fat supplementation to finishing cattle that examines days on feed. Theoretically, it could be assumed that adding moderate levels of fat to finishing diets would increase the energy density of the diet allowing those animals to finish quicker and reduce days on feed. Bock et al. (1991) observed tendencies for both increased in backfat and yield grade when adding soybean oil or tallow at 3.5% of the diet DM compared to controls. Montgomery et al. (2005) also saw a linear increase in backfat when feeding 0, 5, 10, or 15% GERM. They also observed a quadratic increase in the percentage of yield grade 4 carcasses, with steers receiving 15% GERM in their diets having the greatest percentage. These studies would indicate that these cattle may possibly need less days on feed to reach the same body composition endpoint as cattle receiving no added fat in their diets; however, it is important to note that different sources and levels of added fat may cause different outcomes in intake, efficiency, and fat measurements. Initial and final body weights were not different between the two treatments ($P \geq 0.71$). These results are similar to Ludden et al. (1995) who observed no differences in final body weight of finishing steers when adding 5% lard to their diet. Conversely, Engle et al. (2000) observed a tendency for decreased

final weights when adding 4% soybean oil to diets. Dry matter intake was not different for cattle fed 5% germ when compared to those in the control treatment. Previous researchers have also seen no difference in DMI when feeding supplemental fat in cattle diets (Zinn, 1989; Brandt and Anderson, 1990; Brandt et al., 1992). In contrast, Montgomery et al. (2005) reported that when GERM was added to a dry-rolled corn diet at 5, 10, and 15% there was a linear decrease in DMI. These authors also observed a decrease in DMI when feeding tallow at 4% or GERM at 10 and 15% of a steam-flaked corn diet in a second experiment. Krehbiel et al. (1995) also observed a linear decrease in DMI when feeding steer calves a dry-rolled corn based diet with 2 or 4% added tallow. Ramirez and Zinn (2000) observed decreased DMI when feeding 4% tallow, yellow grease, or griddle grease to yearling steers receiving a steam-flaked corn based diet. It is possible that the reason we observed no effect of fat supplementation on DMI is due to the level of fat that was added to the diet. In the above experiments, fat was generally supplemented at levels of 4% of the diet DM or higher; whereas, in our experiment adding 5% GERM to the diet is equivalent to approximately 2.25% added fat.

Adding GERM to the diet resulted in increased average daily gain ($P = 0.04$) when adjusted HCW were used to adjust the final BW. Previous reports on the effects of supplemental fat on ADG have been variable. Several authors have reported improved ADG when adding fat to cattle diets (Zinn, 1989; Brandt and Anderson, 1990; Montgomery et al., 2005). Conversely, other studies have reported no effect (Brandt et al., 1992; Ramirez and Zinn, 2000) or decreased ADG (Hatch et al., 1972) when diets are supplemented with fat. The differences in statistical significance of ADG may be reflective of the differences in final weights obtained with these two methods (Table 3) combined with numerically lower days on feed for cattle consuming GERM. This would result in larger differences in ADG due to a larger difference in final weights obtained by adjusting for HCW, which favored the 5% Germ treatment. In addition, adding supplemental fat to finishing diets has been shown to increase carcass weight, carcass fat, and KPH, which would play a role in final weights obtained by adjusting HCW (Zinn, 1992).

Adding GERM to the diet did not affect F:G ($P \geq 0.21$). This agrees with other authors who have also reported no change in feed efficiency when adding fat to finishing diets (Hatch et al., 1972; Buchanan-Smith et al., 1974). However, improved feed efficiency has been a more common result of supplementing finishing cattle with fat. Brandt and Anderson (1990) reported improved feed efficiency for steers fed a flaked milo diet containing 3.5% added fat in the form

of soybean oil, tallow, or yellow grease. Similarly, Ramirez and Zinn (2000) fed yearling steers a steam-flaked corn based diet containing 4% added fat in the form of tallow, yellow grease, or griddle grease and observed improved feed efficiency for cattle supplemented with fat over that of the controls.

The percent of cattle that fell out of the natural program due to being treated for illness was not affected by treatment ($P = 0.47$). Percent death loss tended ($P = 0.06$) to be increased for cattle receiving 5% GERM in their diet; however, death loss was minimal in both treatments and affected less than 1% of the animals (0.07 vs 0.74 for Controls vs 5% Germ, respectively).

Except for liver abscesses, all carcass traits measured were unaffected by finishing treatment ($P \geq 0.15$). Similar results were obtained by Krehbiel et al. (1995) when feeding calves 0, 2 or 4% tallow for the entire feeding period. No differences were observed for HCW, QG, or YG in this experiment. Brandt et al. (1992) also saw no differences in carcass characteristics when adding 4% yellow grease to diets based on steam-flaked corn or sorghum grain. In addition, Hatch et al. (1972) added 3 or 6% animal fat to dry-rolled corn based diets and observed no effects of fat supplementation on carcass characteristics. In contrast to the above experiments, Zinn (1989) reported linear increases in HCW, KPH, marbling score, and retail yield when feeding steers 0, 4, or 8% supplemental fat. Brandt and Anderson (1990) fed a flaked milo diet containing 3.5% added fat in the form of soybean oil, tallow or yellow grease. They observed heavier HCW when adding yellow grease to the diet and increased dressing percentages for cattle supplemented with fat when compared to controls. Montgomery et al. (2005) observed linear increases in fat thickness and KPH and a quadratic increase in USDA Yield Grade 4 carcasses when increasing amounts of GERM were added to steam-flaked corn diets.

The incidence of liver abscess was reduced by 12% when GERM was added to the diet (67.9 vs 55.9%; $P = 0.01$). The percent of mild (A-) abscesses was unaffected by treatment ($P = 0.97$). The percentage of moderate (A) abscesses tended ($P = 0.11$) to be reduced and severe (A+) abscesses were reduced by 8.2% when GERM was added to the diet. These results are similar to Montgomery et al. (2005). They observed a linear decrease in the incidence of liver abscesses in two experiments when cattle were fed increasing levels of GERM. Liver abscesses are believed to occur when *Fusobacterium necrophorum* enters the portal circulation, subsequently colonizing in the liver. This is speculated to be the result of acidosis and resulting

rumenitis (Nagaraja and Chengappa, 1998). In this experiment, GERM replaced steam-flaked corn in the diets, which may have resulted in decreased starch intake, and as a result, the possibility of a decreased incidence of acidosis and subsequent rumenitis. It could also be speculated that the decrease in incidence of liver abscesses is the result of some component of the GERM altering rumen fermentation or inhibiting some portion of the pathway in which liver abscesses are developed.

Implications

The results of this experiment indicate that GERM can be used as a replacement for steam-flaked corn in finishing diets for naturally-raised cattle. Average daily gain was improved by adding 5% GERM to finishing diets. No other performance and carcass characteristics were improved nor negatively affected by adding 5% GERM to diet. In addition, adding GERM to the diet may help control the incidence of liver abscess in naturally-raised cattle, which is a problem many producers of naturally-raised beef encounter in the absence of the use of tylosin or other antibiotics.

Literature Cited

Bock, B. J., D. L. Harmon, R. T. Brandt Jr, and J. E. Schneider. 1991. Fat source and calcium level effects on finishing steer performance, digestion, and metabolism. J. Anim Sci. 69(5): 2211-2224.

Brandt, R. T.,Jr, and S. J. Anderson. 1990. Supplemental fat source affects feedlot performance and carcass traits of finishing yearling steers and estimated diet net energy value. J. Anim Sci. 68(8): 2208-2216.

Brandt, R. T.,Jr, G. L. Kuhl, R. E. Campbell, C. L. Kastner, and S. L. Stroda. 1992. Effects of steam-flaked sorghum grain or corn and supplemental fat on feedlot performance, carcass traits, longissimus composition, and sensory properties of steers. J. Anim Sci. 70(2): 343-348.

Brent, B. E. 1976. Relationship of acidosis to other feedlot ailments. J. Anim Sci. 43(4): 930-935.

Brink, D. R., S. R. Lowry, R. A. Stock, and J. C. Parrott. 1990. Severity of liver abscesses and efficiency of feed utilization of feedlot cattle. J. Anim. Sci. 68(5): 1201-1207.

Brown, H., R. F. Bing, H. P. Grueter, J. W. McAskill, C. O. Cooley, and R. P. Rathmacher. 1975. Tylosin and chlortetracycline for the prevention of liver abscesses, improved weight gains and feed efficiency in feedlot cattle. J. Anim Sci. 40(2): 207-213.

Buchanan-Smith, J. G., G. K. Macleod, and D. N. Mowat. 1974. Animal fat in low-roughage diets for ruminants: The effects of nitrogen source and an amino acid supplement. J. Anim Sci. 38(1): 133-139.

Engle, T. E., J. W. Spears, V. Fellner, and J. Odle. 2000. Effects of soybean oil and dietary copper on ruminal and tissue lipid metabolism in finishing steers. J. Anim Sci. 78(10): 2713-2721.

Hatch, C. F., T. W. Perry, M. T. Mohler, and W. M. Beeson. 1972. Effect of added fat with graded levels of calcium to urea-containing rations for beef cattle. J. Anim Sci. 34(3): 483-487.

Krehbiel, C. R., R. A. McCoy, R. A. Stock, T. J. Klopfenstein, D. H. Shain, and R. P. Huffman. 1995. Influence of grain type, tallow level, and tallow feeding system on feedlot cattle performance. J. Anim Sci. 73(10): 2916-2921.

Ludden, P. A., M. J. Cecava, and K. S. Hendrix. 1995. The value of soybean hulls as a replacement for corn in beef cattle diets formulated with or without added fat. J. Anim Sci. 73(9): 2706-2711.

Montgomery, S. P., J. S. Drouillard, T. G. Nagaraja, E. C. Titgemeyer, and J. J. Sindt. 2008. Effects of supplemental fat source on nutrient digestion and ruminal fermentation in steers. J. Anim Sci. 86(3): 640-650.

Montgomery, S. P., J. S. Drouillard, J. J. Sindt, M. A. Greenquist, B. E. Depenbusch, E. J. Good et al. 2005. Effects of dried full-fat corn germ and vitamin E on growth performance and carcass characteristics of finishing cattle. J. Anim Sci. 83(10): 2440-2447.

Nagaraja, T. G., and M. M. Chengappa. 1998. Liver abscesses in feedlot cattle: A review. J. Anim. Sci. 76(1): 287-298.

Nagaraja, T. G., and K. F. Lechtenberg. 2007. Liver abscesses in feedlot cattle. Vet. Clin. North Am. Food Anim. Pract. 23(2): 351-69, ix.

Ramirez, J. E., and R. A. Zinn. 2000. Interaction of dietary magnesium level on the feeding value of supplemental fat in finishing diets for feedlot steers. J. Anim. Sci. 78(8): 2072-2080.

Tan, Z. L., T. G. Nagaraja, and M. M. Chengappa. 1996. Fusobacterium necrophorum infections: Virulence factors, pathogenic mechanism and control measures. Vet. Res. Commun. 20: 113-140.

Zinn, R. A. 1989. Influence of level and source of dietary fat on its comparative feeding value in finishing diets for steers: Feedlot cattle growth and performance. J. Anim Sci. 67(4): 1029-1037.

Zinn, R. A. 1988. Comparative feeding value of supplemental fat in finishing diets for feedlot steers supplemented with and without monensin. J. Anim Sci. 66(1): 213-227.

Zinn, R. A. 1992. Comparative feeding value of supplemental fat in steam-flaked corn- and steam-flaked wheat-based finishing diets for feedlot steers. J. Anim Sci. 70(10): 2959-2569.

Table 3.1 Experimental diets and nutrient composition (formulated) for cattle fed 0 or 5% full-fat corn germ during the finishing period (dry matter basis).

| | | | | Finishing Treatment | | | |
| | Step-up diets[a] | | | Control | | 5% Germ | |
Item,	1	2	3	4	5	4	5
Steam-flaked corn	45.1	55.2	64.2	72.8	78.5	70.3	73.5
Corn germ	--	--	--	--	--	2.6	5.1
Alfalfa hay	41.3	31.5	21.2	11.9	4.7	11.8	5.9
Sorghum silage	2.6	2.6	2.6	2.6	2.3	2.6	2.2
Soybean straw	2.4	2.4	2.4	2.4	3.6	2.4	2.4
Wet distillers grains	6.1	4.5	4.6	4.6	4.6	4.6	4.6
Mineral supplement	2.5	3.8	5.0	5.7	6.3	5.7	6.3
Nutrient Compostion							
Crude protein, %	14.73	14.23	14.05	13.63	13.32	13.69	13.59
Crude fat, %	3.73	3.76	3.90	4.03	4.11	5.08	6.20
Ca, %	0.90	0.87	0.85	0.78	0.76	0.78	0.75
P, %	0.32	0.32	0.32	0.33	0.33	0.33	0.34
K, %	1.08	0.97	0.86	0.76	0.68	0.76	0.69
NEm, Mcal/kg	36.16	38.15	40.07	41.95	43.11	42.71	44.70
NEg, Mcal/kg	23.32	25.09	26.83	28.49	29.54	28.98	30.58

[a]Step-up diets were fed to all cattle and diets 4 and 5 were fed to the animals in each respective treatment only.

Table 3.2 Laboratory analysis of dried full-fat corn germ samples taken from each load of corn germ delivered to the feedlot (dry matter basis).

Sample date	Dry Matter	Crude Protein	Crude Fat	NDF
03/19/2007	96.19	12.13	41.84	37.45
05/03/2007	96.55	12.88	45.16	34.61
06/14/2007	98.17	12.23	45.87	31.90
08/06/2007	98.08	12.16	45.61	34.34
09/05/2007	99.03	11.89	42.92	39.03
10/02/2007	97.12	12.49	45.70	34.39
10/23/2007	97.27	12.44	45.52	33.33
11/20/2007	97.32	12.50	46.71	36.56
12/17/2007	97.32	12.79	44.91	34.19
01/19/2008	98.13	12.40	45.11	31.42
Mean	97.52	12.39	44.94	34.72
Standard Deviation	0.843	0.302	1.458	2.374

Table 3.3 Feedlot performance of cattle fed 0 (Control) or 5% full-fat corn germ (5% Germ) during the finishing period.

| Item | Treatment | | SEM | *P*-value |
	Control	5% Germ		
Number of head	2,102	2,097		
Number of pens	13	13		
Days on feed	173	168	4.76	0.41
Initial wt, kg	348	347	5.78	0.95
Final wt, kg[a]	559	556	5.21	0.61
DMI, kg/d	9.83	9.94	0.14	0.60
ADG, kg/d	1.23	1.24	0.02	0.63
F:G	8.05	8.01	0.13	0.85
Carcass Adjusted				
Final wt, kg[b]	547	551	4.92	0.58
DMI, kg/d	9.83	9.94	0.14	0.60
ADG, kg/d	1.15	1.22	0.02	0.04
F:G	8.59	8.22	0.21	0.21
Fallouts, %[c]	0.21	0.32	0.11	0.44
Death loss, %	0.07	0.73	0.24	0.06

[a]Calculated as final body weight × 0.96.
[b]Calculated as HCW/0.635.
[c]Fallouts were cattle that were removed from the natural program due to being treated for illness with a medication that is not allowed to given to cattle qualifying for the natural program.

Table 3.4 Carcass characteristics of cattle fed 0 (Control) or 5% full-fat corn germ (5% Germ) during the finishing period.

Item	Treatment		SEM	*P*-value
	Control	5% Germ		
Carcass wt, kg	348	350	3.115	0.61
Dressing percentage[a]	61.9	62.6	0.430	0.23
USDA Quality grade, %				
Prime	2.4	3.4	0.794	0.39
Premium choice	39.6	36.5	2.952	0.44
Low choice	44.3	47.1	2.716	0.47
Select	12.6	12.6	1.768	1.00
Standard	0.9	0.4	0.223	0.15
USDA Yield grade, %				
YG 1	0.5	0.8	0.242	0.37
YG 2	23.5	19.7	3.637	0.45
YG 3	59.6	60.8	3.055	0.77
YG 4	15.3	17.3	2.356	0.55
YG 5	1.1	1.4	0.386	0.57

[a]Calculated as HCW/(final weight × 0.96).

Table 3.5 Liver abscesses in cattle fed 0 (Control) or 5% full-fat corn germ (5% Germ) during the finishing period.

Item, %	Treatment		SEM	*P*-value
	Control	5% Germ		
Total abscesses	67.9	55.9	2.965	0.01
Mild abscesses[a]	27.3	27.2	1.337	0.97
Moderate abscesses[b]	18.6	14.9	1.582	0.11
Severe abscesses[c]	21.9	13.7	2.382	0.02

[a]Mild = livers with one or two small abscesses.
[b]Moderate = livers with two to four well organized abscesses less than one inch in diameter.
[c]Severe = livers with one or more large abscesses.

CHAPTER 4 - Effects of Concurrent Metaphylaxis Using Chlortetracycline and Tulathromycin on High-Risk Cattle Health and Performance

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Abstract

High-risk stocker calves were delivered to the Kansas State University Beef Stocker Unit in November of 2007 and March of 2008 (n = 463, initial BW = 447 lb). Upon arrival calves were weighed, tagged, and given *ad libitum* access to long-stem prairie hay and water. The following day calves were vaccinated against clostridial and viral diseases, dewormed, given tulathromycin (1.1mL/100 lb or 1.1mL/45.4 kg), and bull calves were castrated. Treatments consisted of three growing diets top dressed with either no pellets (Con); pellets containing chlortetracycline (4 g/lb or 8.89 g/kg) administered at a rate of 10 mg/lb (22.1 mg/kg) BW for two 5 d intervals with a 1 d break in between (CTC); or pellets containing no chlortetracycline fed in the same amount per unit BW (1.12 lb/hd) and for the same time period as the CTC treatment (PP). All calves were weighed at the end of the separate 41 d receiving periods and performance and health data were analyzed. No differences were found between treatments for any of the performance criteria measured on a deads in or deads out basis. In addition, no differences were found for morbidity or mortality among the three treatments.

Introduction

The shipping and receiving period is one of the most stressful experiences during the lifetime of a calf. Stressors include weaning, commingling, transportation, processing, feed and water changes, and disease challenge placed on the animal upon entering a stocker operation or feedlot (Hutcheson and Cole, 1986). Two major results of these stressors are decreased appetite and loss of body mass (Hutcheson and Cole, 1986). This combination of stressors leads to decreased immunity and increased risk of disease. The bovine respiratory disease complex (BRDC) is a significant and costly disease of the feedlot industry (Smith, 1998; NAHMS, 2000). This disease complex affects the highest percentage of placements and has one of the highest treatment costs of all diseases affecting feedlot cattle (NAHMS, 2000). In addition to treatment costs and death loss, respiratory disease can negatively impact feedlot performance (Wittum et al., 1996; Bryant et al., 1999; Thompson et al., 2006) and carcass characteristics (Gardner et al., 1999) of animals resulting in decreased profit.

There are a number of choices producers have for preparing calves to go into feedlot operations. Vaccination, preconditioning and backgrounding have all shown benefits in terms of reducing morbidity. Preconditioning should increase farm gains, reduce transit shrink, and improve feedlot health and performance while improving profits (Cole, 1985). Vaccination and preconditioning programs can reduce the likelihood of a calf being treated for BRD during the first 28 days after arrival the feedlot (Macartney et al., 2003). Beef producers have the opportunity to enhance immunity through pre-weaning management and vaccination programs (Galyean et al., 1999). However, not all producers find an economic incentive to preconditioning or vaccinating their cattle. In such cases, when calves that are considered to be at high risk for contracting BRD enter the feedyard, they can be mass medicated with a number of treatment regimens.

Mass medication is the treatment of all cattle at arrival processing in spite of observed health status (Neumann and Lusby, 1986). It can also be done by feeding antibiotics in the ration to all cattle. Several antibiotics are available for metaphylactic treatment of animals upon arrival. Two of these drugs are chlortetracycline and tulathromycin. Chlortetracycline has been shown to improve performance of high-risk calves (Perry et al., 1986; Loerch and Fluharty, 1998). In addition, feeding chlortetracycline has decreased morbidity (Gallo and Berg, 1995). Tulathromycin has been shown to increase average daily gain (Booker et al., 2007), decrease

morbidity (Booker et al., 2007; Schunicht et al., 2007; Step et al., 2007)**,** and decrease mortality (Booker et al., 2007; Schunicht et al., 2007)**,** when compared to metaphylactic treatment using florfenicol, oxytetracycline, tilmicosin phosphate, or ceftiofur crystalline free acid. However, there is no research examining the effects of concurrent metaphylaxis using tulathromycin and chlortetracycline. Therefore, the objective of this study was to examine the effects of concurrent metaphylaxis using tulathromycin and chlortetracycline upon arrival on high-risk stocker calf health and performance.

Materials and Methods

Two 41 day receiving studies were conducted at the Kansas State University Beef Stocker Unit during November of 2007 and March of 2008 to determine the response of high risk stocker calves to concurrent metaphylaxis with tulathromycin and chlortetracycline. All cattle were sourced from an order buyer in Tennessee. Prior to each study cattle were received over three consecutive days. Upon arrival all calves were weighed, tagged, mass medicated with tulathromycin (Draxxin®, 1.1 mL/100 lb, Pfizer Inc.; Exton, PA), and palpated for sex (bull or steer). Calves were then given *ad libitum* access to long stem prairie hay and water over night. The following day calves were vaccinated against clostridial (Cavalry 9™, Schering Plough Animal Health; Summit, NJ) and respiratory diseases (Bovishield Gold 5™, Pfizer Inc.; Exton, PA), dewormed (Ivomec Plus®, Merial; Duluth, GA), and bulls were surgically castrated. Calves that arrived in March were also poured for lice (Cylence®, Bayer Animal Health; Shawnee Mission, KS). Each load was then blocked by arrival date and placed within one of 3 feed alleys (6 pens/alley) and randomly assigned to one of the three treatments for a total of 18 pens/study. Castrated bulls were equally distributed among the six pens within each alley. Cattle were weighed and revaccinated 12 days following initial processing and were weighed again following the 41 d feeding period. Calves were stepped up using three growing diets ranging from 29% to 36.5% concentrate (Table 1). Diets were fed with the addition of the following treatments: no top dress pellets (Con); top dressed with chlortetracycline-containing pellets (CTC); or top dressed with the same pellets that did not contain any chlortetracycline (PP). The CTC treatment was top dressed at a level to supply cattle 10 mg of CTC per pound of BW (22.22 mg/kg). The PP pellets were top dressed at an equal amount per unit BW as the CTC pellets. CTC and PP treatments were top dressed for two periods that lasted for five days (d 1 to 5 and d

7 to 11). Cattle were observed daily for signs of illness and injury by personnel blinded to treatments. Calves were treated for respiratory disease only following a moratorium of 5 d post-metaphylaxis with tulathromycin. All cattle were treated according to standard protocol as described in the stocker unit Standardized Operating Procedures (SOP) for animal health. In this SOP, calves that were determined to need treatment were given 100 mg/mL enrofloxacin (5 mL/100 lb or 5 mL/45.35 kg; Baytril®, Bayer Animal Health; Shawnee Mission, KS) as a first treatment and returned to their home pens. Calves were then reevaluated after 48 hours and if they required a second treatment they were given 300 mg/mL florfenicol (6 mL/100 lb or 6 mL/45.35 kg; Nuflor®, Schering-Plough Animal Health; Summit, NJ). Calves were then returned to their home pens and reevaluated after 48 h to determine if further treatment was necessary. If calves were determined to need a third treatment they were given 200 mg/mL oxytetracycline (4.5 mL/100 lb or 4.5 mL/45.35 kg).

Bunks were checked at approximately 0630 and 1430 h daily, after which the amount of feed to be delivered to each pen of calves was determined. Feed was delivered in amounts sufficient to result in slick bunks both morning and afternoon. The calves were fed at approximately 0700 and 1500 h daily. These calves were fed their respective diets for 41 days.

Cattle were weighed on d 0 and 41. Daily DMI was determined for each pen of calves along with daily gains and feed efficiencies. Health records were used to determine the number of animals treated and percent death loss.

Statistical analysis

Performance and health data were analyzed using the random effects MIXED model procedure of the Statistical Analysis System (SAS Institute, Cary, NC). Treatment was included in the model as a fixed effect and study and start date were included as a random variables. Values were determined to be statistically different when $P \leq 0.10$.

Results and Discussion

Performance data are presented in table 2. Initial body weight was different among the three treatments as a result of animals within each load being blocked by alley and randomized to pens by body weight and sex (bull vs. steer). Final BW was also different among the three treatments; however, it is reflective of initial weights with the PP calves having the heaviest final BW, the CTC calves having the lowest final BW and the CON calves being intermediate. Daily

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DMI was affected by treatment ($P = 0.09$). It followed the same pattern as initial and final BW (PP consumed the most feed and CTC consumed the least). Average daily gain and feed efficiency were not affected by treatment ($P > 0.39$). Similar results were seen by Lofgreen, (1983) when feeding chlortetracycline and sulfamethazine to calves. Other authors have also found no differences in average daily gain or feed efficiency when feeding chlortetracycline (Rumsey et al., 2000; Reid et al., 2006). In contrast to these data, chlortetracycline has been shown to increase daily gains and improve feed efficiency when fed alone or in combination with sulfamethazine (Perry et al., 1986; Loerch and Fluharty, 1998). Feeding chlortetracycline following mass medication with both oxytetracycline and sulfadimethoxine (Lofgreen, 1983) or tilmicosin phosphate (Duff et al., 2000) has produced little to no effect on calf performance.

Health data are presented in table 3. The percentage of total animals removed from their pens due to illness was unaffected by treatment (P = 0.80). In addition, the percentage removed due to respiratory disease was also not different among the three treatments (P = 0.80). The percentage of animals removed twice and percentage of calves retreated due to respiratory disease did not differ among the three treatments (P > 0.38). Additionally, there were no differences in death loss among the three treatments (P = 0.25). Other authors have also noted no differences in calf health when feeding chlortetracycline alone or in combination with sulfamethazine (Perry et al., 1971; Lofgreen, 1983; Reid et al., 2006). Duff et al., (2000) also saw no differences in morbidity or mortality of calves when using concurrent tilmicosin phosphate and feed additive chlortetracycline for metaphylactic treatment of calves. However, Lofgreen (1983) observed significant decreases in the number of calves treated and treatment days/calf purchased when feeding chlortetracycline following treatment with injectable oxytetracycline followed by sulfadimethoxine.

Implications

This experiment showed no additive effects of metaphylaxis using tulathromycin concurrently with two 5-day periods where chlortetracycline was fed. This data may be beneficial to producers when designing treatment protocols for newly received high-risk stocker calves.

Literature Cited

Booker, C. W., S. M. Abutarbush, O. C. Schunicht, G. K. Jim, T. Perrett, B. K. Wildman et al. 2007. Evalutation of the efficacy of tulathromycin as a metaphylactic antimicrobila in feedlot calves. Vet. Ther. 8(3): 183-200.

Bryant, L. K., L. J. Perino, D. Griffin, A. R. Doster, & T. E. Wittum. 1999. Bovine Pract. 33(2): 163-173.

Duff, G. C., D. A. Walker, K. J. Malcolm-Callis, M. W. Wiseman, & D. M. Hallford. 2000. Effects of preshipping vs. arrival medication with tilmicosin phosphate and feeding chlortetracycline on health and performance of newly received beef cattle. J. Anim Sci. 78(2): 267-274.

Gallo, G. F., & J. L. Berg. 1995. Efficacy of a feed-additive antibacterial combination for improving feedlot cattle performance and health. Can. Vet. J. 36: 223-229.

Gardner, B. A., H. G. Dolezal, L. K. Bryant, F. N. Owens, & R. A. Smith. 1999. Health of finishing steers: Effects on performance, carcass traits, and meat tenderness. J. Anim Sci. 77(12): 3168-3175.

Hutcheson, D. P., & N. A. Cole. 1986. Management of transit-stress syndrome in cattle: Nutritional and environmental effects. J. Anim Sci. 62(2): 555-560.

Loerch, S. C., & F. L. Fluharty. 1998. Effects of programming intake on performance and carcass characteristics of feedlot cattle. J. Anim. Sci. 76(2): 371-377.

Lofgreen, G. P. 1983. Mass medication in reducing shipping fever-bovine respiratory disease complex in highly stressed calves. J. Anim Sci. 56(3): 529-536.

Macartney, J. E., K. G. Bateman, & C. S. Ribble. 2003. Health performance of feeder calves sold at conventional auctions versus special auctions of vaccinated or conditioned calves in Ontario. J. Am. Vet. Med. Assoc. 223: 677-683.

NAHMS. 2000. Feedlot '99 part II: Baseline reference of feedlot health and health management. Available: http://nahms.aphis.usda.gov/feedlot/feedlot99/FD99pt2.pdf Accesed on October, 22, 2007.

Neumann, A. L., & K. S. Lusby. 1986. Receiving Programs for Stressed Stocker and Feeder Cattle. Pages 153-168 in Beef Cattle. Eighth ed. Jon Wiley & Sons, United States.

Perry, T. W., W. M. Beeson, M. T. Mohler, & R. B. Harrington. 1971. Value of chlortetracycline and sulfamethazine for conditioning feeder cattle after transit. J. Anim Sci. 32(1): 137-140.

Perry, T. W., J. G. Riley, M. T. Mohler, & R. V. Pope. 1986. Use of chlortetracycline for treatment of new feedlot cattle. J. Anim Sci. 62(5): 1215-1219.

Reid, E. D., P. S. Erickson, S. Hodgdon, E. Lennon, & P. C. W. Tsang. 2006. Chlortetracycline supplementation of yearling dairy heifers. J. Anim Sci. 84(9): 2406-2409.

Rumsey, T. S., K. McLeod, T. H. Elsasser, S. Kahl, & R. L. Baldwin. 2000. Performance and carcass merit of growing beef steers with chlortetracycline-modified sensitivity to pituitary releasing hormones and fed two dietary protein levels. J. Anim Sci. 78(11): 2765-2770.

Schunicht, O. C., C. W. Booker, P. T. Guichon, G. K. Jim, B. K. Wildman, T. J. Pittman et al. 2007. An evaluation of the relative efficacy of tulathromycin for the treatment of undifferentiated fever in feedlot calves in nebraska. Can. Vet. J. 48: 600-606.

Smith, R. A. 1998. Impact of disease on feedlot performance: A review. J. Anim. Sci. 76(1): 272-274.

Step, D. L., T. Engelken, C. Romano, B. Holland, C. Krehbiel, J. C. Johnson et al. 2007. Evaluation of three antimicrobial regimens used as metaphylaxis in stocker calves at high risk of developing bovine respiratory disease. Vet. Ther. 8(2): 136-147.

Thompson, P. N., A. Stone, & W. A. Schultheiss. 2006. Use of treatment records and lung lesion scoring to estimate the effect of respiratory disease on growth during early and late finishing periods in south african feedlot cattle. J. Anim Sci. 84(2): 488-498.

Wittum, T. E., N. E. Woollen, L. J. Perino, & E. T. Littledike. 1996. Relationships among treatment for respiratory tract disease, pulmonary lesions evident at slaughter, and rate of weight gain in feedlot cattle. J. Am. Vet. Med. Assoc. 209(4): 814-818.

Table 4.1 Experimental diets and formulated nutrient content for calves in fed no pellets (CON), fed pellets containing chlortetracycline (CTC), or pellets without chlortetracycline (PP) during the 41 day receiving studies.

Item,	Ration 1	Ration 2	Ration 3
Dry-rolled corn, %	30.00	30.67	36.76
Wet corn gluten feed, %	28.00	35.96	36.76
Alfalfa hay, %	23.00	15.49	15.01
Prairie hay, %	16.00	15.19	8.47
Mineral supplement,%	3.00	2.70	3.00
Nutrient composition (formulated)			
Crude Protein, %	16.07	16.54	16.21
Ether Extract, %	3.87	4.46	4.58
Ca, %	1.06	0.83	0.84
P, %	0.46	0.51	0.51
K, %	1.18	1.03	1.07
NE_M, Mcal/kg	0.43	0.45	0.46
NE_G, Mcal/kg	0.28	0.31	0.32

Table 4.2 Performance of calves receiving no pellets (CON), pellets containing chlortetracycline (CTC), or pellets without chlortetracycline (PP).

Item,	Treatment[a,b]			SEM	*P*-value
	CON	CTC	PP		
# Head	154	155	154		
# Pens	12	12	12		
Initial wt., lb	447[c,d]	442[c]	452[d]	5.72	0.07
Final wt., lb	576[c,d]	569[c]	584[d]	5.67	0.06
Daily DMI, lb	13.63[c,d]	13.46[c]	14.13[d]	0.285	0.09
ADG, lb	3.15	3.11	3.22	0.14	0.39
G:F, lb	0.229	0.233	0.230	0.011	0.50

[a]CON = fed three growing diets only; CTC = three growing diets top dressed with pellets containing chlortetracycline (4 g/ lb CTC) to provide 10 mg CTC per lb BW; PP = three growing diets top dressed with pellets containing no chlortetracycline administered at the same amount per unit of BW as those in the CTC treatment (1.12 lb/hd).
[b]Pellets were top dressed from d 1 to 5 and d 7 to 11.
[c,d]Numbers within the same row without common superscripts differ $P \leq 0.10$.

Table 4.3 Health of calves receiving no pellets (CON), pellets with chlortetracycline (CTC), or pellets without chlortetracycline (PP).

Item, %	Treatment[a,b]			SEM	*P*-value
	CON	CTC	PP		
Pulls	25.7	25.7	22.7	0.06	0.80
Respiratory pulls	24.4	25.1	22.0	0.06	0.80
2nd Pulls	2.0	2.5	2.0	0.01	0.38
2nd Respiratory pulls	4.6	5.5	4.4	0.01	0.64
Death loss	2.0	2.0	3.3	0.01	0.25

[a]CON = fed three growing diets only; CTC = three growing diets top dressed with pellets containing chlortetracycline (4 g/ lb CTC) to provide 10 mg CTC per lb BW; PP = three growing diets top dressed with pellets containing no chlortetracycline administered at amounts per unit of BW as those in the CTC treatment (1.12 lb/hd).
[b]Pellets were top dressed from d 1 to 5 and d 7 to 11.